BUILDING A SUSTAINABLE AND RESILIENT FUTURE FOR CALIFORNIA

CALIFORNIA 100

VISION & STRATEGY FOR THE NEXT CENTURY

ABOUT CALIFORNIA 100

The California 100 Initiative envisions a future that is innovative, sustainable, and equitable for all. Our mission is to strengthen California's ability to collectively solve problems and shape our long-term future over the next 100 years.

California 100 is organized around 5 policy themes and 5 core values, and driven by interrelated stages of work: research, policy innovation, and engagement with Californians. California 100's work is guided by an expert and intergenerational Commission.

Through various projects and activities, California 100 seeks to move California towards an aspirational vision—changing policies and practices, attitudes and mindsets, to inspire a more vibrant future. This Regional Analysis was produced as part of California 100's research stream of work.

The California 100 initiative is incubated through the University of California and Stanford.

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INTRODUCTION

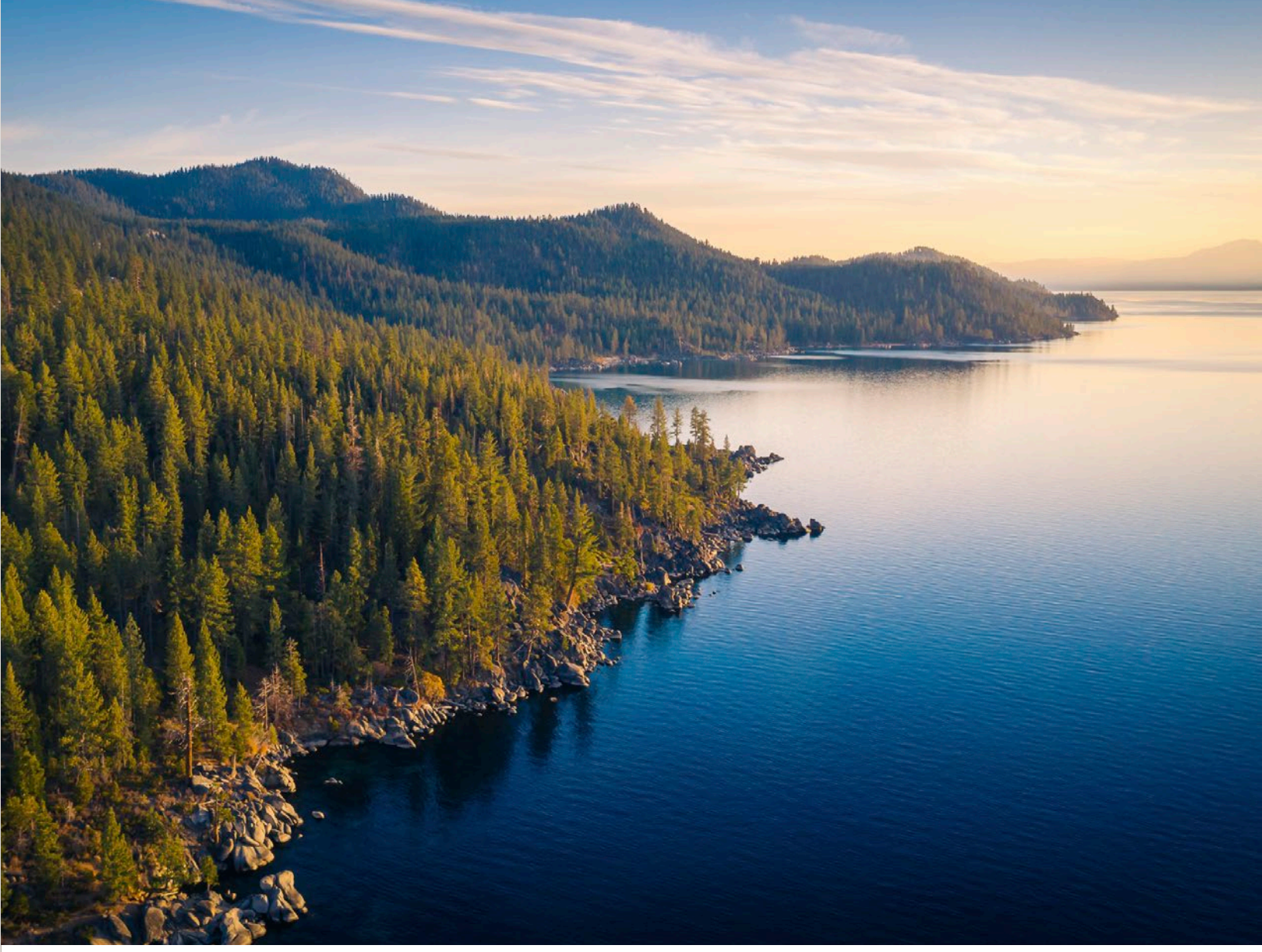
DEFINING SUSTAINABILITY AND RESILIENCE

Sustainability and resiliency include investing in steps to adapt to the consequences of climate change as sea levels rise, wildfires become more extreme, and water becomes increasingly scarce.

Sustainability has been defined by several governmental and nongovernmental agencies over time, though the most often cited definition comes from the United Nations Brundtland Commission in 1987: ***sustainability*** entails "meeting the needs of the present without compromising the ability of future generations to meet their own needs."[1] This definition captures the scope of sustainability as outlined in this report, which discusses the challenges California faces to preserve natural resources amidst a changing climate, reduce emissions from pollution and greenhouse gas emissions, and ensure an inclusive, equitable, and healthy future for all Californians.

Resiliency is different from sustainability and complementary to it. The U.S. Environmental Protection Agency (EPA) defines ***resilience*** as "a capability to anticipate, prepare for, respond to and recover from significant multi-hazard threats with minimum damage to social well-being, the economy and the environment."[2]

While much of this report focuses on the environmental factors that contribute to long-term sustainability and resiliency, these two concepts extend to encompass economic and social considerations. If California is to achieve a sustainable and resilient future, it must ensure that the needs of all residents are addressed.



CALIFORNIA'S PAST AND ONGOING EFFORTS TO PROMOTE SUSTAINABILITY AND RESILIENCE

SUSTAINABILITY

California has long been at the forefront of sustainability and resiliency efforts. However, because of the state's size, economy, and population, California faces several environmental threats, many of which have been exacerbated by climate change. Throughout its history, California has taken steps to promote environmental sustainability and resiliency, including investing in steps to adapt to the consequences of climate change as sea levels rise, wildfires become more extreme, and water becomes increasingly scarce.

Below are a few examples of California's commitment to promoting sustainable and resilient practices to protect communities and the environment.

Table 1 **Sustainability Efforts in California to Consider Present Needs Without Compromising for Future Generations**

INITIATIVE	ACHIEVEMENTS OR GOALS (NOT EXHAUSTIVE)
California Air Resources Board (CARB, formed in 1967)[3]	• *Vehicle emissions standards*: since its inception, CARB has set strict standards for vehicles sold in California, including zero-emission vehicle mandates in 1990, and reducing emissions from the auto industry over time, and also from power plants and oil refineries. • Helped develop the Global Warming Solutions Act, a law passed in 2006 that established a framework for reducing greenhouse gas emissions levels by 2020. The implementation of this law, and its mandates, is managed by CARB.
Clean Air Act	In 1967, California developed and enacted air pollution controls. Although the first state in the nation to develop such policies, California set the standard for what would later become the federal Clean Air Act.[4]
California Environmental Quality Act (CEQA)	In 1970, California developed the California Environmental Quality Act (CEQA), which mandates state and local agencies identify and work to mitigate the effects of development projects on the environment. However, even if a proposed project has identified environmental risks, this does not necessarily result in its denial, and is then often at the discretion of local elected officials.[5]
Renewable Portfolio Standard	In 2002, California became the first state in the U.S. to set a Renewable Portfolio Standard program, which required utilities to generate at least 20% percent of electricity from renewable sources by 2017. This has since expanded with the passage of SB 100 in 2018, which mandates that California move its electrical grid capacity to 100% clean energy by 2045.[6] According to the ASCE, California is currently at 47.5% of that target between its nearly 30% percent reliance on renewables, and nearly 18% on hydropower.[7]
Energy Efficiency Standards	California has some of the most stringent energy efficiency standards in the country, which apply to buildings, vehicles, and appliances. These standards have helped the state reduce its energy consumption and greenhouse gas emissions, and standards like the Building Energy Efficiency Standards are updated every three years by the California Energy Commission to reduce energy waste in new building construction.[8]

Cap-and-Trade Program	In 2008, the California Air Resources Board adopted a scoping plan for California Assembly Bill (AB) 32, which outlined a path to achieving the state's 2020 greenhouse gas reduction target, which included a cap-and-trade program. In 2010, California voters defeated a ballot initiative that would have delayed the proposal's implementation, so in 2013, the cap-and-trade rule officially began in 2013, setting a limit on emissions in the most-polluting sectors.[9] In 2017, AB 398 extended the cap-and-trade program through 2030 with two-thirds supermajority support from both representatives of both sides of the chamber.[10]
Sustainable Communities Strategies	As an additional component of the 2008 AB 32, California passed legislation that required organizations planning metropolitan regions to develop Sustainable Communities Strategies (SCSs), which focus on ensuring that existing urban areas have accessible housing, job opportunities, and high-quality transit options.[11] The goal of the legislation is to promote transit-oriented metropolitan planning, and compact development in order to reduce greenhouse gas emissions.[12]
Zero-Emission Vehicle Mandate	In 1990, California set a mandate requiring automakers to increasingly manufacture and sell zero-emission vehicles (ZEVs) in California, thereby reducing emissions from transportation to improve the state's air quality. Since it was first passed, the mandate has been updated regularly, most recently in August 2022 when Governor Newsom called for 100% percent of passenger vehicles sold in California to be zero-emission by 2035.[13]
Water Conservation and Management	California has enacted several policies to improve its water conservation, including programs that promote water efficiency, particularly during drought periods with water use restrictions. Other policies have set water-use efficiency standards for appliances and plumbing fixtures, in an effort to address the state's ongoing drought crisis. Likewise, Governor Newsom has dedicated nearly $9 billion to modernize the state's water infrastructure and respond to the drought emergency.
Sustainable Groundwater Management Act (SGMA)	In 2014, California passed the Sustainable Groundwater Management Act (SGMA), which requires local water management agencies to develop and implement strategies to achieve sustainable groundwater management policies over the next 20 years.[14] The ability to assess its progress is limited given its recent passage, and longer time horizon; however, the implementation of SGMA has already begun to face challenges, including difficulty collaborating across stakeholders, identifying data-informed measures for supporting sustainable groundwater management, and funding constraints. Others have noted that SGMA may have potential negative consequences on agricultural production and those who depend on the industry economically, often in rural communities.
Ecosystem Restoration and Protection	California is also investing in the restoration of vulnerable ecosystems across the state, including protection projects like wetland restoration and watershed management, to enhance resilience in the face of climate change, improve water quality, and protect habitats.

RESILIENCE: ANTICIPATE AND PREPARE FOR THREATS AND RISKS

Early Californians, including the indigenous people of California, had a deep understanding of their environment and relied on their knowledge to anticipate and prepare for potential environmental threats. One way they did this was through careful observation of their surroundings. They paid close attention to changes in weather patterns, animal behavior, and the growth cycles of plants, which could all signal potential environmental hazards. For example, if they noticed an unusual amount of rainfall, they might prepare for flooding or landslides, or if they observed animals moving to higher ground, they might anticipate some natural disaster.

Additionally, indigenous Californians used traditional ecological knowledge passed down through generations to inform their preparations. They had a deep understanding of the local ecology, including which plants were useful for food, medicine, and other purposes, and which could be harmful. This knowledge helped them anticipate potential threats, such as droughts or wildfires, and make preparations accordingly. For example, they might gather and store extra food and water during times of plenty to prepare for times of scarcity.

Now, California employs monitoring systems, early warning systems, and preparedness planning to anticipate potential environmental threats and risks. Specifically, California uses advanced monitoring systems to keep

track of weather patterns, water levels, seismic activity, and other environmental factors that could pose a threat. For example, the California Department of Water Resources operates a network of sensors and gauges throughout the state to monitor water levels and forecast potential flooding events.

Similarly, California has implemented various early warning systems to alert residents of impending environmental threats. For example, the state has an earthquake early warning system that can provide seconds to minutes of warning before an earthquake strikes.

California has also developed comprehensive preparedness plans for various environmental threats, such as earthquakes, wildfires, and floods. These plans outline specific actions that residents and emergency responders should take in the event of a disaster, such as evacuation procedures and shelter locations. The state also emphasizes public education and outreach to inform residents about potential environmental threats and how to prepare for them. This includes educational campaigns on topics such as earthquake safety, wildfire prevention, and emergency preparedness.

RESILIENCE: RESPOND TO THREATS AND RISKS

Actively responding to environmental threats in California typically involves a coordinated effort between multiple agencies to mitigate the impacts of the threat and protect public safety. Therefore, mobilizing and coordinating resources during an active hazard is critical to a successful response.

For example, in the case of a wildfire, active response might involve mobilizing firefighting crews to the affected area and deploying aircraft to drop fire retardant or water from the air. Evacuation orders might be issued for nearby communities, and shelters and other resources may be set up for evacuees. Additionally, efforts might be made to prevent the fire from spreading further by creating fire breaks, which involve removing vegetation and other materials that could fuel the fire.

On the other hand, active response to an earthquake might involve search and rescue efforts to locate and assist anyone who is trapped or injured. Teams may be dispatched to inspect buildings, roads, and other infrastructure for damage and safety hazards. Emergency services might be activated to provide aid and assistance to affected communities.

In the case of a flood, active response might involve deploying sandbags or other materials to protect homes and businesses from rising water levels. Emergency crews might be dispatched to assist with evacuations or rescue operations. Resources such as boats, helicopters, and other equipment may be used to transport people to safety or provide supplies to areas cut off by floodwaters.

Although a drought might seem like a slower threat, California must also actively respond to severe droughts, extreme heat events, and water shortages in order to preserve the state's water resources and mitigate the drought's impacts. For example, one of the most critical ways to actively respond to a drought is to conserve water. The state might issue water use restrictions or guidelines, such as limiting outdoor watering or requiring more efficient irrigation practices for farmers. The public might also be encouraged to conserve water through public awareness campaigns and incentives for reducing water use. During heat waves, the state might provide cooling centers to ensure that residents have access to lower temperatures to protect their health.

Managing groundwater resources is another critical aspect of responding to a drought. California has implemented laws and regulations to protect groundwater resources and prevent overuse. Active response to a drought might involve increased monitoring of groundwater levels, regulating groundwater pumping, and implementing measures to recharge depleted aquifers.

RESILIENCE: RECOVER FROM THREATS AND RISKS

Demonstrating resilience through recovery after an environmental threat has passed might involve rebuilding communities, restoring infrastructure, and preparing for future threats. For example, after a wildfire, California might replant burned areas, restore damaged infrastructure, and develop programs to help prevent future fires, such as through brush management and prescribed burns. Additionally, communities might come together to support each other in the aftermath of the fire and develop long-term community plans for recovery.

After a flood, recovery might involve repairing damaged homes and businesses, restoring damaged infrastructure such as roads and bridges, and implementing flood mitigation measures, such as building flood walls or moving homes out of flood-prone areas. Additionally, communities might work together to develop emergency response plans and ensure that critical infrastructure, such as hospitals and emergency services, are prepared for future floods.

CALIFORNIA'S CURRENT ACTIVE SUSTAINABILITY AND RESILIENCE STRATEGIES

Although this list is not exhaustive of California's efforts to address environmental sustainability and resiliency in the future, such programs do demonstrate the state's position as a national leader in the face of a growing population and climate change. Notwithstanding these efforts, climate change has magnified environmental concerns in recent decades, including extreme heat, flooding risk, wildfires, water scarcity, among other issues, that California has begun to prepare for and adapt to, and must continue to do so quickly.

Being resilient to climate change and its effects requires the state to have systems in place that allow communities to survive in the face of unforeseen and unpredictable changes. Among its recent efforts to address the impending changes brought on by climate change, California has led multiple initiatives to develop projections based on the latest climate science, strategies to address these impacts at both the community and statewide level, and programs to implement these strategies across statewide agencies and departments.

The state has introduced a number of efforts to coordinate across agencies and stakeholders using cohesive strategies to enhance the state's efforts at sustainability and resiliency. Beginning in 2006, California released iterations of its Climate Change Assessment reports, which are scientific reports compiled by agencies across the state, to outline the many ways that climate change will affect the state, its communities, and its environmental habitats.[15] The most recent report, released in 2018, is the fourth iteration of this report.

Following its publication, in 2021, the California Natural Resources Agency updated the California Climate Adaptation Strategy (CAS), a plan first drafted in 2009, which outlines strategies and priorities for California's adaptations to climate change and its impacts.[16] Among these priorities for promoting sustainability and resilience in California included strategies to address some of the most pressing challenges faced by the state; namely, enhancing California's infrastructure, including its dams, roads, bridges, access to clean water, among others; shifting land-use practices to promote a more sustainable agriculture industry; and incorporating equity planning into how the state implements these strategies, with a concerted focus on disadvantaged communities across the state.

These two documents—the 2018 Fourth Climate Change Assessment and the 2021 Climate Adaptation Strategy—combined establish California's Integrated Climate Adaptation and Resiliency Program (ICARP), which coordinates the implementation of the strategies and priorities identified by the Climate Adaptation Strategy and Climate Assessment.

Table 2 **California's Integrated Climate Adaptation and Resiliency Program**

Initiative	Focus
California Climate Adaptation Strategy (CAS)	Following the passage of AB 1482 in 2015, the California Natural Resources Agency and Strategic Growth Council was tasked with developing an adaptation plan to the effects of climate change every three years.[17] The focus of the plan has been to provide adaptation goals from across multiple domains, including public health, biodiversity, water, agriculture, and energy.
Fourth Climate Change Assessment	Following the passage of AB 32 in 2006, California has been producing climate assessment reports, which assess the risks and impacts of climate change on industries and regions throughout the state. This scientific report is designed to inform policy actions by the state to promote resilience and identify adaptation strategies.[18]
Integrated Climate Adaptation and Resiliency Program (ICARP)	Housed under the Governor's Office of Planning and Research, the ICARP is a program that is designed to coordinate climate adaptation efforts across state agencies and departments, including the implementation of needs and strategies identified by the CAS and Fourth Climate Assessment.[19]

This report both provides an overview of the many climate disasters that California is facing as well as its ongoing and iterative efforts to promote sustainability and resilience for future generations. Because of its position as a national economic hub, home to the country's largest population, and as a consequence of its natural features, including the significant portion of land that lies along the coast, in fire-vulnerable regions, or along fault lines, California faces many future environmental and sustainability challenges.

Due to California's comprehensive planning and resilience efforts—particularly through the Climate Adaptation Strategy and the Climate Change Assessment—we have a wealth of evidence that California has identified the threats and risks facing the state that are associated with climate change, and that it has taken steps to determine specific actions to help improve its resilience. We take the opportunity in this report to discuss select resilience strategies identified in these plans to demonstrate California's efforts towards promoting sustainability and resilience in the face of an ever changing environment.

DROUGHT, HEAT, AND WILDFIRES

California has been facing a multitude of climate-related challenges that have resulted in significant economic, social, and environmental impacts. Drought, extreme heat events, and severe wildfires are among the most pressing issues that have affected the state in recent years. According to the U.S. Drought Monitor, as of April 2022, more than 80 percent of California was experiencing exceptional to extreme drought conditions. This prolonged dry period has led to significant reductions in agricultural production, reduced water supplies for households and industries, and increased wildfire risks.

Extreme heat events are another major challenge that California faces due to climate change. Over the last few years, the state has experienced unprecedented high temperatures, especially during the summer months. In 2021, California recorded its hottest summer on record, with temperatures soaring above 120°F in some parts of the state.[20] These heat waves have resulted in numerous health-related issues, including heat exhaustion, dehydration, and even death, particularly for vulnerable populations such as the elderly, young children, and low-income communities.

In recent years, California has experienced some of the most devastating wildfires in its history. In 2020 alone, more than 4 million acres of land were burned, and over 10,000 structures were destroyed, resulting in sig-

nificant economic losses and numerous fatalities.[21] Climate change has increased the frequency and severity of these wildfires, making them even more challenging to contain and control. Despite significant efforts by the state government to mitigate these risks, such as creating the Office of Energy Infrastructure Safety, the scale and intensity of these disasters highlight potential shortcomings in California's current plans to become more resilient and sustainable in the face of climate change.

The problem facing the state is compounded by the fact that California is one of the largest emitters of greenhouse gases in the world, making it an important battleground for climate change mitigation efforts. This section will examine the issues related to drought, extreme heat events, and severe wildfires in California, and explore the steps the state needs to take to become more resilient and sustainable in the face of climate change.

DROUGHT

As a state, California is particularly vulnerable to drought due to its naturally arid climate. Beyond its natural inclination towards drought, human-induced climate change has exacerbated warming throughout the state, leading to some of the most severe droughts recorded in recent years.

Drought can be defined as periods of little to no precipitation that result in shortages of water. In California, the effects of drought can be acutely felt by industries, like agriculture, and by communities, either through its primary effects, including water-use restrictions and an increased risk of heat-related illnesses, or its secondary effects, including greater wildfire risk.

California has seen multiple significant and extended droughts over the past 20 years, during which the state experienced below-average precipitation. In particular, 2020 research from NASA found that severe droughts are linked to increasingly frequent and severe heat waves, with the most pronounced temperature changes in inland urban areas that often experience heat island effects—excessive warming due to a lack of vegetation and more surfaces that retain heat, like roads and buildings—and are not buffered by coastal breezes.[22]

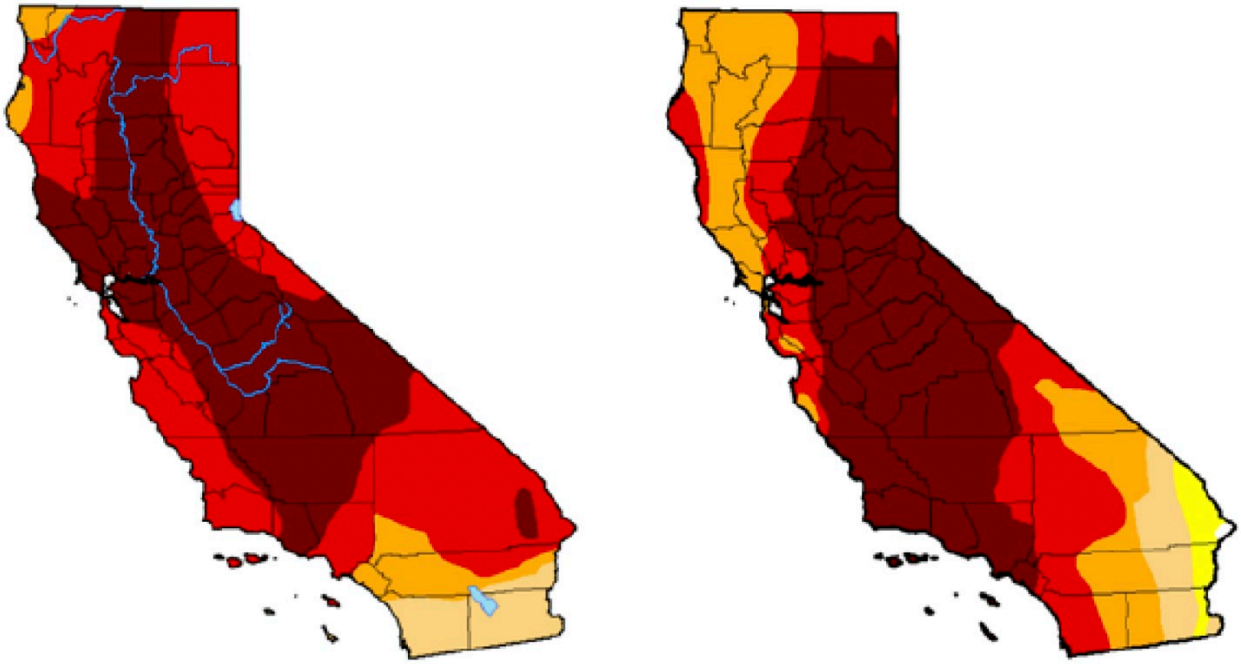
California's most severe drought in modern history occurred between 2012 and 2016. This drought was particularly severe because it lasted for several years, which led to significant impacts on the state's water resources, agricultural industry, and ecosystems. According to the U.S. Drought Monitor, the peak of the drought was in 2014 when 58 percent of the state was experiencing "exceptional drought" conditions, the most severe category of drought.[23]

The 2012-2016 drought had far-reaching effects, impacting agricultural production, water shortages, wildfires, and the health of the state's ecosystem. For example, the drought led to a decline in agricultural production and an estimated loss of $2.7 billion in 2015 alone. Many farmers had to fallow their land due to a lack of water, and some crops were left unplanted.[24] Additionally, the drought had significant impacts on the state's ecosystems, particularly its forests. The drought stressed trees, making them more susceptible to pests and diseases, which led to increased mortality rates. Additionally, the drought affected aquatic ecosystems, causing some rivers and streams to dry up completely.[25]

Statewide drought conditions by the end of the 2021 water year were comparable to those experienced during 2012 to 2016, the most severe drought since instrumental records began. The area of California land affected by extreme drought during the 2021 water year was larger compared to 2012 to 2016.[26]

Just over 18 months ago, in October 2021, Governor Gavin Newsom expanded the drought emergency proclamation to include every county across the state.[27] According to the proclamation, August 2021 was the hottest and driest month on record since tracking began, leaving reservoirs statewide at some of their lowest historical levels.[28] As of October 2021, Lake Oroville, one of the state's largest reservoirs, sat at only 28 percent of its total capacity.[29] Although a drought isn't necessarily cause for climate alarm, the current drought is, especially in combination with an unrelenting heat dome and thunderstorms threatening lightning strikes on parched land.[30]

Figure 1 **Drought Intensity in California, Comparison of Drought Conditions, 2021 and 2015**



SOURCE: Office of Environmental Health Hazard Assessment (OEHHA). "Drought." Indicators of Climate Change (2022).

The impacts of drought can extend to environmental, social, and economic consequences, affecting water availability for urban uses, agriculture, hydroelectricity generation, and ecosystems. For example, the 2012-2016 drought had far-reaching impacts, including tree mortality, increased wildfire risk, and threats to ecosystems like fish habitats. Moreover, drought can affect the availability of water to farmers, which increases groundwater pumping, leading to compromised water management systems and shortages of drinking water. This issue is particularly pronounced in low-income communities and communities of color, which disproportionately face access to safe, affordable water.[31]

During periods of drought, many ecosystems across California are affected, including forests and aquatic environments. As water flow reduces and temperatures rise, many species including salmon and steelhead populations, are at heightened risk of survival.[32] Likewise, drought leads to increased tree mortality, which can lead to reduced grazing land for livestock, thereby increasing the forests' susceptibility to wind and water erosion.[33] Moreover, as drought drains vegetation in forests of moisture, the risk of wildfire increases as there is a greater abundance of dead trees, or fuel for wildfires during periods of high temperatures and gusty conditions.[34]

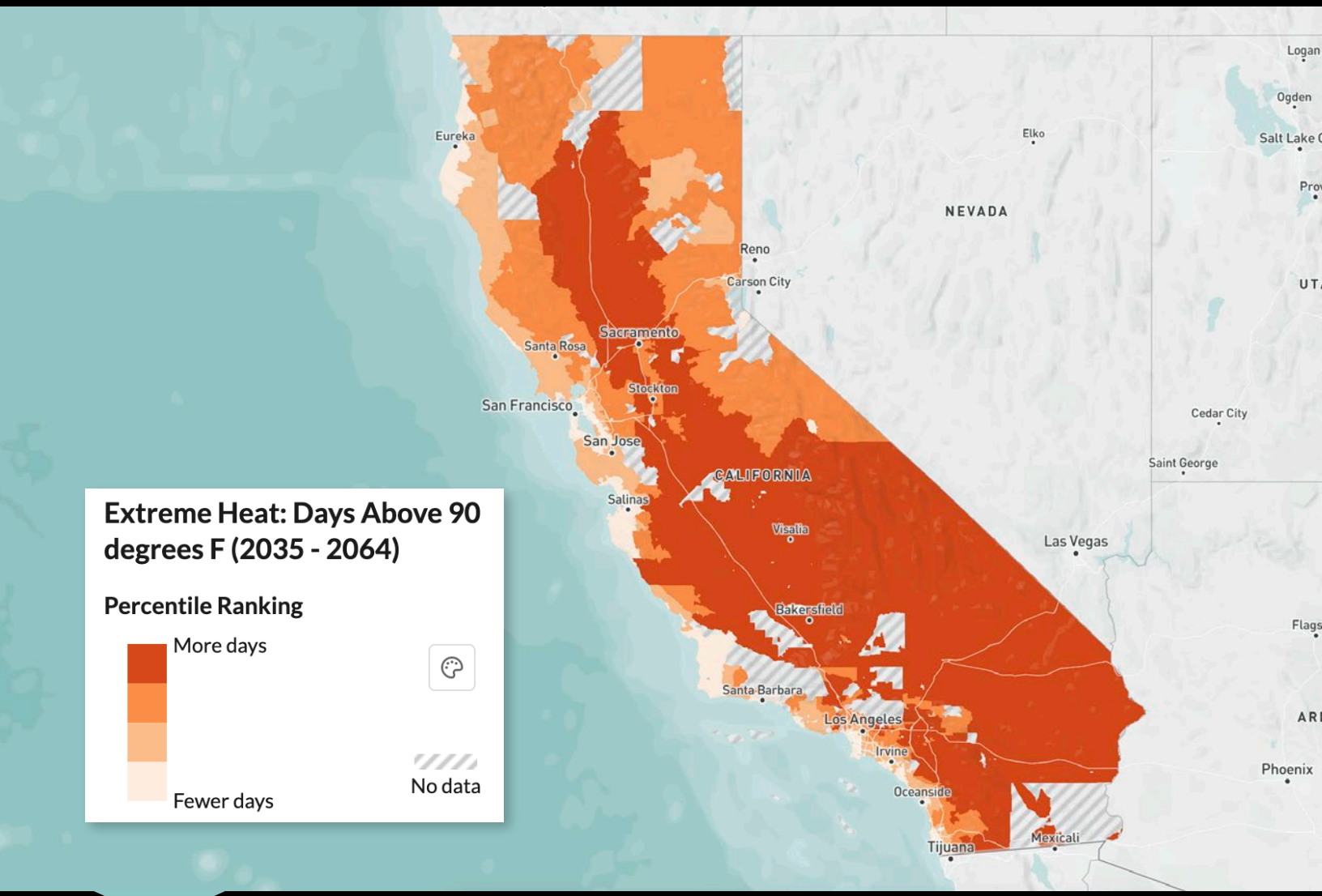
THE EFFECT OF RECENT RAINFALL IN 2023 ON CALIFORNIA'S DROUGHT CONDITIONS

In spite of the powerful storms that struck California in the weeks leading up to and into 2023, California remains in an active drought emergency.[35] Such extreme levels of precipitation may lead many Californians to assume that the drought is over; however, if periods of wet weather are followed by dry, hot spring and summer months—as was the case following the 2021 - 22 winter season when spring temperatures climbed rapidly—the drought may, in fact, be intensified.[36] That said, as of early April 2023, the number of Californians experiencing at least moderate drought conditions was about 25 percent, down from 100 percent just one year ago.[37] In the short-term, therefore, these storms have eased the effects of drought in California, but temperatures in the spring and summer months will determine how much they are able to impact the state's conditions in the long-term.[38] We address the interactions between severe droughts and extreme precipitation in the next section on Water.

EXTREME HEAT EVENTS

Climate change is magnifying the dangers of extreme heat. In recent years, the number of severe heat waves and extreme heat events in California have been growing. Extreme heat events—the hottest days and nights—both pose danger to human health and to the environment.[39] On extreme heat days, temperatures are at or above the highest 2 percent of historical daily highs, while on extreme heat nights, they are at or above the highest 2 percent of historical daily lows.[40] Five or more consecutive extreme heat days or nights make up a "heat wave." In September 2022, California experienced a record-breaking heat wave lasting more than 10 days, with cities including Sacramento, Stockton, and Fresno reaching extremes up to 116 degrees.[41]

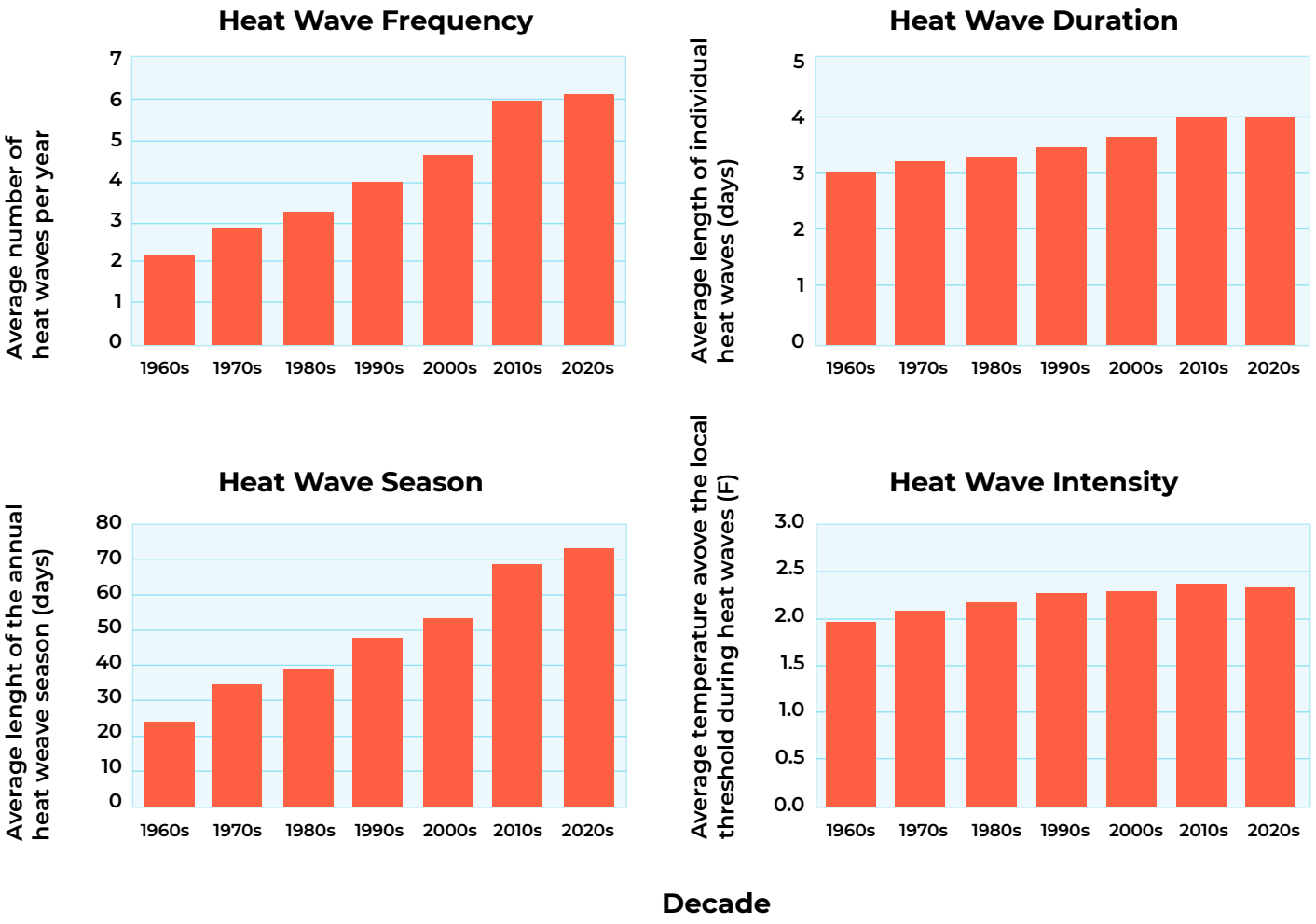
Figure 2 **California is Projected to Experience More Extreme Heat Days Each Year, Particularly in Densely Populated Areas of the State**



SOURCE: "California Healthy Places Index: Extreme Heat Edition." UCLA Luskin Center for Innovation and Public Health Alliance of Southern California.

Research from the Scripps Institute has found that if greenhouse gas emissions continue to accumulate at their current rate, warming in California may exceed 4 degrees in the next 50 years.[42] Greenhouse gases—like carbon dioxide emitted from human activities, including the burning of fossil fuels—collect in the atmosphere and trap heat, leading to temperature rises.[43] Research from the Scripps Institute also found that with a more arid climate as a consequence of extreme heat and drought, wildfires may become increasingly frequent; as historical summer temperatures have risen over the past 50 years, the number of wildfires has increased fivefold.[44]

Figure 3 **Heat Wave Characteristics Across the U.S. Have Worsened Over the Past 50 Years**



SOURCE: U.S. EPA. "Climate Change Indicators: Heat Waves," February 4, 2021.

Heat waves, which have been increasing in duration and magnitude globally, pose a great risk to human health as they can contribute to heat exhaustion, dehydration, blood clots, and death.[45] In fact, extreme heat causes the most weather-related deaths in the United States. In 2021, extreme heat killed more Americans than any other weather-related event, such as floods or wildfires, yet heat often fails to garner the same attention as other extreme weather.[46]

Although California tracks the number of heat-related deaths per year, a 2021 Los Angeles Times investigation found that because the state does not track real-time data related to the health effects of heat waves, it may be severely undercounting deaths related to extreme heat.[47] According to the analysis, the number of people who have died as a result of extremely hot weather is likely six times California's official mortality data, or nearly 4,000 people between 2010 and 2019.[48] Nationally, according to CDC data, approximately 700 people die each year from heat-related causes, yet a 2020 study from the journal *Environmental Epidemiology* found that many thousands more likely died due to heat.[49]

As Californians continue to experience higher temperatures, a growing body of research has indicated that heat exposure can have immediate and long-term effects on individuals: limited-resource households now have to spend more on air conditioning or other means of cooling their homes, students experience negative impacts on their ability to learn in a classroom, and residents must endure the physical and mental toll of heat.[50] The effects of severe heat are also often felt by lower-resourced communities, as those with greater means may be able to either afford air conditioning or work jobs that do not require them to be in a field or a poorly-ventilated warehouse.[51]

In the summer of 2022, Governor Gavin Newsom declared a state of emergency due to strains on the electrical energy grid from high demand across several western states.[52] In addition to spiking demand for air conditioning and electricity, heat waves have the added effect of reducing the efficiency of wires along the electrical grid, thereby straining access to electricity. Moreover, the heat itself can cause power lines to sag, so much so that the risk of a line touching and igniting vegetation (and therefore, sparking wildfires) increases.[53]

LIGHTNING AND THUNDERSTORMS

According to the National Oceanic and Atmospheric Administration (NOAA) National Weather Service, approximately 1,800 thunderstorms are occurring at any given time, resulting in about 16 million thunderstorms each year. Most thunderstorms last about 30 minutes and are typically about 15 miles in diameter.[54]

Thunderstorms thrive under certain conditions, which require moisture and rapidly rising warm air. In 2020 some 170 million lightning strikes occurred across the country, about 22 percent below average. California was 51 percent below average with 283,000 strikes, despite the deadly August 2020 surge. In 2021, nationwide strikes were about 15-20% below average.[55]

Because moisture and warmth are crucial to thunderstorms, they occur more often in the summer, particularly in humid areas. The high humidity, in conjunction with warm temperatures, creates massive amounts of warm, moist air rising into the atmosphere, where it can easily form a thunderstorm. Scientists have indicated that climate change could magnify the risks of thunderstorms igniting wildfires in California, like those that occurred in August 2020, when about 14,000 lightning strikes

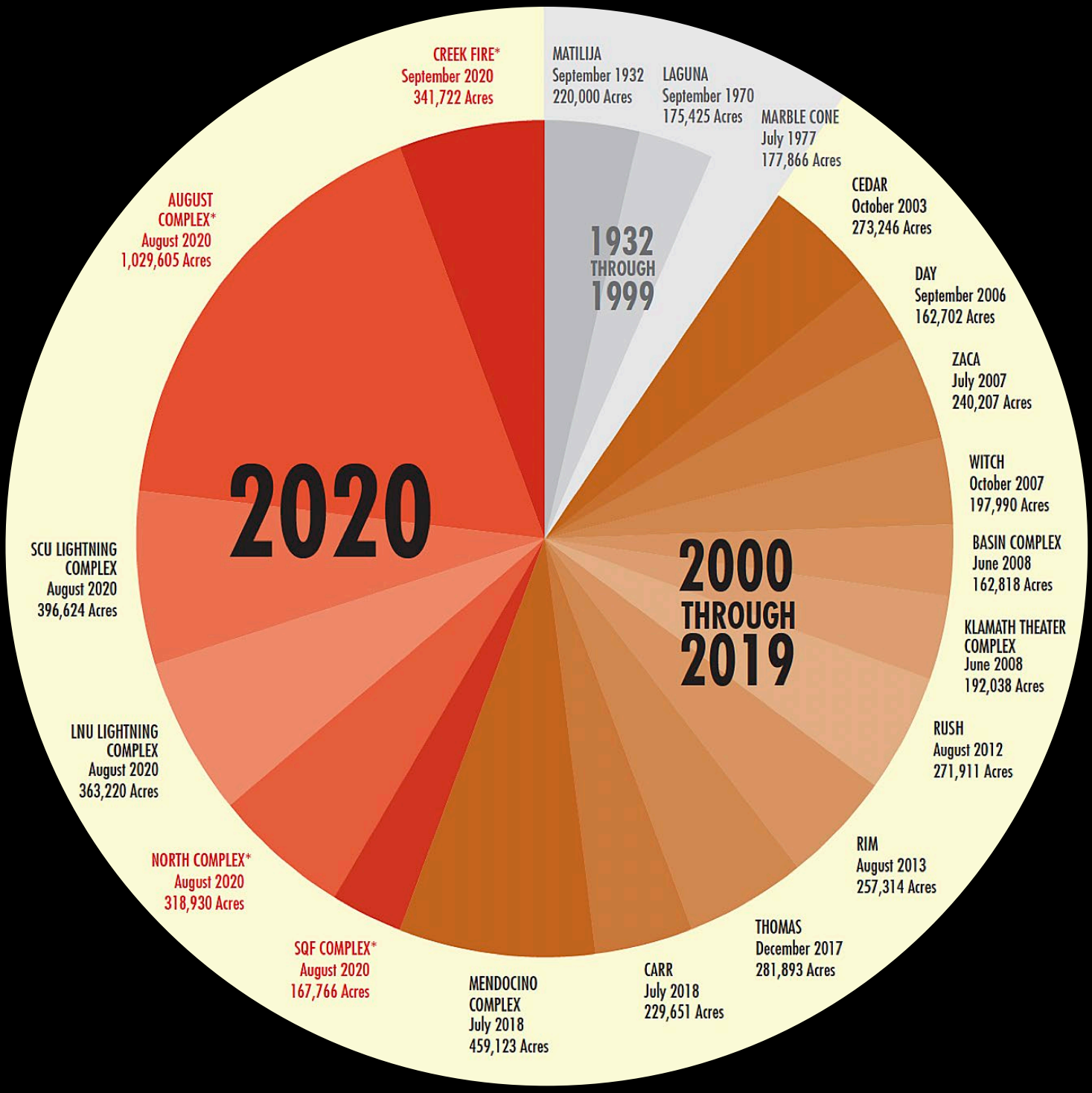
ignited 900 fires throughout the state.[56] Research from 2023 that analyzed lightning patterns between 1992 and 2018 predicted that as the atmosphere continues to warm, the frequency of lightning strikes will increase – referred to as "hot lightning."[57] A 2014 study found that the rate of such lightning will increase, on average, 12 percent for each degree Celsius of global warming, or up to 50 percent over the next century if greenhouse gas emissions are emitted at their current pace.[58]

This trend is concerning because lightning can play a significant role in sparking wildfires. National wildfire statistics show that although most wildfires are caused by human activity – roughly 89 percent between the years 2018 and 2022 – wildfires caused by lightning tend to burn more acreage.[59] As such, although lightning-caused wildfires are less frequent, they accounted for 53 percent of burned acres between 2018 and 2022 nationally.[60] In California, where drought has led to more dead trees and consequently, more fuel for wildfires, lightning strikes can become even more dangerous, particularly as lightning strikes can be unpredictable, and often in remote, hard-to-access parts of the state.[61]

WILDFIRES

For thousands of years, wildfires have been a natural occurrence in California because of the region's arid climate and its forested landscape. Before European settlement, wildfires ignited by lightning or as part of controlled-burn practices by Native Americans burned regularly throughout the summer and fall months. These fires helped to periodically clear underbrush, thereby clearing potential wildfire fuel with smaller fires, and allowing for regeneration of important vegetation. By 1850, the newly-established California legislature formally banned controlled burns. The rapid dismantling of the practice had devastating consequences for California forests, which had adapted to regular burns. Without frequent fires, underbrush and small shrubs build up, creating fuel for more extreme fires. The frequency and severity of such fires, however, has been increasing significantly in recent decades, driven by a combination of factors including climate change, forest-management policies and practices, and human activity and development in fire-prone areas. According to California's Fourth Climate Change Assessment, urban regions in Southern California, like Los Angeles and San Diego, face the highest risk of wildfires, whereas the threat continues to grow in the forested, mountainous regions in Northern California due to climate change and human encroachment.[62]

Figure 4 **The Top 20 Largest California Wildfires**



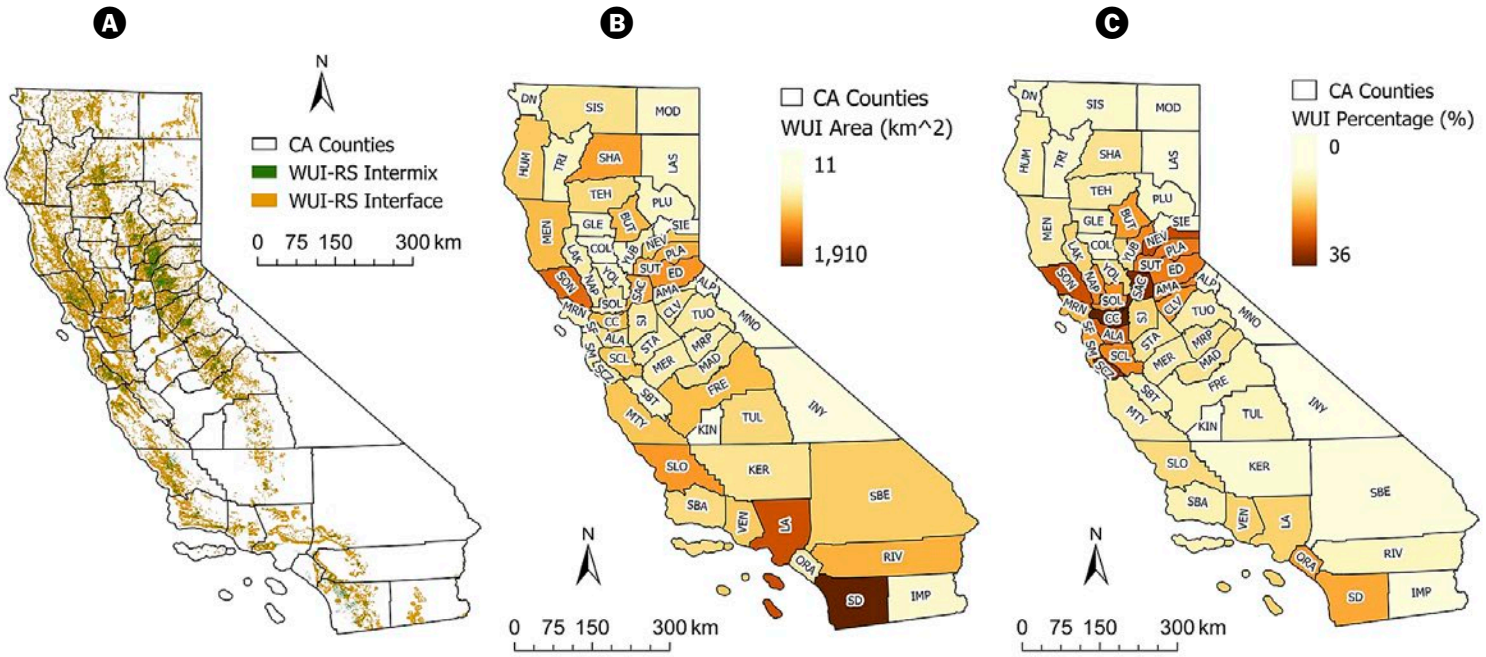
SOURCE: Governor's Forest Management Task Force. "California's Wildfire and Forest Resilience Action Plan: Recommendations of the Governor's Forest Management Task Force," January 2021.

HOUSING GROWTH IN THE WILDLAND-URBAN INTERFACE (WUI)

Wildfires have also become a more extreme and damaging phenomenon as more human development occurs in wildfire-prone areas. These areas are known as wildland-urban interface zones (WUI), where human activity and development coincide with open, undeveloped land.[63] These clusters are found throughout the forested, mountainous regions in Northern California, as well as in the coastal regions of Southern California.[64]

As of 2020, more than 16 million homes in the Western U.S. are built within WUI areas —about one-third of which are in California— and these rates are rising steadily over time.[65] Explanations for why construction in these high-risk regions are manifold; however, often these regions tend to be lower-cost than their urban counterparts, many of which have restricted development of higher-density housing.[66] As more people move into these regions, the likelihood of a fire igniting rises simply because humans cause an estimated 95 percent of fires each year in California.[67]

Figure 5 **High Proportions of People Live in WUI Zones in Many California Counties**



SOURCE: Li, Dao, Kumar, Nguyen, and Banerjee. "Mapping the Wildland-Urban Interface in California Using Remote Sensing Data." Nature, April 6, 2022.

Because the Western U.S. is at a constant threat of wildfire ignition, some experts suggest that building less in wildfire-prone regions may not be feasible, and that attention should be paid instead to protecting homes in such regions.[68] After large fires occur in urban areas of the state, no one seems to question whether residents will rebuild in nearby or the same locations. However, people regularly question whether residents in Paradise, California—the site of the destructive 2018 Camp Fire that killed 85 people and destroyed nearly 19,000 structures in Butte County—should remain.[69] Within a few months of the Camp Fire, the city of Paradise issued permits to rebuild housing. However, only 11 houses had been rebuilt one year later, demonstrating that, without plans to protect homes from wildfire risks wherever they are built, Californians may not feel safe from wildfire in their home communities.[70]

In 2005, California expanded its building codes for homes built in WUI designated areas beginning in 2008, requiring that all such residential construction meet fire safety standards, including using fire-resistant building materials, landscaping to minimize the spread of a fire, and making water available to firefighters, among others.[71] Following the 2018 Camp Fire, a review of the structures burned found that 51 percent of homes that had been built following these requirements were not damaged, whereas only 18 percent of those built prior to these mandates did.[72]

Although building requirements appear to ameliorate the effects of wildfires on residen-

tial construction, many millions of homes throughout the state have been built prior to their implementation, leaving these residents at risk.[73] Moreover, in the destructive 2017 Thomas Fire in Ventura in Santa Barbara Counties, the majority of the structures that burned already had fire-resistant exteriors and roofs.[74] As such, despite improvements to building codes that require greater use of fire-resistant materials, wildfires remain unpredictable, with no guarantees of protection. According to 2021 research from the National Bureau of Economic Research, a home built in 2008 following California's updated fire code is 40 percent less likely to burn than an otherwise identical home built in 1990.[75]

In recent years, California has increased the number of homes that have been designated as built within WUI, and yet even in repeat-burn zones, construction continues. For example, in Middletown, California, a small community in Lake County, new development was promised — five resort hotels, a golf course, villas, and housing developments — in an area that had been burned three times in the past 7 years.[76] A judge ultimately blocked the development, marking one of several new legal rulings to stop developments in remote regions in California that are particularly fire prone, including developments near San Diego and Los Angeles. Following a change in 2018, the California Environmental Quality Act (CEQA) was updated to emphasize that wildfire risk must be a factor to be considered during environmental reviews. Among these considerations include whether a new project would impair wildfire emergency response plans, increase wildfire risk in a given area, or lead to risks associated with post-fire slope instability and consequential runoff.[77]

Power and power lines can also have consequential impacts on remote, high-risk communities, often found in WUI zones. Not only does access to power affect residents' ability to be notified of evacuations and immediate danger, but the infrastructure in these communities is often also antiquated and at a heightened risk of combustion. Although, historically, fewer than 10 percent of reported wildfires have been attributed to utility infrastructure, the majority of the most destructive fires in California history have been caused by power lines.[78] According to a review by the California Department of Forestry and Fire Protection, the cause of Camp Fire was determined to be faulty transmission lines owned by Pacific Gas & Electric (PG&E).[79] Nearly a year after the 2018 Camp Fire, PG&E moved to shut off the power of 800,000 of its customers throughout 31 Northern California counties in an effort to reduce wildfire risk during periods of high wind.[80] Although experts have indicated that this may be the best practice during periods of dangerous fire weather, residents in regions like Paradise worry that if another fire were to break out, they may be left potentially unaware and defenseless.[81]

CALIFORNIA'S APPROACH TO SUSTAINABILITY AND RESILIENCE FOR THESE HEAT CHALLENGES

SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY

GHGs contribute to warming the Earth's climate and can intensify the severity of heat waves, drought, and wildfires in California. Because of this, the California Air Resources Board has recommended several measures aimed at reducing greenhouse gas emissions by 85 percent from the 1990 levels by 2045, as part of their 2022 Scoping Plan for Achieving Carbon Neutrality.[82] Some of these strategies include promoting renewable energy like hydrogen instead of the combustion of fossil fuels, reducing vehicle emissions by calling for 100 percent zero-emission-vehicle sales by 2035, transitioning to cleaner energy sources, such as wind and solar power, increasing the amount of carbon dioxide captured through land and new technologies, and increasing efforts to protect natural resources that provide economic and food security for many residents.[83]

Many policy experts warn, however, that the state's 2045 goal of cutting greenhouse gas emissions may be ambitious, but not feasible.[84] For example, one of the strategies proposed to reduce emissions requires carbon capture and storage, by methods including replanting trees and collecting carbon and injecting it into the ground; according to Air Resources Board officials, however, plans to initiate such projects do not begin until 2028.[85]

CALIFORNIA'S WILDFIRE AND FOREST RESILIENCE ACTION PLAN

In January 2021, the Governor's Forest Management Task Force released its comprehensive strategy for wildfire and forest resilience for the state. The California Wildfire and Forest Resilience Action Plan is a document that outlines the state's strategy for reducing the risk of catastrophic wildfires and increasing the resilience of California's forests.[86] The plan includes a variety of goals and initiatives related to forest management, community preparedness, and climate change adaptation.

The plan begins with an overview of the current state of California's forests and the challenges posed by climate change and wildfire risk. It then lays out a series of goals related to forest health, including increasing the pace and scale of forest restoration, reducing the risk of catastrophic wildfires, and improving the resilience of ecosystems to climate change:

1. Scale-up forest thinning and prescribed fire efforts to reduce long-term greenhouse gas emissions and harmful air pollution from large and catastrophic wildfires;

2. Integrate science-based climate adaptation and resilience strategies into the emerging statewide network of regional forest and community fire resilience plans;

3. Drive forest management, conservation, reforestation and wood utilization strategies that stabilize and increase the carbon stored in forests while preserving biodiversity and revitalizing rural communities;

4. Improve electricity grid resilience; and
5. Promote sustainable land use.[87]

The plan also includes initiatives aimed at improving community preparedness and reducing the risk of wildfire damage to homes and infrastructure. These include expanding defensible space requirements around homes, promoting the use of fire-resistant building materials, and increasing public education and outreach efforts.

In addition to these initiatives, the plan highlights the need for increased investment in research and development to improve our understanding of wildfire risk and forest management strategies. It also emphasizes the importance of collaboration between federal, state, and local agencies, as well as with private landowners and community groups, in order to achieve its goals.[88]

CALIFORNIA'S OFFICE OF ENERGY INFRASTRUCTURE SAFETY

In 2019, the California Public Utilities Commission (CPUC) established the Wildfire Safety Division in response to devastating wildfires caused by utility infrastructure. By 2021, the Wildfire Safety Division transitioned to the Office of Energy Infrastructure Safety (Energy Safety) under California's Natural Resources Agency.[89] Energy Safety is responsible for ensuring the safety and reliability of California's energy infrastructure, including electrical infrastructure, natural gas and petroleum pipelines, and hydroelectric facilities.

Energy Safety's mission is to advance long-term utility wildfire safety by developing data-driven, comprehensive utility wildfire mitigation evaluation and compliance criteria, by collaborating with local, state and federal agencies, and supporting efforts to improve utility wildfire safety culture and innovation.[90] The office operates under several guiding principles, one of which is to deliver short-term results while promoting a long-term utility vision to reduce wildfire and underground risk and to build safety cultures.[91]

Energy Safety assesses electrical corporations' Wildfire Mitigation Plans, safety culture assessments, safety certifications, and executive compensation structures. These mitigation plans should describe how the electrical corporation is constructing, maintaining, and operating its electrical lines and equipment in a manner that will minimize the risk of catastrophic wildfire. Energy Safety also conducts annual Safety Culture Assessments for each electrical corporation to evaluate their progress toward safety culture maturity.[92]

STRATEGIC FIRE PLAN

California's Department of Forestry and Fire Protection (CAL FIRE) is responsible for preventing and responding to wildfires in California. The Fire Plan is designed to enhance fire prevention efforts in the wildland urban interface (WUI) areas, which are areas where development meets natural vegetation. One objective of the Strategic Fire Plan is to prioritize prevention through public education,

community preparedness, and proactive fuel reduction efforts. This includes managing vegetation around homes and communities, creating defensible space, and implementing early warning systems to detect and respond to fires as soon as possible.

Another objective is to improve firefighting capacity and response by investing in equipment, technology, and personnel. CAL FIRE aims to increase the number of firefighters and improve their training and support systems. They also plan to use technology such as drones, aircraft, and satellite imagery to enhance their ability to detect and respond to fires.

The plan also emphasizes the importance of collaboration with other agencies, organizations, and stakeholders to coordinate efforts and share resources. This includes working with local governments, utilities, and private landowners to manage forests and reduce the risk of wildfires.[93]

VEGETATION MANAGEMENT PROGRAM

California has established the Vegetation Management Program, which is a statewide initiative led by CAL FIRE, to manage vegetation to reduce fuel loads in high-fire-risk areas. One of the primary goals of the initiative is to reduce the amount of fuel at risk of combustion, including dead trees and brush, with activities such as prescribed burns and the thinning and removal of trees and vegetation.[94]

In January 2022, Governor Newsom proposed $1.2 billion in forest health and fire protection initiatives, which includes investments to continue reducing the vegetation that is likely to burn in a wildfire, reforestation efforts, and firefighting equipment.[95] Experts argue that this is a step in the right direction, though the California government needs to ensure coordination and the rapid deployment of funding to begin forest management actions quickly.

CALIFORNIA'S EXTREME HEAT ACTION PLAN

In April 2022, California released a statewide initiative, the Extreme Heat Action Plan, which outlined the following goals to reduce vulnerability to heat throughout the state: first, building public awareness, second, strengthening community services and response, third, increasing resilience of the built environment, and fourth, utilizing nature-based solutions.[96] Already, the city of Los Angeles has introduced the position of Chief Heat Officer. As the third city in the country to develop such a position, Los Angeles named Marta Segura to lead the effort of organizing, communicating, and coordinating the city's resources and policies to mitigate the effects of extreme heat.[97] Such efforts include focusing on communities that are acutely affected by the heat island effect, or the phenomenon in which a region with a significant amount of urban development, concrete, and asphalt retains heat much more than a neighboring community with trees and greenery would.[98]

Although the statewide Extreme Heat Action Plan also proposes strategies to address extreme heat – including adding more green infrastructure, better coordination with providing public messages, planting more trees to reduce the heat island effect – and recognizes the vulnerabilities of heat by low-income communities, experts have urged for a more coordinated and comprehensive response from the California legislature to mitigate the effects of extreme heat.[99]

In September 2022, California became the first state to also implement a heat ranking system to warn residents of the dangers of extreme heat exposure.[100] The new law requires that the California Environmental Protection Agency develop this ranking system by 2025, which is expected to increase public awareness of the severity and danger of heat, as is already done for natural disasters like hurricanes and fire risk.

The state has also designated millions of dollars to develop cooling centers, plant more trees in urban areas, and other greening measures to support vulnerable Californians; however, many argue that although the state has acknowledged the dangers of extreme heat, the California legislature must adopt policies in addition to providing warnings to residents that comprehensively address the dangers of heat in the state.[101]

During extreme heat events, some places in California set up facilities to provide relief through "cooling centers" in public buildings, such as libraries, community centers, and senior centers. These centers offer air conditioning, hydration, and other support to help people cope with the effects of high temperatures. They are particularly important for vulnerable populations such as the elderly, homeless, and those without access to air conditioning. For example, during the 2021 heat wave in California, the City of Los Angeles opened dozens of cooling centers across the city, including in public buildings and recreation centers.[102] Sacramento similarly set up cooling centers for residents.[103] These centers provided free water, air conditioning, and other support to help people cope with the extreme heat.

CALIFORNIA'S COMEBACK PLAN

In response to the threat of drought in the state, one of California's major investments has been the 2021 Governor's California Comeback Plan, a $100 billion plan that allocates roughly $5 billion to addressing drought and climate change in the state.[104] This funding includes initiatives like investing in water infrastructure projects for drinking water and wastewater, supporting the Sustainable Groundwater Management Act (SGMA) implementation process to improve water security and quality, and providing grants to farmers to reduce greenhouse gas emissions and reduce reliance on irrigated water.[105] This report covers these strategies in detail in the next section on Water.

CONCERNS ABOUT CALIFORNIA'S PLANS FOR DROUGHT, WILDFIRES, AND EXTREME HEAT

CONCERNS ABOUT THE SCOPING PLAN FOR ACHIEVING CARBON NEUTRALITY

Despite these extensive plans and strategies, California still has a long way to go to ensure its preparedness and resilience for future wildfires and extreme heat events. Specifically, many experts have expressed concerns that California's plans do not go far enough to ensure the highest levels of mitigation for the state's health amidst rising climate change. For example, last June of 2022, CalMatters released a series of articles explaining how "California's plan for handling the [climate] crisis is flawed."

The first article argues that California's plan to combat climate change is flawed because it fails to address the root causes of the problem, such as the state's reliance on fossil fuels and agriculture. The author argues that the state's climate policies focus too much on reducing emissions rather than making systemic changes to the economy and society. Specifically, the article points out how critics say that the California Air Resources Board's scoping plan has not been transparent on how it plans to achieve its goals, leaving legislators and others in the climate discussion confused over the scoping plan's projections. The article quotes expert Danny Cullenward, an economist and vice chair of the Independent Emissions Market Advisory Committee, saying "The draft scoping plan does California a disservice... It focuses on long-term goals at the expense of near-term action."[106]

The second article similarly expressed criticism from experts stating that the scoping plan plans to phase out fossil fuels too slowly and "relies too much on technologies to remove or capture emissions, while the oil and gas industry has said the ramp-up of clean energy is too ambitious."[107]

Carbon capture is a process that involves capturing carbon dioxide emissions from industrial processes, power plants, or other sources, and storing or repurposing them so they do not enter the atmosphere and contribute to climate change. This can involve a variety of methods, including capturing emissions at the source, transporting the carbon dioxide to a storage site, and injecting it underground into geological formations or using it for enhanced oil recovery. The goal of carbon capture is to reduce greenhouse gas emissions and help mitigate the effects of climate change.

The articles cite criticisms from environmental advocates who argue that the plan lacks clear targets and accountability measures. For example, the scoping plan includes evidence that California captured about 2 million tons of carbon dioxide in 2021, but critics point out that no carbon capture facilities exist, so how is this statement possible?[108] After hearing these criticisms CARB acknowledged that the use of carbon capture technology by 2025 is "unlikely, and those emissions will be emitted into the atmosphere."[109] Moreover, to achieve the plan's goals, experts project that California will need "about 30 times more electric vehicles on the road, six times more electric appliances in homes to replace gas appliances, 60 times more hydrogen supply and four times more wind and solar generation capacity."[110] These requirements may ultimately strain California's energy grid more than the state is prepared for.

The state needs to speed up the construction of new solar and wind infrastructure, improve existing power lines, and increase battery storage capacity, according to air board staff, in order to handle the spike in electricity demand. Additionally, California will require backup dispatchable power to make up for energy losses when renewable energy sources like wind and solar are unable to generate electricity due to weather changes. It seems likely that California will have to continue relying on climate-warming fossil fuels, especially natural gas, without these significant upgrades and investments. If sufficient renewable energy is not available by 2045, an additional 10 gigawatts of natural gas capacity will be required, according to air board officials, to support the electrical grid.[111]

In order to achieve carbon neutrality in 2045, Scenario 3, which is CARB's preferred option, predicts that technologies will need to remove nearly 80 million tons of carbon dioxide from the atmosphere. According to this "ideal scenario," by 2030, most oil refineries must have installed carbon capture technology, and by 2045, all cement, clay, glass, and stone facilities must have done the same. However, as noted above, this technology does not yet exist as of 2023.[112]

CONCERNS ABOUT THE STATE'S PLANS FOR WILDFIRE RESILIENCE AND PREPAREDNESS

As noted in the earlier section on wildfires in California, creating defensible space in developed areas and arming homes with fire-resilient materials is the most effective preparation.[113] Because 95 percent of wildfires are caused by humans—including 10 percent

caused by power lines in California—preparing and protecting homes and people from human-caused wildfires requires our power lines and energy grid to be resilient to high winds and hot weather, but California's plans do not always focus on these efforts.

For example, the U.S. Forest Service and California have invested heavily in reducing fuels in coniferous forests to reduce wildfire risk, but this approach has several problems according to UC Davis conservation scientist, Mark Schwartz. Firstly, Schwartz explains that ecosystems such as grasslands, shrublands, woodlands and coniferous forests are all fire-maintained and expected to burn. In fact, we need them to burn in many cases to maintain their ecosystem goods and services.[114]

Second, Schwartz notes, rural communities are collectively the generators of risk to each other and to public lands, which contrasts with the current public opinion that these communities are only victims of the problem. Thus, he concludes, California needs to foster change in risk attitudes and behaviors by people in rural areas. Specifically, Schwartz identifies home hardening and creating defensible space as the major strategies for reducing wildfire risk.[115]

Thirdly, most of the highly damaging fires are wind-driven, not fuels driven, and to reduce wildfire risk more effectively, we would need to manage wind, not fuels.[116] Climate models suggest that the likelihood for rapidly moving fires is increasing owing to patterns of delayed

precipitation and high wind events in the autumn months.[117]

Schwartz directs policymakers to consider advocating for more wildfire acreage albeit at lower burn severity, but he still notes that we will fail to prevent occasional large fires. We also need to foster change in risk attitudes and behaviors by people in rural communities, creating an environment that reduces the risk of loss of life and property damage when there are wildfires rather than eliminating wildfires.[118]

Schwartz identifies three strategies policymakers can use to drive societal change: information, incentives, and penalties. Agencies have provided information, and financial incentives are available to encourage landowners to adopt risk-reducing strategies. However, incentives alone are not enough, and penalties must also be part of the solution. Schwartz suggests that California should consider holding private property owners accountable for damage caused to adjoining properties due to individual failure to comply with fire-safe practices. States and counties are adopting building code changes to make future buildings more fire-safe, and recent policy changes in California require state inspection for required fire risk abatement through defensible space for homes sold in very high fire risk areas.[119]

Concerns about California's Ability to Prevent Wildfires Started by Utility Companies

The majority of the most destructive fires in California history have been caused by power lines.[120] In order to become more resilient in the face of more intense and severe wildfires, utility companies like PG&E have been investing in upgrading old equipment, removing vegetation near power lines, and enhancing monitoring systems by installing video cameras and weather stations that monitor local climate conditions in places where equipment is located.[121]

According to a federal judge's estimate in January 2022, PG&E's electrical equipment started fires that burned nearly 1.5 million acres, destroyed 23,956 structures and killed 113 Californians over 12 years.[122] Critics, including Governor Gavin Newsom, have contended that the company prioritized profits over safety measures.[123] Despite dedicating billions of dollars to improving its wildfire mitigation plans, including burying 10,000 miles of transmission lines underground, PG&E continues to find itself responsible for deadly and destructive wildfires.[124]

Although California established the Office of Energy Infrastructure Safety in 2021 to provide wildfire-related safety certifications for utility companies, the California State Auditor's office found that the Energy Safety office "approved plans despite some utilities' failure to demonstrate that they are appropriately prioritizing their mitigation activities, and subsequent reviews have found that some utilities failed to focus their efforts in high fire-threat areas."[125] For the state's investor-owned utilities, California legislators established a wildfire insurance fund so that they could be compensated for the damages they pay to people injured in fires that their equipment started. However, a utility is assumed to have acted "reasonably" if it has

a safety certification for the time period during which the fire occurred, unless evidence to the contrary can be produced. This means that the utility may not be required to repay the fund in the future.[126]

According to the state auditor's report, the Energy Safety office's procedure for approving utility wildfire plans doesn't guarantee that advancements are being made in regions that are particularly vulnerable to wildfires. The three biggest utilities in the state—PG&E, Southern California Edison, and San Diego Gas & Electric Co.—all received 2020 safety certifications from the Energy Safety office even though each of their plans had "serious deficiencies." Specifically, none of the three utilities had adequately explained in their 2020 plans how they would use risk modeling to focus on the areas of the grid that were particularly vulnerable to fire risk.[127]

PG&E specifically has been held to account publicly for its role in recent wildfires in the state. In September 2022, California codified PG&E's goal to bury 10,000 power lines within 10 years into law.[128] PG&E has estimated it will spend $11 billion burying power lines by 2026.[129] However, this law also commits the state to a controversial wildfire mitigation plan. According to critics, burying so many power lines will be expensive and hurt ratepayers in the short run, but will benefit PG&E shareholders by providing a sizable return in the long run. However, PG&E watchdogs claim that the utility hasn't demonstrated that burying lines is the most economical way to lessen wildfires.[130] In 2022, PG&E reported that it put at least 175 miles of its power lines underground, more than double the amount from 2021.[131] However, the company still struggles with old, fragile infrastructure.

WATER

As California is largely dependent upon precipitation to supply the state's water, the ongoing drought conditions have had significant impacts on California's water resources. Specifically, the water supply and the natural groundwater recharge is dependent primarily upon precipitation in the form of rain and snow, though climate change is changing the proportions of whether this precipitation falls as rain or snow. This proportion varies region by region, year by year, season by season.[132]

Drought conditions in the state are anticipated to lead to more precipitation falling as rain, rather than snow, while more frequent atmospheric rivers are expected.[133] The result can lead to challenges managing reservoir levels, which may fill prematurely, forcing managers to release water in the spring to reduce flood risk, while less snowpack in the Sierra Nevada leads to less water available during the warm summer and fall months. The California Office of Environmental Health Hazard Assessment predicts that the state will continue to experience precipitation "whiplash," under which the state experiences rapid shifts between extreme drought and severe storms that result in heavy precipitation, which can have effects not only on the state's water supply, but also on communities and infrastructure vulnerable to flooding events.[134]

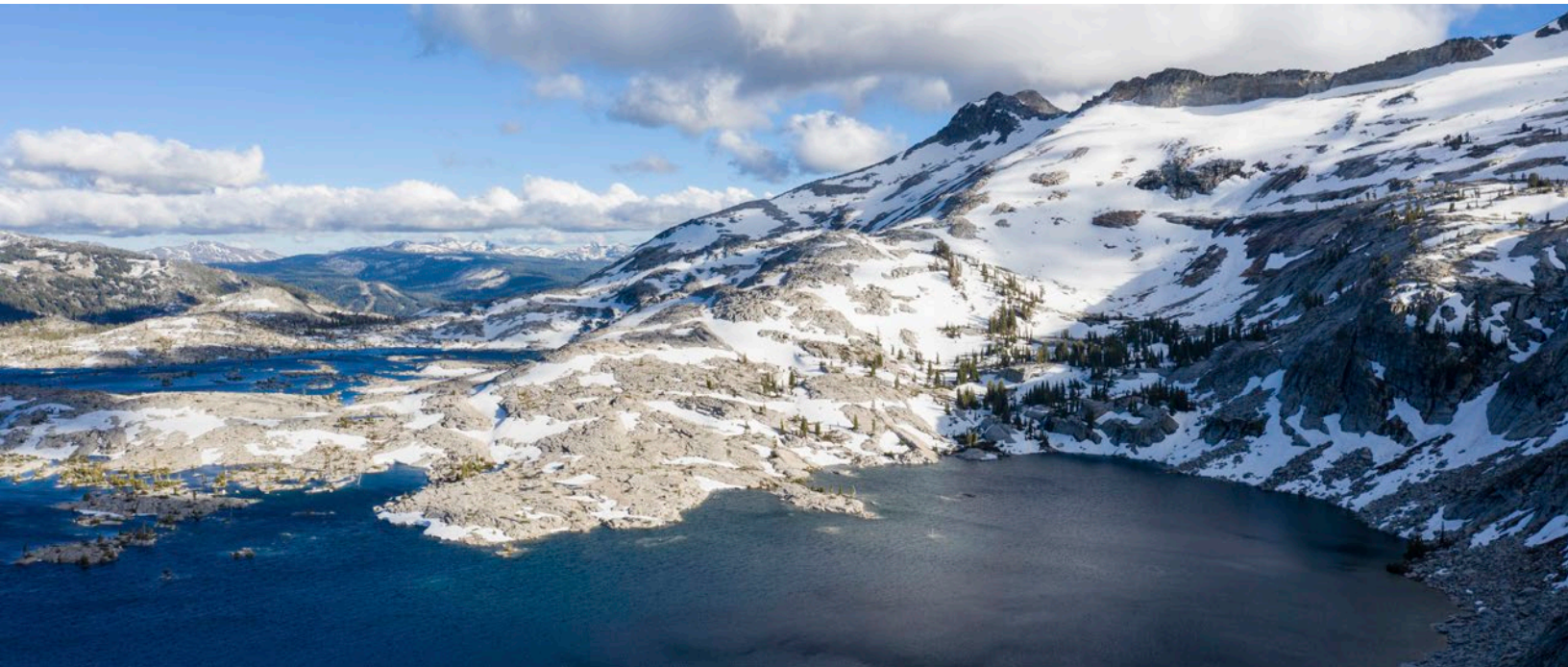
The volume of water used by people in California for agriculture, urban, and environmental

purposes ranges from 60 million acre-feet per year to 90 million acre-feet per year.[135] According to the state's Water Supply Strategy, California may experience a loss of 10 percent of this volume—from 6 to 9 million acre-feet lost—to hotter, drier conditions. For comparison's sake, California's largest reservoir – Shasta – holds 4.5 million acre-feet.[136] Therefore, California must prepare for a future where water availability, quality, and distribution is in question year to year.

PRECIPITATION AND SNOWPACK

California's annual precipitation varies widely across the state, with some areas receiving significant rainfall and others experiencing desert-like conditions. According to the National Oceanic and Atmospheric Administration (NOAA), the average annual precipitation for California is around 22 inches (55 cm). However, this varies depending on location and can range from less than 5 inches (12.7 cm) in the Mojave Desert to more than 100 inches (254 cm) in parts of the Sierra Nevada mountains. The Sierra Nevada Mountains receive some of the highest annual precipitation in California. This precipitation falls primarily as snow and provides critical water resources for the state's agricultural industry and urban areas in the form of melting snowpack throughout the year.[137] However, it is not always possible to use snow and rain as a source of water. In places like forested watersheds, about 60 percent of precipitation naturally evaporates or is absorbed by vegetation. The remaining water is naturally contained in rivers and streams, where it supports fish and other wildlife and preserves the water quality, where about 50 percent of it remains.[138]

The precipitation patterns in California are highly variable and are influenced by a range

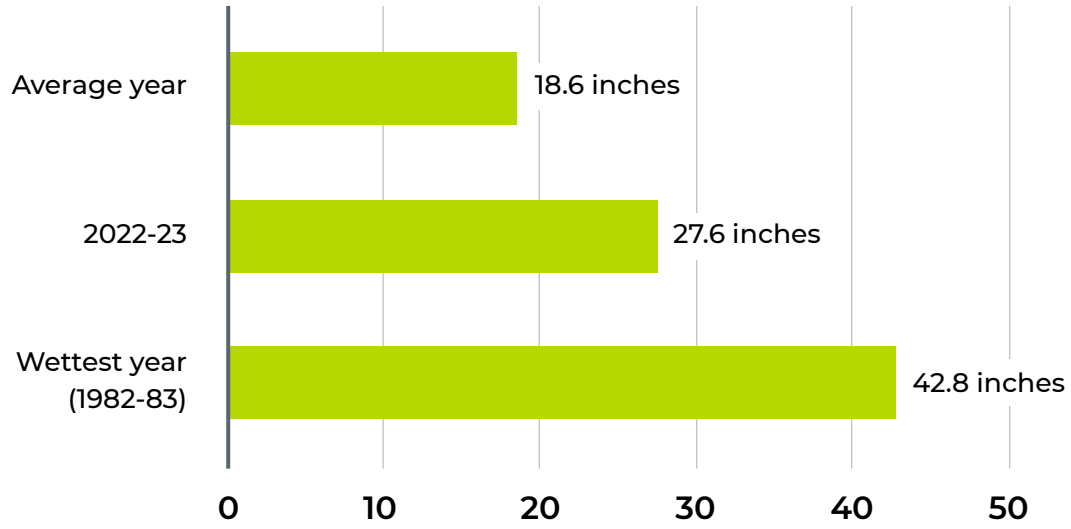


of factors, including atmospheric conditions, ocean currents, and topography. The state typically experiences most of its precipitation between November and April, with the summer months being relatively dry.

However, between October 2022 and March 2023, California experienced record rainfall following 31 atmospheric rivers, or weather phenomena that cause hurricane-like levels of precipitation, high winds, and storm surges, along the coast.[139] Across the state, California had received 142 percent of average rainfall by late-April 2023, according to the state Department of Water Resources.[140] Moreover, in the first few weeks of January, 700 landslides were reported, tens of thousands of people were evacuated, and multiple fatalities were recorded.[141] By March 2023, Santa Rosa had formally experienced rainfall that was more than three times higher than the previous March average. As of March 20, there had been a startling 9.34 inches of rainfall, whereas by this point in the month, the city typically receives just under 3 inches.[142]

One atmospheric river alone in early March 2023 shattered daily rainfall records across

Figure 6 **California's Typical Annual Rainfall Vs. High Rainfall Years, Inches of Rainfall in California between October and March**



SOURCE: Rice, Doyle. "Trillions of Gallons Have Soaked California. Is This the State's Wettest Winter Ever?" USA TODAY, March 29, 2023.

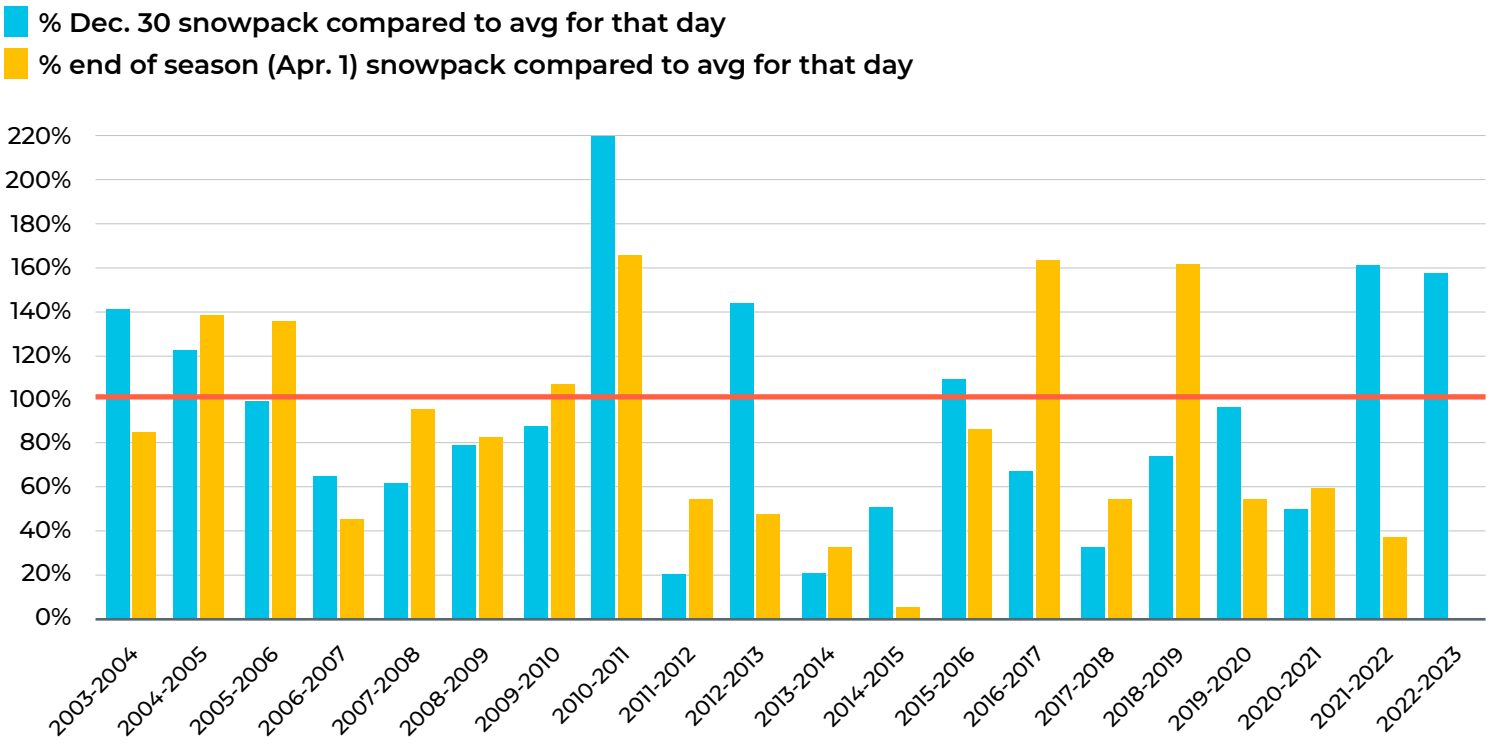
Southern California. Since November 2022, downtown Los Angeles had received 24.49 inches of rain—an incredible 208 percent of the region's average historical annual rainfall (11.78 inches). In a similar situation, Santa Barbara had received 24.03 inches of rain since November 2022, which is almost twice as much as it typically receives (13.95 inches). This total includes the 4.22 inches of rain that fell on a single day in January, which resulted in an atmospheric river event that caused downed trees and power lines, landslides, and washed-out roads throughout Santa Barbara County.[143] On average, atmospheric rivers provide between 30 to 50 percent of California's annual precipitation, while about 40 percent comes from snowpack in the Sierra Nevada.[144]

Too much rain, however, in such a short period of time can have devastating consequences for communities across the state: about 90 percent of California's flood damage is caused by atmospheric rivers.[145] According to researchers, record-breaking events like that of early 2023 may represent the future of weather in California, with cataclysmic storms growing more intense and more frequent.[146]

As the climate warms, the number and severity of atmospheric rivers is projected to increase, with potentially hazardous results.[147] A warming climate is also expected to lead to a higher proportion of the state's precipitation to fall as rain, rather than as snowpack in the mountains, which the state has historically relied upon during warmer summer months to meet water demand.[148] The state's water resources depend on the Sierra Nevada snowpack. The snow serves as a natural reservoir, storing 30 percent of California's freshwater supply on average each year as it melts into rivers and man-made reservoirs in the spring and summer.[149] The atmospheric rivers that struck California in the early months of 2023 have caused snowpack in the Sierra Nevada to melt earlier in the year, filling reservoirs to capacity, and forcing those who manage water storage facilities to release this water to minimize flooding risks as inflow rates reach up to half a million gallons per second.[150]

In April 2023, California's Department of Water Resources (DWR) conducted its fourth snow survey of the season, and found that the ***statewide*** snowpack's water equivalent was 61.1 inches—237 percent of the average for this time of year.[151] This is the deepest snowpack recorded in more than 70 years.[152] Under ideal circumstances, this snowpack is banked until the spring and summer months, thereby refilling reservoirs used by farmers and communities throughout the state. However, when storms release as much precipitation as witnessed by the state in early 2023, much of this water is released or is not captured as runoff.[153] Moreover, if the state experiences an early heat wave, much of the snowpack that has been captured in the Sierra Nevada may melt prematurely, leading to both the loss of future water supplies and to flooding, particularly in the Central Valley region of the state.[154] A fast and early snowmelt can also lead to a worse fire season.[155] Experts continue to warn that a large amount of early-season snow does not necessarily guarantee a plentiful end-of-season snowpack.[156]

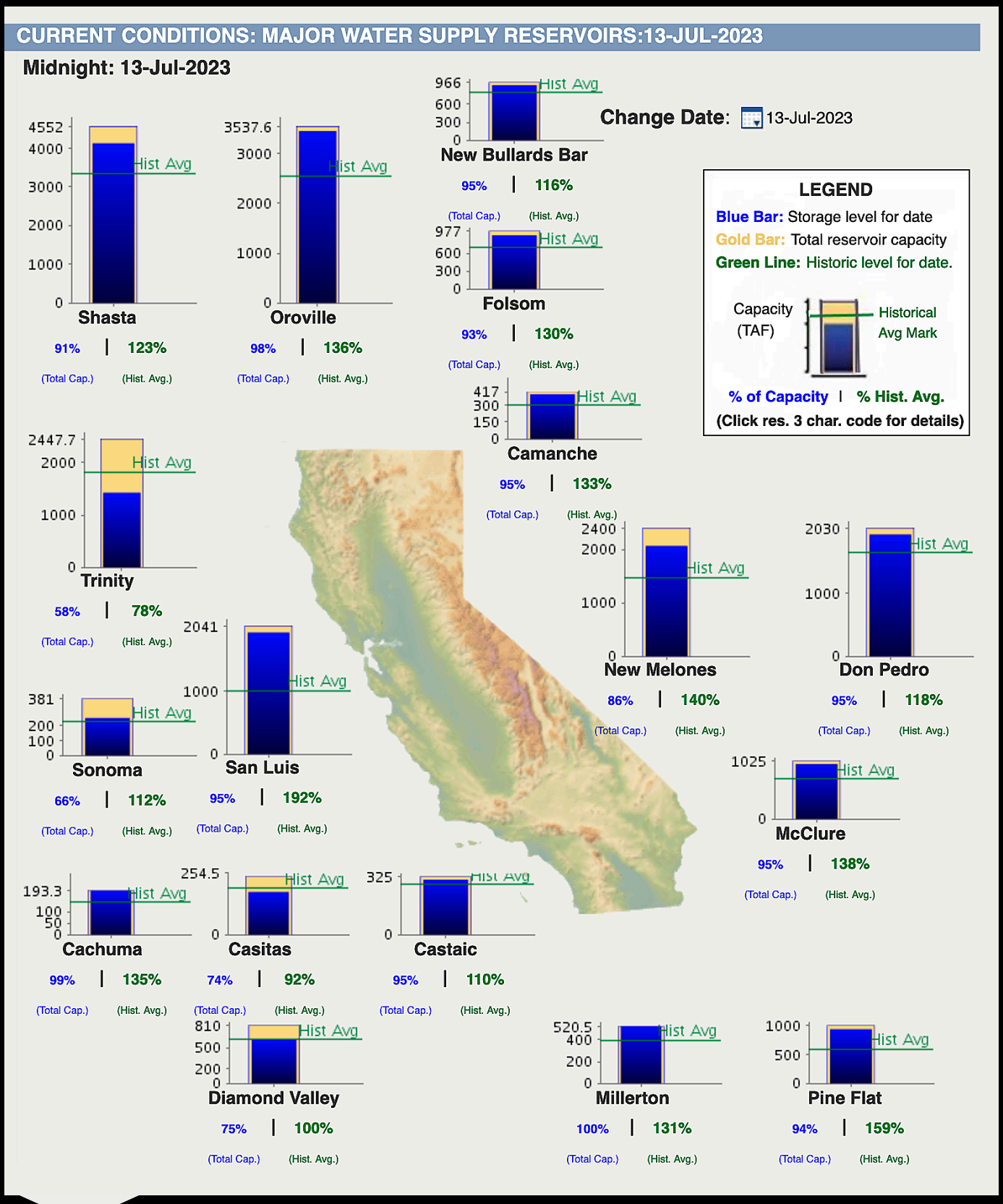
Figure 7 **California's 2023 Snowpack Third Largest in Two Decades**



SOURCE: California Department of Water Resources; Nickerson, Scooty. "California's Snowpack near a Decade High. What's It Mean for the Drought?" Orange County Register, January 1, 2023; data obtained on 12/30/2022.

Moreover, the state faces challenges with capturing and storing this rainfall during bouts of intense weather. Unlike snow, rain is not "stored in the mountains" so that it can be accessible as it slowly melts. Rather it runs-off quickly. California's water infrastructure, much of which was developed during the mid-20th century, was designed to capture *surface water* from snow-melt which is more predictable and reliable than rainfall. And it did not bother to think about the recharge of aquifers. However, when there are significant levels of precipitation in the form of rain, the state's reservoirs become overwhelmed quickly leaving much of it to end up as runoff in rivers and, ultimately, the ocean.[157] Without much consideration for replenishing underground aquifers, California's infrastructure of the 20th century was designed to move water from north to south for irrigation, human consumption, and flood prevention. As a result, stormwater runoff largely flows out to sea without capture.[158]

Figure 8 **California's Reservoir Levels as of July 2023 Against Historical Averages**



SOURCE: California Department of Water Resources, Data Exchange Center, July 2023.

The state's flood and water infrastructure will continue to face climate-driven challenges in order to move and store as much of this flood water as possible, just as the drought years showed how California's water system faces other climate challenges. Due to an improvement in the state's water supplies, DWR announced in late March 2023 that the forecasted State Water Project (SWP) deliveries would rise to 75 percent, up from the 35 percent previously announced in February 2023. As a result, Governor Newsom has rolled back some drought emergency provisions that are no longer needed due to improved water conditions. Nevertheless, the state has also maintained some measures to continue building up long-term water resilience and to support regions and communities still facing water supply challenges.[159]

Winter storms have benefited the snowpack and reservoirs, but groundwater basins are still recovering much more slowly. Many rural communities continue to face challenges

getting enough water, especially those that depend on groundwater supplies that have run out due to a protracted drought. Millions of Californians' access to water will continue to be impacted by the ongoing drought conditions in the Colorado River Basin. In light of the continued swings between wet and dry conditions, the state of California continues to urge residents to adopt water conservation as a way of life.[160]

But what happens if California loses its snowpack in the future? A 2021 study notes that "anthropogenic climate change is decreasing seasonal snowpacks globally, with potentially catastrophic consequences on water resources, given the long-held reliance on snowpack in water management."[161] It further reports that the western U.S. can expect declines of nearly 25 percent in snowpack and snow water equivalent by 2050. Because these projected changes undermine our conventional water management practices, California must build resilience to extreme and persistent low snowpack conditions.

WATER USE IN THE STATE

On average, 90 percent of the water used in California is either allocated to the maintenance of habitats, wetlands, and other ecosystems (50 percent) or for agricultural use (40 percent).[162] Only about 10 percent of the state's water supply is used by residents. Regardless, during the 2012-16 drought, California's residents were the group mandated to reduce water usage by roughly 25 percent statewide.[163]

According to a review by the PPIC Water Policy Center, the greatest potential for saving water long-term lies in the state's agricultural sector, and specifically, in its irrigation practices.[164] About 80 percent of water used in California is dedicated to agriculture, and much of this water is dedicated to growing feed for livestock.[165] In 2020, almonds consumed 13 percent of the total water used for California agriculture.[166] In 2021, many agricultural producers lost their water allocations from the Sacramento-San Joaquin Delta watershed in addition to their federal allocations, leaving farmers increasingly reliant on depleted groundwater stores.[167]

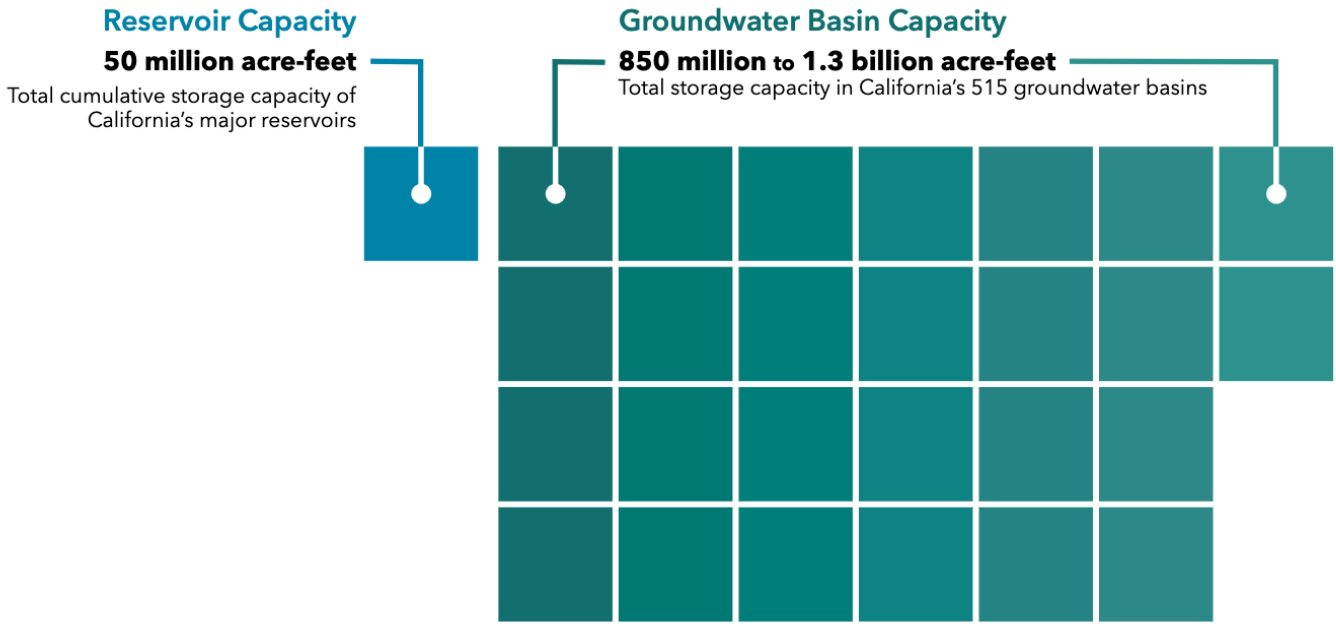
Farmers in California have been experimenting with science and technology options to help them deal with the growing water crisis. Some tools, like satellite and drone technology and soil moisture sensors that gauge an orchard's *evapotranspiration*—the amount of water that trees draw from the earth and exhale into the atmosphere—have only recently become widely used. However, growers are out of quick fixes. It takes time for innovative solutions to help people reduce their water footprint. Because fruit and nut trees take more than 20 years to mature, many research projects to engineer drought-resistant crops won't bear fruit for decades.

Regardless, due to increasing water uncertainty, between 1980 and 2015, California farmers reduced their water usage by 14 percent, while increasing crop production 38 percent.[168] However, the rate of decline in urban water use has been much more rapid: in 2015, each person used about 35 percent less water than they did in 1980.

GROUNDWATER

During years of drought, California often turns to using and pumping groundwater reserves as a way to supplement surface water supplies. Groundwater is water that is stored underground in soil and rock formations called *aquifers*. It is an important resource for drinking water, agriculture, industry, and other sectors of the economy. Groundwater is replenished naturally through the process of infiltration, which occurs when water from precipitation or surface water sources percolates through the soil and into underground aquifers. Groundwater can be accessed through wells and other extraction methods, but overuse or contamination of groundwater can have negative impacts on both the quality and availability of this important resource. Even though the state's 515 groundwater basins can store far more than the state's reservoirs combined, less than half the groundwater is available for use because it is either too deep to be pumped economically or of poor quality.[169]

Figure 9 **California's Groundwater Basin Capacity is Significantly Larger Than Its Reservoir Capacity**



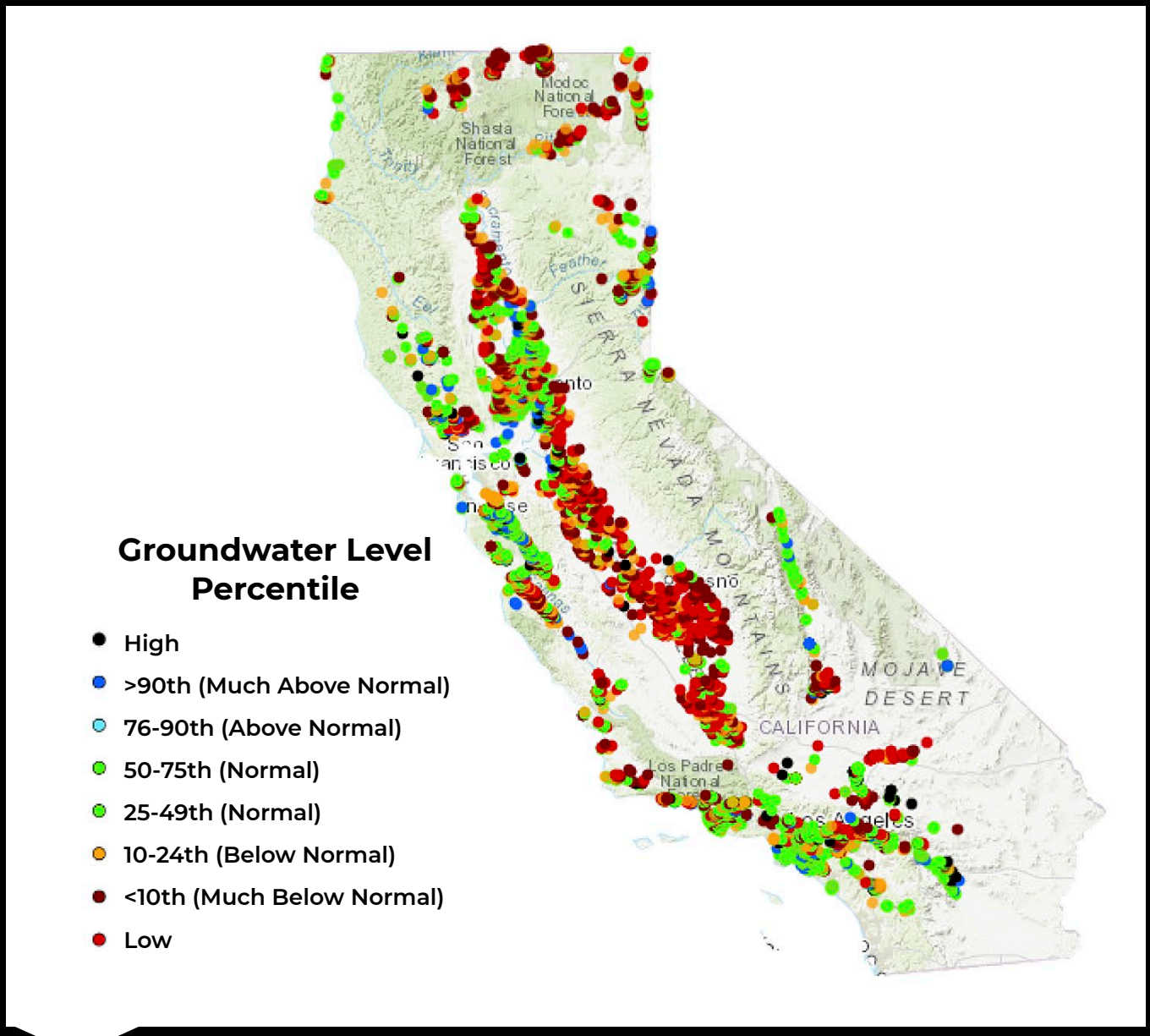
SOURCE: California Department of Water Resources. "California Water Resilience Portfolio," July 2020.

The recent drought from 2012-2016 led to increased reliance on groundwater resources as surface water supplies became scarce. According to a report by the Public Policy Institute of California, groundwater is part of California's drought reserve, but the state has treated it more like part of our regular water supply. In fact, during the drought, groundwater served as more than 60 percent of our water supply, when it is typically only 30 percent of our total water.[170] Some experts report that this level of unsustainable groundwater pumping during the drought is likely to take decades to recover from.[171]

In an average year, California's farmers use approximately 34 million acre-feet of water (one of which is equivalent to 326,000 gallons).[172] During a good year, much of this water comes from the state's system of dams, aqueducts, and irrigation canals filled with water from rivers or melted snow. During a dry year, however, many farmers turn to groundwater.[173] Groundwater depletion in California, and particularly in the Central Valley is the result of prolonged drought coupled with rising demand for water use for both communities and agriculture, with relatively minimal regulation and oversight.[174]

For decades, farmers throughout the Central Valley have over-pumped groundwater basins, which has led to land subsidence, or the phenomenon in which groundwater is drawn more quickly from underground aquifers than it is replenished, leading to the sinkage of land.[175] Despite the 2023 atmospheric rivers, flooding, and precipitation, California still faces depleted groundwater reserves—particularly in the San Joaquin Valley—due to the years of drought the state has faced.[176]

Figure 10 **Groundwater Reserves in California as of April 23, 2023**



SOURCE: California Department of Water Resources. "California Water Watch."

Groundwater depletion has been particularly striking in the San Joaquin Valley, where the land has sunk by as much as 28 feet in some places since the 1920s.[177] Land subsidence puts both infrastructure – including flood management tools like levees, bridges, and roads – at risk, as well as the aquifers themselves. As land sinks, the storage of groundwater can be permanently reduced, which could impact future water supplies.[178] Because of these threats to the water supply, concurrent with the funding from Proposition 1 was the passage of the Sustainable Groundwater Management Act (SGMA), which was supposed to prevent continued overdrafting of groundwater, ensuring sustainable reserves for future generations.[179] According to the 2019 ASCE review, however, the SGMA is a starting point for improving water resilience for the future, but more will be needed to ensure a steady supply for future generations.[180]

Despite the significant amount of rainfall in the winter of 2023, groundwater recharge is a slow process, requiring many wet years to replenish its storage. Water from heavy rains can reach shallow groundwater basins in a matter of days, but it can take months to reach places where wells must pump from deep underground aquifers, like those in the San Joaquin Valley. Even a season's worth of storms is not usually enough to restore wells left high and dry by years of overdraft.[181]

One of the means by which California can artificially replenish aquifers is through infiltration basins or injection wells. For more than 100 years, the U.S. Geological Survey (USGS) has been studying artificial groundwater recharge efforts, with particular interest in recharge in California beginning in the 1960s.[182] Beginning in 2022, California piloted a program with the Merced Irrigation District to divert and store floodwaters – up to 10,000 acre feet – to support agriculture in the region.[183] As of 2016, California has approved about 20 permits for groundwater recharge projects, with programs like that in Merced designed to demonstrate the feasibility of capturing floodwaters for groundwater recharge as part of the state's goal to expand recharge capacity by at least 500,000 acre-feet.[184]

Although storms in 2023 helped to replenish reservoirs like Oroville, which stood at more than 75 percent full as of early March 2023, water management officials must release waters from these reservoirs to make room for additional water from precipitation and melting snowpack throughout the spring and summer months.[185] Some of this water ends up released into oceans, though increasingly, efforts have been made to divert this water to groundwater storage.[186] Replenishing aquifers can help the state transition to sustainable groundwater usage but requires the capacity to redirect and store water underground when it becomes available.[187]

Currently, California does not have the infrastructure or capacity to divert excess rainfall to hold for groundwater recharge, though this has become a priority for Governor Newsom.[188] In August 2022, the state released its report, "California Water Supply Strategy: Adapting to a Hotter, Drier Future," which calls on the Department of Water Resources and the State Water Board to collaborate with local agencies to expand the state's ability to capture excess water from winter storms as a result of climate change.[189] We discuss this report in detail in the later section describing California's approach to sustainability and resilience for its water challenges.

FLOODING

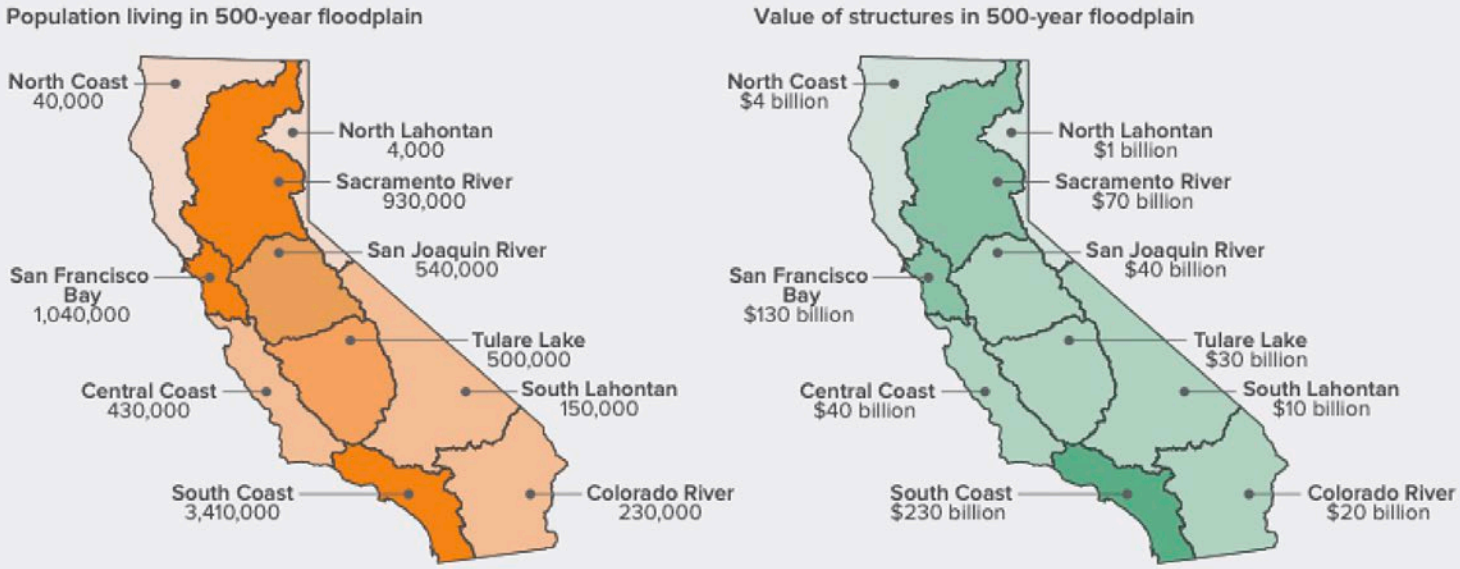
According to geological data, catastrophic flooding events caused by atmospheric rivers have occurred periodically throughout California's history – as frequently as every 100 to 200 years.[190] The most recent event occurred early in the state's history, and has been referred to as the "Great Flood of 1862," which researchers have concluded was caused by atmospheric rivers.[191] For years leading up to the event, California had experienced an unusually severe drought, with little precipitation; but in December 1861, torrential rain fell across California, leading to the deaths of approximately 4,000 people, while causing more than $100 million in damage (equivalent to billions of dollars today).[192] The flooding was particularly severe in the Central Valley, where a 300-mile long sea formed, eviscerating the cattle ranching industry that had developed under Mexican rule.[193] Decades of prolonged drought, which had already limited livestock production, and the cataclysmic flooding in the early 1860s forced the Mexican *rancheros* to sell their land to farmers, who capitalized upon the opportunity for irrigating crops, developing the agricultural industry that dominates the region's economy today.[194] Experts warn, however, that if California were met with a storm of a similar magnitude to that of 1861-62, the Central Valley would again be at risk of flooding.

California has experienced severe flooding as recently as early 2023 due to the atmospheric rivers dropping record rainfall on the state. In the past, atmospheric river events have caused significant flooding and damage in

California, such as the 2017 Oroville Dam crisis and the 2019 Russian River floods. According to the state's Indicators of Climate Change in California report from 2022, the chances of an extreme 200-year flood event—last seen in the "Great Flood" of 1861-1862—is more likely than not to occur within the next 40 years.[195] A storm of this size today would likely cause a significant number of fatalities and economic losses close to a trillion dollars.[196]

Figure 11 **Roughly 20 Percent of California's Population Lives in Flood-Prone Areas**

MILLIONS OF RESIDENTS AND MANY BILLIONS OF DOLLARS IN PROPERTY ARE VULNERABLE TO FLOODS



SOURCE: Mount, Jeffrey, Ellen Hanak, Jay Lund, Matt Kondolf, Carolyn Kousky, Nicholas Pinter, and Brett Sanders. "California's Water: Preparing for Floods" PPIC Water Policy Center, October 2016.

A critical element of California's flood management system is its system of levees, many of which date back to the Gold Rush era, when colonizers would construct levees – embankments often made of soil or rock along riverbanks or other bodies of water to protect against rising floodwaters – to protect against flooding.[197] Today, there are over 20,000 miles of

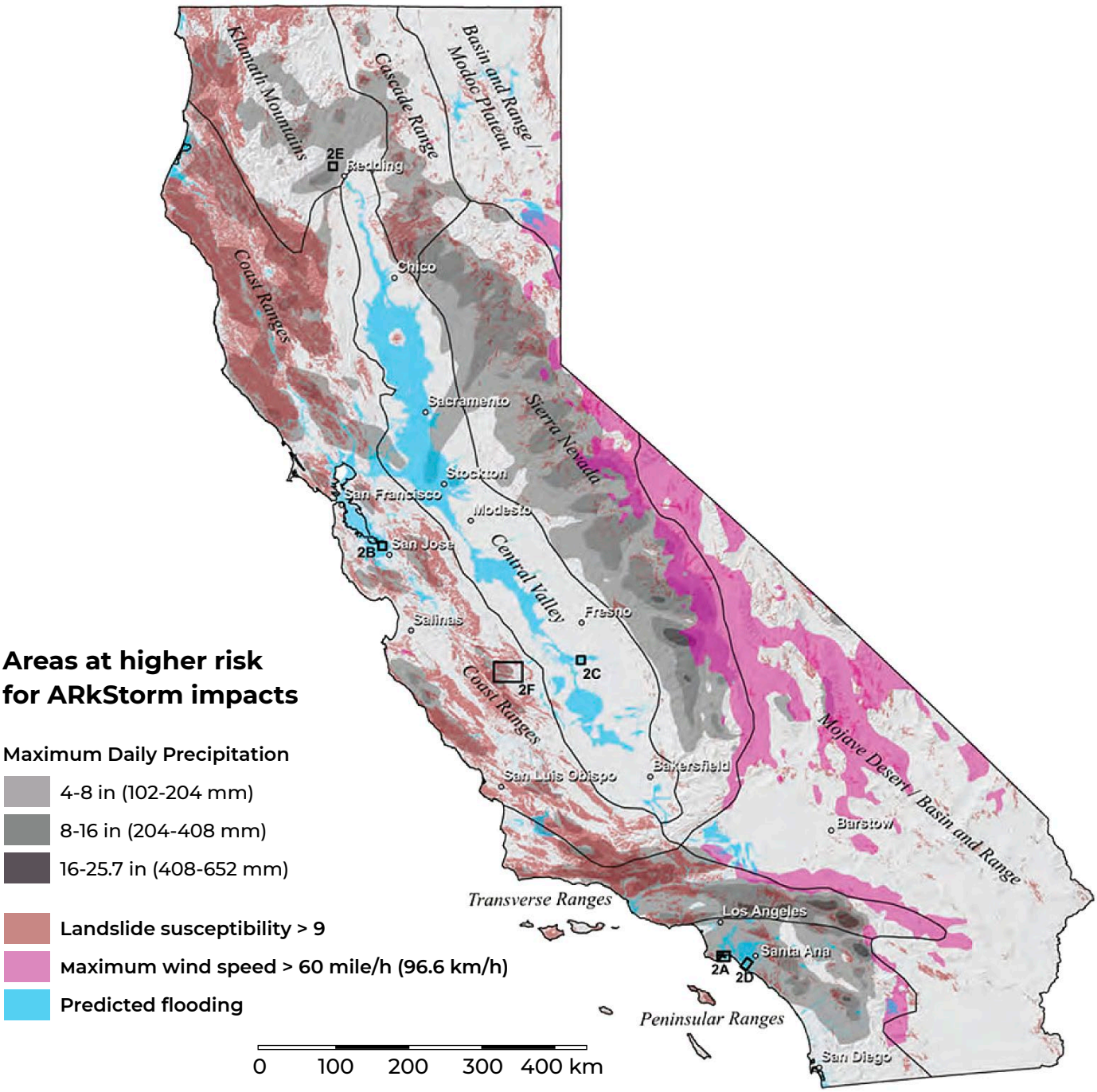
levees and channels in the state, many of which are managed by local governments, though some are operated by private landowners.[198]

Other means of flood control include reservoirs, which serve to collect water during wet periods to be held for use during dry periods, often in the summer months. Some of the largest reservoirs include the Oroville Reservoir, found in the Sierra Nevada foothills, capable of storing up to 3.5 million acre feet of water, or serving roughly 27 million Californians and 750,000 acres of farmland.[199] Some rural communities have reduced flood risk significantly by widening channels and allowing rivers to spread out across natural floodplains. This approach also helps recharge groundwater and creates wildlife habitat and recreational opportunities.[200]

In February 2017, heavy rainfall from atmospheric rivers caused damage to the spillway of the Oroville Dam, which is the tallest dam in the United States. The damage to the spillway prompted officials to evacuate more than 180,000 people living downstream of the dam due to the risk of catastrophic flooding.[201] The crisis highlighted the importance of maintaining and improving critical infrastructure such as dams and spillways in the face of changing weather patterns and increased flood risk.

In 2011, NOAA and the U.S. Geological Survey partnered with more than 100 experts to develop the outcomes associated with what is referred to as the ARkStorm (Atmospheric River 1,000, or a plausible storm event that could exceed precipitation levels experienced every 500 to 1,000 years).

Figure 12 **ARkStorm Mega-Flood Predictions for California**



SOURCE: U.S. Geological Survey. "Summary Map Showing ARkStorm Predictions for California," January 12, 2017.

AGING LEVEE AND RESERVOIR INFRASTRUCTURE

Many of the state's thousands of miles of levees are in need of repair. On average in the past decade, the state has spent $70 million per year on maintenance to its flooding infrastructure. However, according to a recent review by the state, the cost to adequately upgrade levees and other flood prevention defenses is more than $34 billion.[202] Moreover, another analysis by PPIC found that, on an annual basis, the investment required to make these improvements is between $800 million to $1 billion—a significantly higher cost than the state's current annual spending.[203] Potential improvements include strengthening the foundations of levees, which have either eroded during past flooding events, require better drainage mechanisms to prevent seepage, must be raised higher, or require reinforcement with additional soil or concrete and steel.[204]

Table 3

Select Grades from the Most Recent Assessment of California's Infrastructure

Infrastructure	Grade	Discussion
Levees	**D**	• The responsibility for managing levees across California is fragmented, with multiple institutions involved in their construction, maintenance, and regulation – one study estimated up to 1,300 agencies are involved. • In recent years, California has invested in its aging levee infrastructure, with local agencies spending more than $1 billion annually on flood management activities; however, the ASCE estimates that $45 billion is needed to improve California's levee systems, with 15 percent of that funding for levees in the Central Valley, alone.
Dams	**C-**	• More than 50 percent of dams owned by state, federal, or local organizations are categorized as high-hazard dams, which means that their failure could result in loss of human life and economic damage. And roughly two-thirds of California's dams are at least 50 years old, and constructed based on an outdated understanding of hydrology.[205] • Although in 2018, the California Water Commission approved roughly $2 billion to construct two new reservoirs, and expand two others, actual construction remains decades away due to permitting, environmental reviews, and the acquisition of water rights.[206] • According to the ASCE, the cost to maintain and repair dam deficiencies throughout the state is more than $2.5 billion, excluding the funding to construct new dams following the passage of Proposition 1 in 2014, and the funding required to repair the Oroville dam, which is roughly $1 billion.
Stormwater	**D+**	• Among the infrastructure included under this category are drains, pipes, ditches, canals, and other infrastructure that protects against flooding. In general, one of the critical challenges with this infrastructure, much of which is dated throughout the state, is the frequency of flooding events, particularly in rural parts of the state. • The ASCE estimates that funding needed to adequately address future drainage infrastructure and water quality maintenance is between $37.5 to $75 billion over the next 20 years. Part of the challenge of funding such maintenance is that this infrastructure is typically maintained at the level of the municipality, rather than at the state, requiring cities or counties to fund these projects.
Drinking Water	**C**	• The infrastructure storing and supplying water across the state is also aging, with several mainline pipes in cities like San Francisco and Los Angeles up to 100 years old. According to the ASCE, supplying water to the state has long been a challenge due to the large swings in availability from year to year. To manage this, the state constructed a large network of water storage and conveyance facilities, which are aging. • Following a 2017 review, the Environmental Protection Agency reported that the funding required to make the necessary updates to California's water infrastructure would be about $51 billion. In recent years, California has passed a number of bonds to address this deficit, including Proposition 1 (2014, $7.5 billion) and Proposition 68 (2018, $4 billion); however, these projects are still underway and are not sufficient to address the nearly $40 billion in remaining repair costs.

SOURCE: American Society of Civil Engineers. "California Infrastructure Report Card," 2019.

Funding for the maintenance of California's flood protection system is split between several agencies, including federal organizations like the U.S. Army Corps of Engineers, state organizations including the California Department of Water Resources, and local governments that have established their own flood control agencies often supported by local taxes.[207]

Another major contributor to funding are statewide bonds voted upon by California residents; in 2014, California voters approved Proposition 1, a $7.5 billion in funding for efforts to support water management efforts, including additional storage facilities for water, protections for local rivers and watersheds, flood management, among other aspects of the state's water system.[208] Consequently, representatives from flood-prone communities, Stockton and Fair Oaks, have proposed Senate Bill 638 to be voted on in 2024, which designates $4.5 billion in flood protection efforts across California, including levee improvements, particularly in the Central Valley.[209] As extreme atmospheric rivers continue to strike California, the Central Valley is at risk because it is home to many rivers and waterways that can flood during such events, inundating not only agricultural fields, but also destroying communities, homes, and businesses, worth an estimated $223 billion between the economic agricultural contributions, and infrastructure.[210]

MUDSLIDES

As noted earlier, wildfires will likely continue to affect California, even when their destruction is not as severe. Regardless, the state must therefore also reckon with the increased risk of mudslides, a form of fast-moving landslides that result in the rapid movement of debris down a slope.[211] Often, mudslides occur in recently burned areas known as 'burn scars,' though they can even occur up to 2 to 5 years after a wildfire.[212] As fire moves across a landscape, it burns plants that release chemicals that create a water-resistant surface on the soil, which then impedes future water absorption so that debris accumulates along the surface of a hill, leading to mudslide susceptibility.[213] A similar decrease in permeability of the soil can also be caused by prolonged drought, which California also faces.[214] Geologists also note that California is particularly at risk of mudslides because of the age of its mountains – as they are relatively young, mountains and hills are more likely to be in motion, raising the risk of a mudslide.[215]

In December 2017, the Thomas Fire burned through more than 280,000 acres of land in Ventura and Santa Barbara Counties, and was the largest wildfire recorded at the time in California's history, destroying more than 1,000 structures.[216] Just one month later, heavy rainfall in the city of Montecito triggered severe mudslides, killing 23 people and destroying hundreds of additional structures.[217] The rebuilding, according to some researchers, raises concerns about the safety of development in high-risk regions, suggesting that construc-

tion efforts should instead be focused in safer areas.[218] In January 2023, five years after the deadly 2018 event, a period of severe rain in the same Montecito community forced evacuations of the entire community due to heightened mudslide risk.[219]

Like wildfires, mudslides have long played a part in California's history. Early in its history, Los Angeles experienced a series of floods and mudslides. Notably, as the city was establishing its aqueduct system in the mid-1920s, the St. Francis Dam—a 205 foot-high dam that held 12 billion gallons of water—collapsed in 1928, killing more than 400 people and causing millions of dollars in damage.[220] Completed just two years earlier, the St. Francis Dam had filled to capacity and ruptured, causing a landslide that carried debris through the Santa Clara River Valley as far as 55 miles away.[221] In 1995, it was determined the site upon which the dam had been constructed was an ancient landslide site, which had moved under the weight of the enormous dam.[222]

Within the first few weeks of January 2023 alone, California had already reported hundreds of mudslides.[223] Because of the frequency of mudslides, mechanisms exist to manage their effects, including debris basins, which are typically downslope from canyons or hills that collect debris.[224] However, such basins need to be regularly removed of debris in order to prevent further risk.

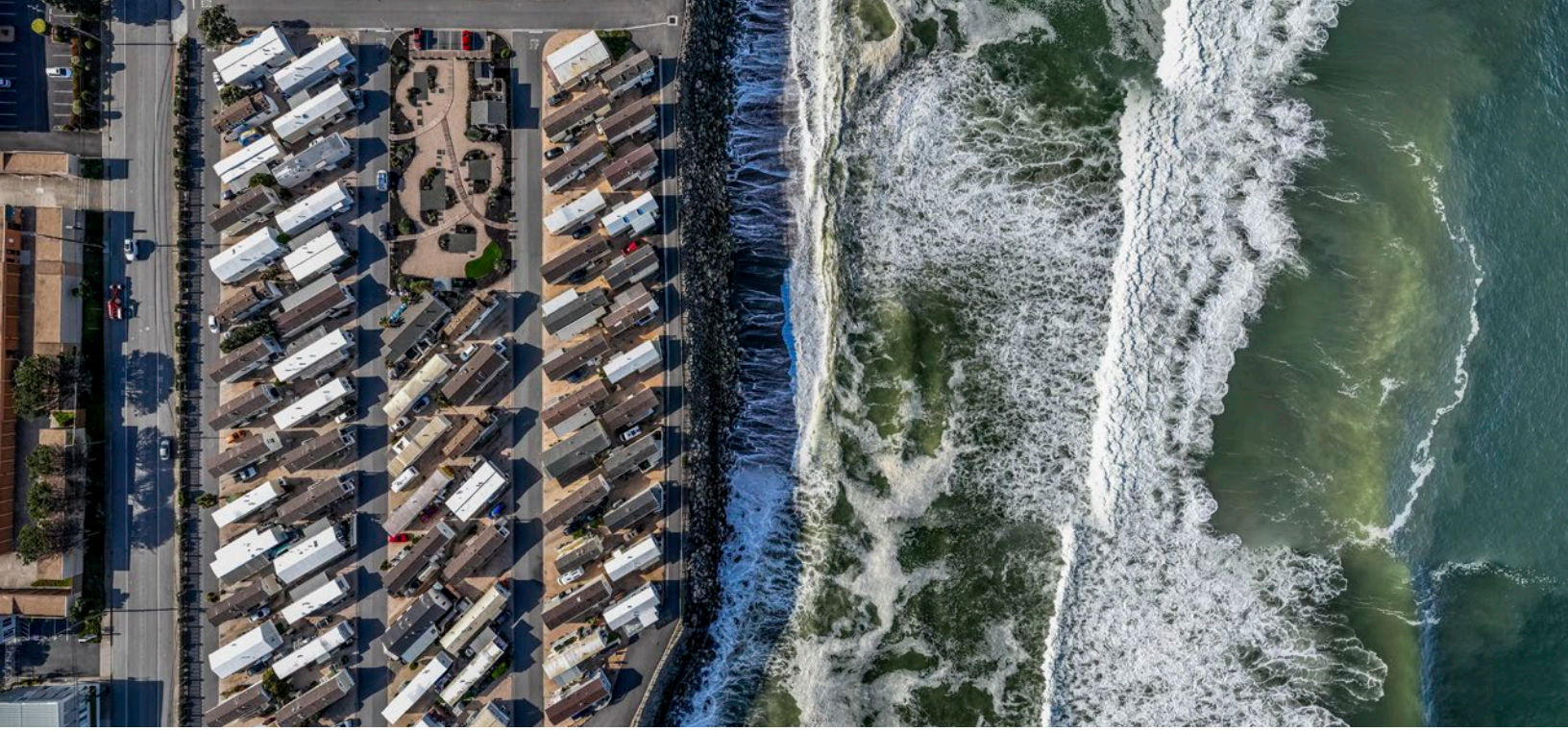
Following the deadly mudslides in Montecito in 2018, Santa Barbara County initiated efforts to expand the debris basins in the region. These efforts include making debris basins in the region larger and able to handle debris ranging in size from rocks and boulders to tree stumps.[225] However, funding, and ultimately approving such projects can take time. The construction of a 90,000-cubic-yard debris basin in Montecito was finished in October 2022, five years after the mudslides.[226] Likewise, of the total $21 million required to fund its development, the state secured $13.5 in funding from the Federal Emergency Management Agency (FEMA), and sought additional funding from the state's community development block grant.[227] During the period of intense atmospheric rivers in early 2023, Santa Barbara County Flood Control reinforced the importance of debris basins for protecting communities from debris flows by clearing many of its debris basins, restoring their capacity.[228]

SEA LEVEL RISE

As a coastal state, California is particularly vulnerable to the effects of sea level rise, as many urban and low-lying communities have developed along its 840 miles of coastline. Since 1950, the sea along California's coast has risen six inches, and some projections indicate that by 2050, the waters along the West Coast of the U.S. will rise by another eight inches.[229] This rise is driven by several factors, though melting glaciers and ice caps and thermal expansion have been the most significant causes.[230]

According to a recent study by the California Ocean Protection Council Science Advisory Team, melting ice in Greenland and Antarctica will soon become the most significant cause of sea-level rise globally, and melting in West Antarctica will have an outsized impact in California.[231] Because of the Earth's gravitational pull on ocean waters and the manner in which the Earth rotates, for every foot of sea-level rise that occurs because of melting in West Antarctica globally, the rise will be approximately 1.25 feet along the coast of California.[232]

According to the Fourth National Climate Assessment by the U.S. Global Change Research Program, two-thirds of beaches in Southern California are on track to disappear.[233] In a state where roughly 25 million



people live near or along the coast, the loss of beaches and encroachment of water will put an estimated $100 billion of infrastructure at risk.[234] Sea level rise also heightens the risk of flooding within coastal communities, and can also contribute to erosion because elevated tides can reach further inland, degrading cliff walls and beaches.[235]

Moreover, rising sea levels can negatively affect groundwater supplies, carrying both saltwater and potentially contaminated water into the freshwater aquifers.[236] Although the most significant effects of sea level rise may not be felt for years, researchers have warned that California must take actions now to prepare for the impending rise, and reduce emissions to mitigate future warming.[237]

In California, coastal counties occupy 22 percent of the state's land area, 68 percent of its population, and generate 80 percent of its GDP. However, climate change is already affecting California's coasts, with the Fourth Climate Assessment projecting that Southern California beaches may erode between 31 and 67 percent by 2100 without policy changes, and statewide damages from sea-level rise could amount to almost $17.9 billion by 2050 due to a 20-inch rise (95th percentile).[238] Moreover, much of the nation's goods travel through the Ports of Los Angeles and Long Beach – an estimated 40 percent of the total container cargo for the country – and a rising sea level could imperil the nation's supply chain.[239]

One of the primary effects of rising sea levels is ***coastal erosion***. According to 2022 research from the National Oceanic and Atmospheric Administration (NOAA), erosion may reach up to 130 feet in some parts of Southern California by 2100.[240] Erosion of this magnitude not only jeopardizes communities, including homes, buildings, and infrastructure, but the loss of beaches and bluffs can lead to the shrinkage of habitats for wildlife in such regions. Moreover, erosion of soil and rocks can affect the quality of water in such ecosystems, polluting it with debris and sediment.[241]

CALIFORNIA'S APPROACH TO SUSTAINABILITY AND RESILIENCE FOR THESE WATER CHALLENGES

CALIFORNIA WATER PLAN

The California Water Plan (CWP) is the state's comprehensive strategy for managing California's water resources sustainably. The CWP is updated every five years and is intended to be a roadmap for the state's water management decisions, policies, and investments.

The plan includes information on water supply and demand, water quality, flood management, ecosystem health, and climate change. It also identifies strategies for addressing California's water challenges, such as improving water use efficiency, increasing water storage, and protecting and restoring ecosystems.[242] Overall, the CWP aims to ensure that California has a reliable and sustainable water supply to support its economy, environment, and quality of life for present and future generations.

The CWP is developed through a collaborative process involving state and local agencies, water users, stakeholders, and the public. The latest version of the plan, the 2018 California Water Plan Update, was developed over a two-year period and involved input from more than 3,500 stakeholders. The 2023 Update is currently in progress and should be released by the end of the year. Its focus will be to consider the context of the State Water Code, the Water Resilience Portfolio, the Governor's Priorities on Climate Action, and the input and state needs of stakeholders.[243]

SUSTAINABLE GROUNDWATER MANAGEMENT ACT (SGMA)

Although many of the issues related to groundwater have become exacerbated in recent years due to many years of extended drought conditions, California took action in 2014 to pass the Sustainable Groundwater Management Act (SGMA) to address the overuse of groundwater resources in the state.[244] The law requires local groundwater management agencies to create sustainable groundwater management plans that prioritize the long-term health of the state's aquifers. Governments and water agencies using overdrafted groundwater basins must bring those basins into balanced levels of pumping and recharge by 2042 at the latest under the SGMA.[245] Groundwater recharge is the process of replenishing underground aquifers with water. It typically involves allowing surface water such as rain, snowmelt, or river water to infiltrate into the soil and percolate down into the aquifer.

The SGMA also requires increased monitoring of groundwater resources and the creation of new governance structures to manage

groundwater.[246] The law is intended to ensure that California's groundwater resources are managed in a way that is environmentally sustainable, economically viable, and socially acceptable for the long-term benefit of the state's residents and ecosystems. Managed well, California's groundwater basins can provide a crucial buffer against drought and climate change.[247]

WATER RESILIENCE PORTFOLIO

The California Water Resilience Portfolio is a comprehensive strategy designed to help the state prepare for and adapt to the challenges of a changing climate, as well as to address long-standing water supply and quality issues. The portfolio was released in 2020 by Governor Gavin Newsom's administration, and it is a collaborative effort that involved input from stakeholders across the state.

The portfolio outlines a range of actions that can be taken to build water resilience in California, including prioritizing multi-benefit approaches to meet several needs at once, utilizing natural infrastructure such as floodplains and forests, embracing innovation and new technologies, encouraging regional approaches among water users sharing watersheds, incorporating successful approaches from other parts of the world, integrating investments, policies, and programs across state government, and strengthening partnerships with local, federal, and tribal governments, water agencies and irrigation districts, and other stakeholders.

The portfolio is organized around goals and actions in four categories:

1. Maintain and diversify water supplies,
2. Protect and enhance natural resources,
3. Build connections, and
4. Be prepared.

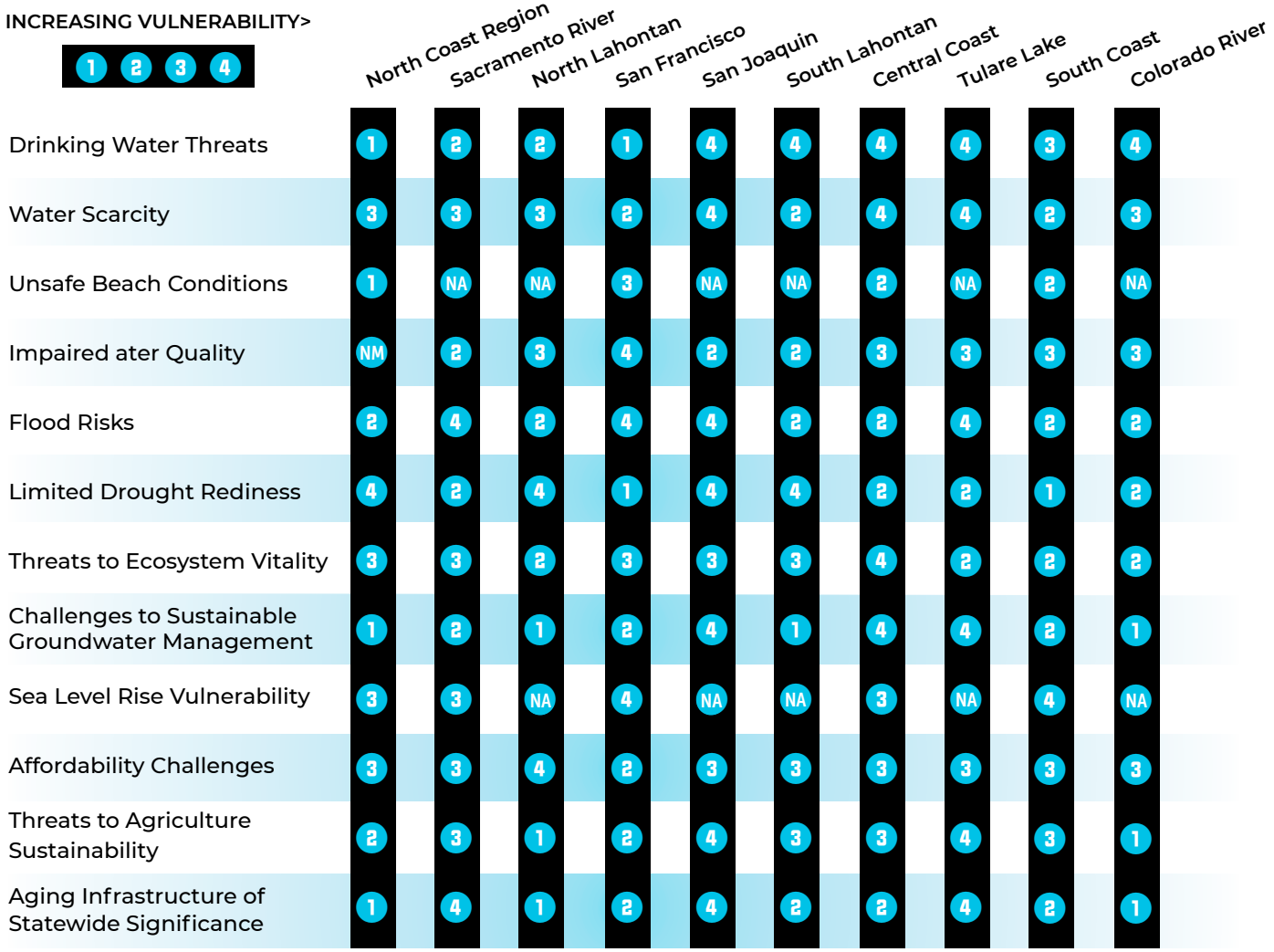
The portfolio acknowledges that it will require time, effort, and funding to carry out the plans and actions of this document and that the pace of implementation will depend upon the feasibility and availability of resources and competing priorities. The portfolio is designed to set a direction and create collective recognition of the ways California can manage water to build climate adaptability that works for people, the environment, and the economy.[248]

In order to maintain and diversify the state's water supplies, to fulfill the human right to water for the more than 1 million Californians who currently lack safe drinking water supplies, and to address a future with a reduced snowpack, the Water Resilience Portfolio acknowledges the state's efforts to:

- Improve water use efficiency,
- Eliminate water waste,
- Reduce water use on ornamental turf and landscaping,
- Recycle water more efficiently,
- Capture rain and storm runoff to recharge aquifers, refill reservoirs, reduce heat island effects, and reduce pollution to rivers and beaches, and
- Use desalination strategies on brackish groundwater and seawater, depending upon local circumstances.[249]

The 2021 Water Resilience Portfolio includes future scenarios of population growth, housing densities, land use patterns, and climate to project future water demand by 2050 in California's 10 hydrologic regions. It also includes a broad snapshot of regional water challenges in order to show the different water needs across the state. The portfolio suggests that projects meant to improve water resilience may be achieved more easily across smaller geographies.

Figure 13 **Regional Vulnerability Indicators**



SOURCE: California Department of Water Resources. "California Water Resilience Portfolio," July 2020.

A progress report on the implementation of California's Water Resilience Portfolio from January 2020 to June 2021 reported that California is making significant strides in implementing the Water Resilience Portfolio and addressing the state's water challenges, but much work remains to be done. The report emphasizes the need for continued investment in water infrastructure and the importance of collaboration and coordination among stakeholders to ensure a sustainable and resilient water future for California.[250]

CALIFORNIA'S WATER SUPPLY STRATEGY

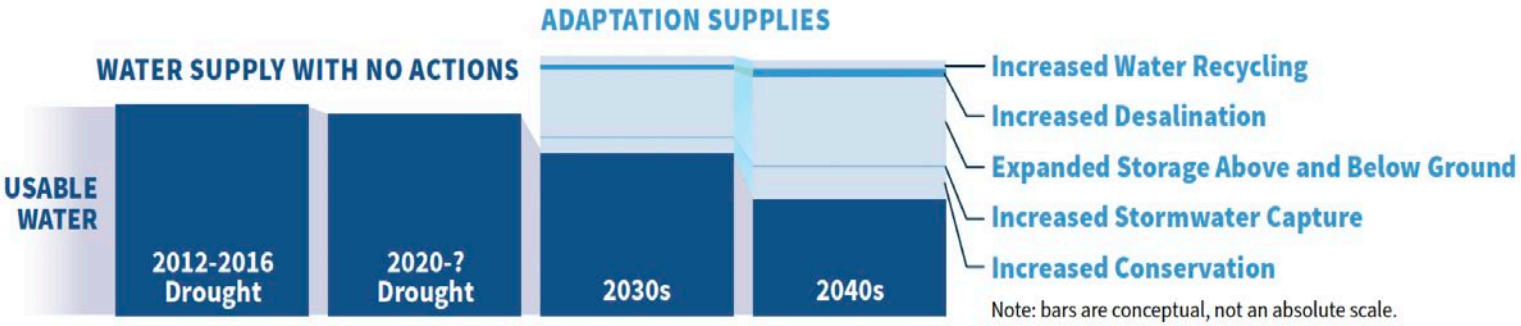
In August 2022, California released its Water Supply Strategy report, "Adapting to a Hotter, Drier Future," which outlines California's approach to ensuring reliable water supplies for its communities, economy, and environment over the next several decades.[251] The report recognizes that California's water supply system is facing multiple challenges, including drought, climate change, aging infrastructure, and increasing demand for water from a growing population.

The report highlights four key actions to enhance water supply resilience:

1. Develop new water supplies through investments in wastewater recycling and desalination technology,
2. Expand water storage capacity above and below ground by 4 million acre-feet,
3. Reduce water demand, and
4. Improve forecasting, data, and management, including water rights modernization.[252]

Each of these actions is broken down into specific strategies and objectives, which are intended to guide water resource management and planning at the state and local-

Figure 14 **California's Water Supply Strategy Projections for Future Water Supplies**



SOURCE: Office of Governor Gavin Newsom. "California's Water Supply Strategy: Adapting to a Hotter, Drier Future." August 2022.

The report also provides an overview of California's water supply system, including sources of water, delivery infrastructure, and regulatory frameworks. It describes the role of different state agencies and organizations in managing and protecting California's water resources, as well as the importance of engaging with stakeholders and communities to build a more sustainable and equitable water future.

Desalination

The state's 2021 Water Reservoir Portfolio includes desalination as a possible goal for the state's water supply future. It notes that California should consider the use of desalination technology where it is cost effective and environmentally appropriate. The portfolio also suggests that California team with federal and academic partners to develop desalination technologies that treat a variety of water types for various uses, with a goal of enabling manufacturing of energy-efficient desalination technologies in the U.S. at a lower cost, same or better quality, and reduced environmental impact than non-traditional water sources.[253]

Similarly, the 2022 Water Supply Strategy directs the state to develop new water supplies through recycling and desalination. Specifically, the Water Supply Strategy sets a state goal to expand brackish groundwater desalination production by 28,000 acre-feet per year by 2030 and 84,000 acre-feet per year by 2040 and to help guide location of seawater desalination projects where they are cost effective and environmentally appropriate.[254]

California currently has four active ocean water desalination facilities that produce nearly 60,000 acre-feet of drinking water.[255] A lesser-known but rapidly growing strategy is brackish groundwater desalination, which cleans up salty water that can then be used for drinking water. According to the 2022 Water Supply Strategy, another 23 brackish groundwater desalination plants have a combined production capacity of 139,627 acre-feet per year in California.[256] Brackish groundwater requires significantly less energy to treat than seawater.[257]

CONCERNS ABOUT CALIFORNIA'S PLANS FOR WATER RESILIENCE AND SUSTAINABILITY

Although California has released multiple plans and strategies to prepare the state for its future water challenges, many experts fear that the state's current approach does not go far enough to build the water resilience California needs. Criticisms of California's Water Supply Strategy came quickly following August 2022. In fact, one month before its release, Max Gomberg, a key state official in water conservation, posted his critique of the state's response and preparation related to water conservation. He wrote that "Sadly, this state is not on a path towards… quickly and permanently reducing agriculture to manage the loss of water to aridification. [This] (and more) [is] necessary for an equitable and livable future." Gomberg quit his job as a water conservation and climate change manager at the State Water Resources Control Board in July 2022 attributing his departure to his "witnessing the agency's ability to tackle big challenges [having been] nearly eviscerated by this Administration."[258]

In the months following the release of the Water Supply Strategy, similar sentiments about the plan's weaknesses and shortcomings were shared. In September 2022, the Los Angeles Times Editorial Board similarly criticized the Governor's plan, leaning on Gomberg's initial dismay "that Newsom hasn't let the [Water Board] do the work it must do to properly manage the state's water."[259] The Times editorial board criticized the fact that the plan simply restates existing programs and policies—"most of them inadequate"—rather than designing or implementing a bold new approach to California's water needs for beyond drought resilience.[260] The board reflected how very different California's plan was from the bold water crisis plan developed to prevent Cape Town, South Africa, from becoming the world's first major city to run out of water in 2018.[261]

The Times Editorial Board recommended that the state establish "pricing structures and conservation incentives to reflect projected 2040 supplies."[262] Moreover, the Times criticized the fact that nowhere in Newsom's plan acknowledges the need to reduce water usage by agriculture, the very key strategy Gomberg identified. CalMatters similarly points out the need to transform California agriculture.

The California Water Resilience Portfolio acknowledges that:

> **"Agricultural water demand will likely continue to outpace available water supplies into the future. Simply put, California agricultural production will be shaped by limits on available water supply. The amount of groundwater available for use will be determined by the annual sustainable yield that each groundwater basin can provide under the Sustainable Groundwater Management Act (SGMA), and it will be lower than historical pumping levels that overdrafted aquifers. Groundwater recharge is important to maximize the amount of groundwater that can be pumped on a sustainable basis."**[263]

However, despite this acknowledgment, neither the portfolio nor the Water Supply Strategy include any steps directly reducing water available for agricultural purposes.

PPIC also criticized the strategy for not going far enough to ensure adequate water resources for California's future; however, its criticisms focused on biodiversity and environmental needs. PPIC experts advocated to expand the Governor's strategy for dam management along California's reservoirs. Specifically, the authors noted that dams have negative effects on California's environment: they affect water quality, block access for certain habitats, and impact water flows. In the current system, operators typically constrain water hydropower operations to manage the environments below dams. However, in addition to having made negligible improvements on the health of rivers throughout the state, PPIC notes that this current approach is complex, inflexible, and difficult to adjust. Therefore, PPIC recommends

expanding dam operators' abilities to control reservoir inflow and storage capacity as the most efficient use of environmental water.[264]

CalMatters assessed the Governor's water goals against California's existing practices and demonstrated some shortcomings in the Water Supply Strategy. First of all, the Governor set a goal of recycling 1.8 million acre-feet of water by 2040.[265] That goal amount is more than double the water recycled in 2021.[266] In fact, the Times Editorial Board similarly criticized this goal because the Governor's 800,000 acre-foot annual target is "actually a rollback from 20-year-old state goals."[267]

The alternative could be building treatment and recycling plants throughout the state—like the Metropolitan Water District's in-progress plant in Carson or Los Angeles city's proposed treatment plant conversion—but these projects will be costly and take time to build and develop. Similarly, desalination projects of sea and groundwater require high energy and operating costs that will not allow them to serve as a panacea to the state's supply issues.[268]

Case Study: **Cape Town, South Africa**

The water supply crisis in Cape Town, South Africa, was due to a severe drought that lasted from 2015 to 2018. The drought caused the city's reservoirs to dry up, and the city was facing the possibility of running out of water entirely. The city officials declared a water crisis and introduced various measures to ensure that they didn't run out of water.

One of the key measures taken was the implementation of strict water restrictions. In

February 2018, the city reduced the daily water consumption limit to just 50 liters per person per day, which is the equivalent of one shower, one flush of the toilet, and a small amount of drinking water. The city also introduced a “Day Zero” campaign to raise awareness about the impending water shortage and to encourage residents to reduce their water usage. The government also offered rebates to residents who installed water-saving devices such as low-flow showerheads and rainwater tanks.

The city also invested in various water supply projects, including the construction of desalination plants, the drilling of boreholes, and the installation of water management devices in households. The government installed six desalination plants along the coastline to convert seawater into drinking water. The desalination plants were built in record time and supplied up to 7 million liters of water per day. The city also drilled over 50 boreholes to tap into the Table Mountain Group Aquifer, a natural underground water reservoir. The boreholes provided up to 40 million liters of water per day. The government encouraged the use of recycled water for non-potable uses such as irrigation and industrial purposes. The city’s wastewater treatment plant was upgraded to produce up to 10 million liters of recycled water per day.

These measures proved successful, and the city managed to avoid running out of water entirely. However, the crisis highlighted the need for more sustainable and resilient water management practices in the face of climate

change. Moreover, there were also criticisms of the projects, including their high cost and potential environmental impacts.

The crisis was largely driven by politics rather than drought management and planning. Government officials ignored warnings from water experts and were slow to implement solutions.[269] Moreover, the response to the crisis was reactive rather than proactive. Measures such as desalination plants were only put in place when the situation became dire.[270]

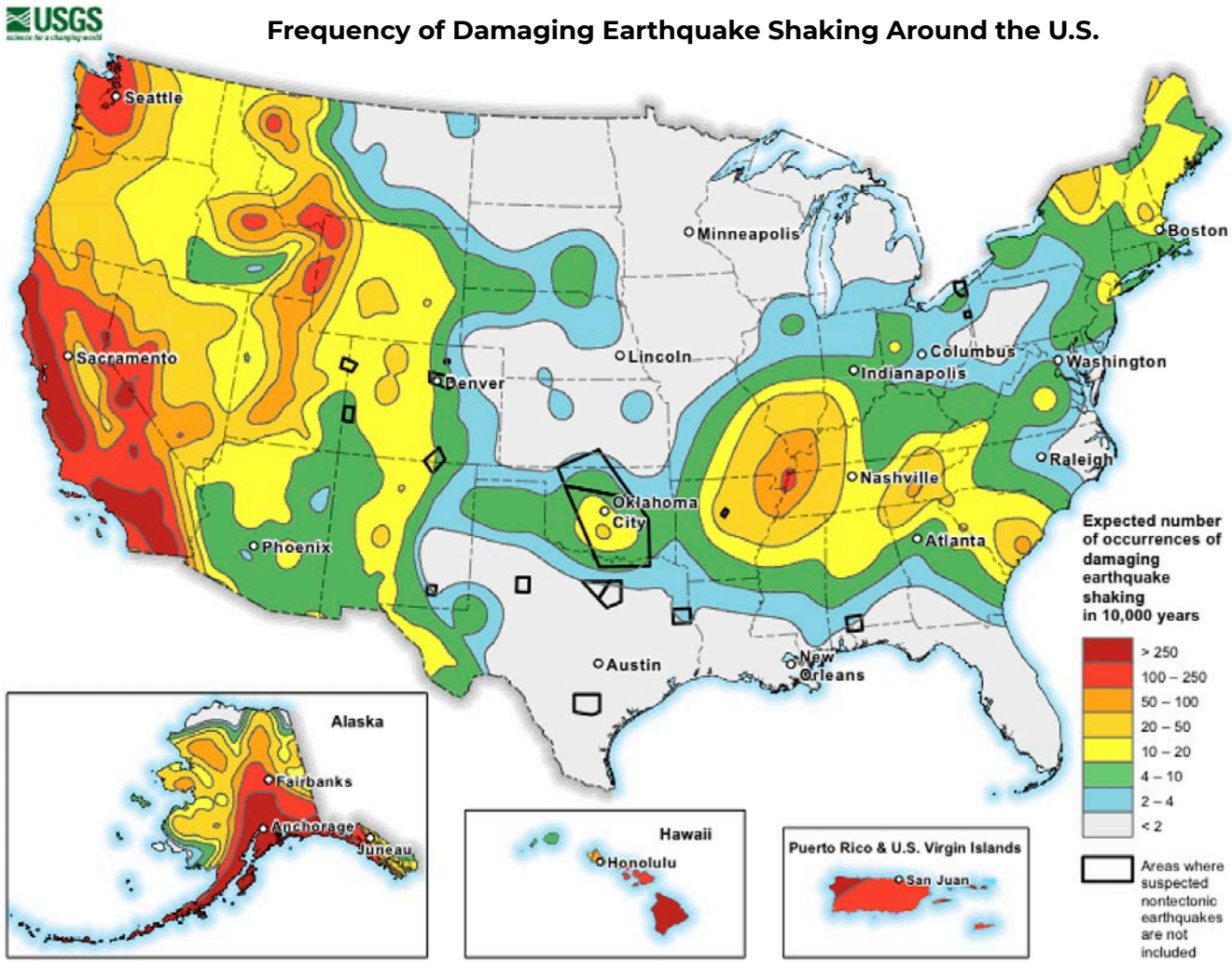
The crisis exposed the vulnerability of cities to climate change and the need for long-term planning to build resilience.[271] There were missed opportunities for collaboration between government, civil society, and the private sector to develop solutions.[272] The crisis highlighted the need for better water management practices, including reducing water demand, improving water reuse and recycling, and investing in infrastructure to increase water supply.[273]

Cape Town's water crisis and response can help California and other places at risk of water depletion become more prepared. Cape Town showed the importance of water conservation and demand management strategies to reduce consumption, such as public awareness campaigns, water restrictions, and price incentives.[274] It also demonstrated the need for investment in water infrastructure, including diversification of water sources, upgrading of water treatment plants, and distribution systems. Because of the amount of time these solutions take to develop, Cape Town showed how critical it is for preemptive and early responses to water scarcity. Cape Town demonstrated the potential of emerging technologies, such as desalination and water reuse, to augment existing water supplies. The crisis also showed that it is important to plan for future droughts and other climate-related impacts on water supply, and to ensure collaboration between public, private, and community groups to address water supply challenges.

EARTHQUAKES

In contrast to the aforementioned climate-driven events that have been gradually changing, and oftentimes worsening due to climate change, earthquakes present sudden, localized risks. California is particularly vulnerable to earthquakes, because it is positioned alongside the boundaries of the Pacific and North American tectonic plates, which meet at the San Andreas fault that runs for 800 miles down the state.[275] In 1857, California experienced its strongest earthquake in history, with a magnitude 7.9 at Fort Tejon. Decades later in 1906, California experienced another 7.9 earthquake—and this time, its most deadly—in San Francisco, killing 3,000 people, causing fires, and destroying buildings and infrastructure.[276]

Figure 15 **The West Coast is At Risk of the Most Frequent and Damaging Earthquakes**



SOURCE: U.S. Geological Survey. "Frequency of Damaging Earthquake Shaking Around the U.S." Accessed April 25, 2023.

Thousands of earthquakes are recorded each year in California.[277] Only two or three per year, however, register above a 5.5 magnitude, or high enough to cause moderate damage.[278]

According to an earthquake forecast model from the U.S. Geological Survey, the likelihood of an earthquake measuring 6.7 magnitude in the Southern California region is 93 percent in

the next 30 years, whereas the risk is an astounding 95 percent for Northern California in the same time period.[279] For earthquakes measuring magnitude 7.5, nearing that of the 1906 San Francisco earthquake, the likelihood is 36 percent in Southern California, and 28 percent in Northern California.[280]

According to USGS research, the reason for the higher likelihood in the Southern California region is because the Southern San Andreas Fault near the Mojave Desert is the most likely to experience a significant earthquake, whereas the Northern San Andreas Fault near San Francisco experienced a sizeable earthquake in 1906, which is still relatively recent.[281]

CALIFORNIA'S APPROACH TO PREPAREDNESS AND RESILIENCE FOR EARTHQUAKES

Because of California's location along active tectonic plates, the state has adapted to focus on preparedness in the face of seismic activity. In 1933, a devastating 6.4 earthquake shook near Huntington Beach in Southern California, causing significant damage to the City of Long Beach, though its effects extended inland to Compton and Huntington Park.[282] In addition to killing at least 120 people, the earthquake also caused about $50 million in damages, much of which happened to schools due to poor construction, while also breaking gas lines and pipes, and uprooting oil derricks in nearby Huntington Beach.[283]

The Long Beach earthquake highlighted the state's need to adapt its building codes and engineering to anticipate seismic events. The same year as the earthquake, California enacted the Field Act (1933), which required that all public schools be designed to meet seismic safety standards, and be subject to frequent inspections by state officials.[284] A 1999 review found that evidence from earthquakes such as the 1994 Northridge Earthquake indicated that schools built in compliance with the Field Act performed better than buildings of comparable age.[285] That year, the state also passed the Riley Act, or the State Earthquake Investigation Commission Act, which developed seismic design standards for all new building construction, ultimately laying the foundation for California's strict building codes.[286]

Since the 1930s, as the state has continued to experience earthquakes and develop a greater understanding of earthquakes and their effects, building codes have continued to reflect the latest research. For example, following the 1971 San Fernando earthquake, new building codes were developed to include stronger requirements for the use of ductile materials that better withstand shaking, while also limiting construction along major fault lines with the Alquist Priolo Act.[287] Likewise, at the federal level, the earthquake, which caused more than

$500 million in damages and took 64 lives, led to increased interest by the federal government, which ultimately formed the National Earthquake Hazards Reduction Program, later the USGS Earthquake Hazards Program, which has made important policy recommendations based on seismic research.[288]

In 1994, many of these new building designs were put to the test with the Northridge earthquake, a magnitude 6.7 that struck the San Fernando Valley in the early hours of January 17, killing more than 60 people and causing more than $20 billion in damage.[289] The Northridge earthquake highlighted the need for revisions to the state's building codes, as many structures believed to be seismic-proof cracked or fractured.[290] In the years following, many insurance companies also began to restrict their coverage for homeowners because of the economic toll of Northridge, leading the state legislature to form the California Earthquake Authority (CEA), through which residential property owners could purchase earthquake insurance.[291] Today, the CEA reports that the majority of homeowners in California purchase their earthquake insurance through the program.

BIODIVERSITY

Biodiversity, which encompasses the range of ecosystems and species in a region, plays a critical role in sustaining life by supporting clean air and water, industries like agriculture and medicine, and natural systems, including pollination and nutrient cycling.[292] Thirty-six regions across the world have received the designation as biodiversity hotspots, or regions that support significant proportions of the world's endemic plant and animal species.[293] In 1996, the California Floristic Province received this designation, which stretches along much of the western coast of the U.S., and is home to some of the world's most diverse vegetation, including the sequoia and redwood, much of which is endangered.[294]

Figure 16 **California's Floristic Province**

SOURCE: Terra Peninsular. California Floristic Province.

Much of California's land is under biodiversity protection; however, with the country's largest population and economy, California also faces challenges retaining this biodiversity, which has been threatened by pollution, climate change, and other human activities, like the diversion of water flow and introduction of invasive species.[295] This is particularly impactful, both on the population and on the state's economy, as California is a major agricultural

supplier: roughly one-half of all agricultural products in the U.S. annually are produced here.[296] Over time, however, human activity like urban development, conversion of land for agricultural purposes, and logging have changed ecosystems across the state. And as climate change continues to exacerbate environmental concerns, including raising atmospheric temperatures and causing fluctuations in precipitation patterns, the state's biodiversity will be affected, which raises alarms for both the many endemic species to the state and for California's economy, which is connected to its abundance of natural resources.

Table 4 **How Climate Change is Affecting Biodiversity**

Climate Concern	Effects on biodiversity
Drought & Excessive Heat	• One of the primary effects of drought on biodiversity is the reduction of habitats. For example, California's wetlands are among its most biodiverse habitats, home to many species of birds, fish, and plants.[297] As a consequence of drought and extreme heat, such habitats have begun to shrink and become more isolated, which can lead to population reductions among species.[298] And when such drops occur at extreme levels, ecosystems can collapse as the web of species begins to deteriorate, leading to further and more widespread changes to the composition of the state's ecosystems.[299] • Similarly, extreme heat can impact biodiversity by stressing species that have not properly adapted, particularly where drought conditions are infrequent or uncommon.[300]
Flooding and Sea Level Rise	• Flooding can also contribute to ecosystem degradation or displacement, which can be particularly devastating for terrestrial animals, such as mammals, birds, and reptiles, though the extent of the impact can depend upon the nature of the flooding and the characteristics of such animals.[301] • Likewise, sea level rise along coastal habitats can become inundated, destroying habitats such as salt marshes, wetlands, or estuaries. As water submerges such habitats, the risk of saltwater intrusion also rises. Saltwater intrusion occurs when high tides infiltrate freshwater habitats or aquifers, contaminating resources upon which communities, plants, and animals rely.[302]

CALIFORNIA'S APPROACH TO SUSTAINABILITY AND RESILIENCE FOR BIODIVERSITY

In order to protect and restore the state's biodiversity, in October 2020, Governor Gavin Newsom issued Executive Order N-82-20 to protect the state's biodiversity with a commitment to conserve 30 percent of California's lands and coastal waters by the year 2030.[303] The order highlights the importance of preserving biodiversity in California, emphasizing the need to take inventory of the current preservation efforts, foster collaboration across state agencies, and predict and monitor the effects of climate change on the state's biodiversity and natural resources. One of the most critical pieces of biodiversity preservation is promoting drought resilience, particularly for freshwater ecosystems in California. In 2022, the state launched the California Programmatic Biological Opinion, which is designed to support restoration projects across critical habitat areas that are biodiversity hotspots.[304] A review from PPIC notes that although these actions are a step in the right direction, the state needs to continue to accelerate the pace at which it invests in preserving such key biodiversity hotspots, in part by accelerating the permitting process.[305]

CONCLUSION

California has a legacy of building infrastructure and adapting the natural geography to serve dual purposes: maintain and support the natural environment and biodiversity and provide resources throughout the state as equitably as possible. This legacy is best exemplified in the State Water Project and California Aqueduct—two projects launched in the late 1950s under Governor Pat Brown. In his first inaugural address on January 5, 1959, Governor Brown said,

> **"Development of our water resources is crucial to every segment of our state — the ranchers in our mountain areas, the farmers who make California the nation's leading agricultural producer and the homeowners in our population, which will grow to 20 million by 1970. No problem has occupied more of my time in the weeks since election than water. Striking progress has been made. I can tell you now that I will soon present a water program, which is rational, realistic and responsive to the needs of all the people of the state."**[306]

Governor Brown followed through on his promises to deliver a statewide water infrastructure, which was innovative for its time. However, just as Governor Pat Brown and his predecessors designed an infrastructure for delivering water around the state, we now face a need for equally audacious efforts to rethink our water infrastructure with an emphasis on conservation, groundwater recharge, and capturing runoff from rain.

Many in the state are ready to announce that the statewide drought has ended given the precipitation and flooding from dozens of atmospheric rivers in late 2022 and early 2023. However, scientists continue to repeatedly remind us that it is too soon to declare the drought over. In fact, at the end of 2021, California received similar rainfalls, and 2022 began with a similar bounty. But then the snow season ended with a snowpack far below normal. Therefore, again, in 2023 and beyond, California may continue to face a similar fate.

Despite record rainfalls, as we address earlier in this report, California relies on the snowpack in the Sierra Nevada to ensure we have adequate supplies of water throughout the summer months across the state. If the snowpack melts too soon, California will need to identify alternative sources of water to maintain agricultural productivity, personal and private use, and natural water supplies.

Scientists maintain that drought concerns are a priority as climate change continues to have an impact on California's weather, despite all the rain and snow that has boosted reservoirs and allowed authorities to lift some water restrictions. In fact, California's Department of Water Resources Director noted in early 2023 that "even though we have this extraordinary snowpack, we know that the droughts are getting deeper and more frequent, and that means we have to use water efficiently no matter what are hydrologic conditions."[307] However, California's existing infrastructure is currently built to work around the snowpack as our primary yearlong reservoir and water management system. In a warming climate, this infrastructure will no longer be satisfactory for the state to collect and distribute adequate water resources year-round.

Experts have begun to identify this extreme swing between rainfall and drought as "climate whiplash."[308] California needs to ensure the infrastructure improvements required to manage the effects of storms that are getting stronger, including restoring floodplains and wetlands that can absorb floodwaters. It also needs to get ready for droughts that are getting worse. To survive during dry years, it is crucial to adopt efficient water management techniques to prevent a repeat of our current groundwater depletion crisis. Water availability may be significantly impacted by funding initiatives that encourage efficiency, water use, stronger forest management to reduce the severity of wildfires—particularly those started in rural, difficult reduction, and wastewater recycling practices.[309]

In particular, California remains vulnerable to water scarcity and shifting precipitation patterns. The state's water scarcity has been exacerbated by climate change, aging infrastructure, and a growing population, and requires policies that prioritize water conservation, groundwater recharge, and a greater ability to capture runoff from precipitation. Addressing California's water challenges will require rethinking our water infrastructure with an emphasis on conservation, including partnerships between government

agencies, water districts, industry, and communities to develop and implement sustainable water management strategies.

Although California has developed many complex plans with goals and action items to prepare for the increase in water scarcity, many experts insist that California is not doing enough to ensure California will have adequate water supplies in the future. In particular, California has hardly begun to reckon with the toll that our agricultural bounty takes on the state's water supplies. Unfortunately, despite the urgency California faces in recharging its groundwater supplies, capturing stormwater, and advancing technological innovations to recycle our water resources, the state has not addressed the primary user of our available water supply: agriculture.

The state must also address its shortcomings in preparing for dry and hot years, and to mitigate the destruction caused by wildfires and extreme heat events during these climate whiplashes. Whether through financial incentives or penalties or a mix of both, holding actual people responsible for both igniting wildfires and being ill-prepared to mitigate wildfire damage—particularly in rural areas—will be a pivot in the state's current approach to wildfire response that may introduce other challenges. Further, investing in stronger forest management to reduce the severity of wildfires—particularly those started in rural, difficult-to-reach areas of the state due to lightning strikes or other natural causes—will be critical to the state's success.

Ultimately, though California's efforts to address sustainability and resiliency in the face of climate change reflect the state's commitment to reducing the impacts of climate change on its communities, environment, and economy, the state must continue to sustain and expand these efforts as the impacts of climate change continue to evolve, in order to ensure a livable state and future for its residents.

In all these efforts, California will have to make sure that all groups are included and that equitable solutions to problems are developed. Poor and marginalized groups are more likely to lack air conditioning and filtration systems in the case of heat waves or wild-fires, they are more likely to be located near environmental hazards, and they are more likely to lack high-quality drinking water. Every effort must be made to be sure that solutions meet everybody's needs.

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