



Climate Change Impacts Across California

Crosscutting Issues

Other Reports
in This Series



Summary

Addressing the widespread impacts of climate change represents a significant challenge for the state, and one that will increasingly occupy the Legislature's agenda in the coming years. A changing climate presents California with five key climate hazards: (1) higher temperatures and extreme heat events, (2) more severe wildfires, (3) more frequent and intense droughts, (4) flooding due to extreme precipitation events, and (5) coastal flooding and erosion from sea-level rise. These hazards will threaten public health, safety, and well-being—including from life-threatening events, damage to public and private property and infrastructure, and impaired natural resources.

More frequent extreme weather and climate-related emergencies will be increasingly disruptive for California's residents and economy. These disruptions often will be unpredictable and will include (1) short-term incidents, such as when wildfire smoke or extreme heat events make it unsafe to work or recreate outside; (2) longer-term impacts, such as when floods or fires damage homes, businesses, and infrastructure; and (3) permanent changes, such as higher sea levels or more prolonged droughts causing current activities to become impractical in certain regions. These impacts will not affect all Californians equally—certain residents will be more vulnerable to experiencing negative impacts based on their underlying health conditions, where they live, their jobs, and the level of economic resources upon which they can draw. Taking steps to prepare for, respond to, and recover from climate change impacts will be costly. Although the federal government may provide some funding for these activities, many of the costs will be borne by the state, local governments, and private businesses and residents.

Given the magnitude of climate change impacts California already is beginning to experience, the Legislature will confront persistent questions about how the state should respond. While the companion reports in this series highlight climate change issues specific to different sectors, certain major themes are applicable across all policy areas. One key question will be what role *state* programs and policies can and should play in adapting to climate change, including how they interact with local adaptation activities, and how they should be funded. For example, the Legislature might consider adopting statewide guidance and standards, assessing and addressing data gaps, offering support and coordination, and providing targeted fiscal support. The Legislature also will want to think about steps the state can take—and avoid taking—to ensure it does not exacerbate climate impacts, as well as how to prioritize across its various climate response priorities. Given that certain groups—such as low-income households, medically sensitive populations, and workers in outdoor industries—generally are more vulnerable to the effects of climate change, the Legislature may want to consider how it can target state programs in ways that support these populations.

Introduction

This report contains four primary sections: (1) a description of the five key climate hazards affecting California, (2) the major ways those hazards impact sectors across the state, (3) significant existing state-level efforts underway to address climate change impacts, and (4) key issues for the Legislature to consider in response to these impacts. Given the complexity of these issues, this report does not contain explicit recommendations or a specific path forward; rather, it is intended as a framing document to help the Legislature adopt a “climate lens” across its policy decisions.

Because some degree of climate change already is occurring and more changes are inevitable, this report focuses primarily on how the Legislature can think about *responding* to resulting impacts. This is particularly important because Californians will increasingly directly experience climate change impacts in their communities, workplaces, and homes. Of note, the state also is engaged in numerous efforts to *limit* the magnitude of climate change by enacting policies and programs to reduce emissions of greenhouse gases (GHGs), though the ultimate effects of such initiatives also will require larger complementary worldwide efforts.

California’s Five Major Climate Hazards

As a result of human activities that warm the planet, the global climate is changing. While efforts are underway—across the state, country, and internationally—to limit the extent of this warming, some degree of climate change already is occurring, and therefore some impacts are inevitable. These impacts are widespread and affect humans, animals, the built environment, and natural resources across the globe—including in California.

As shown in **Figure 1**, climate stressors present California with five key climate hazards: (1) extreme heat events, (2) more severe wildfires, (3) more frequent and intense droughts, (4) inland flooding due to extreme precipitation events, and (5) coastal flooding and erosion from sea-level rise. These hazards will impact public health and safety, public and private property and infrastructure, and natural resources.

Although uncertainty remains about the timing and magnitude of when and how these hazards and their resulting impacts will manifest, the science is conclusive that

they will be part of California’s future. Indeed, many of these changing trends and effects already are beginning to occur—2021 brought record-breaking temperatures, wildfires, precipitation events, *and* drought conditions across the state. Below, we discuss each of California’s climate hazards in more detail.

Temperature Increases and Periods of Extreme Heat

As shown in **Figure 2**, a moderate global emissions climate model projects increases in annual average maximum temperatures in California throughout the 21st century compared to historical baseline averages—ranging from an average of roughly 4 degrees Fahrenheit between 2035 to 2064 to roughly 6 degrees Fahrenheit throughout the last 30 years of the century. As illustrated in the figure, inland areas will experience greater increases in average maximum temperatures than coastal regions. We are already beginning to see these changes. With the exception of 2019, the years from 2014 through 2020 experienced the six highest average annual

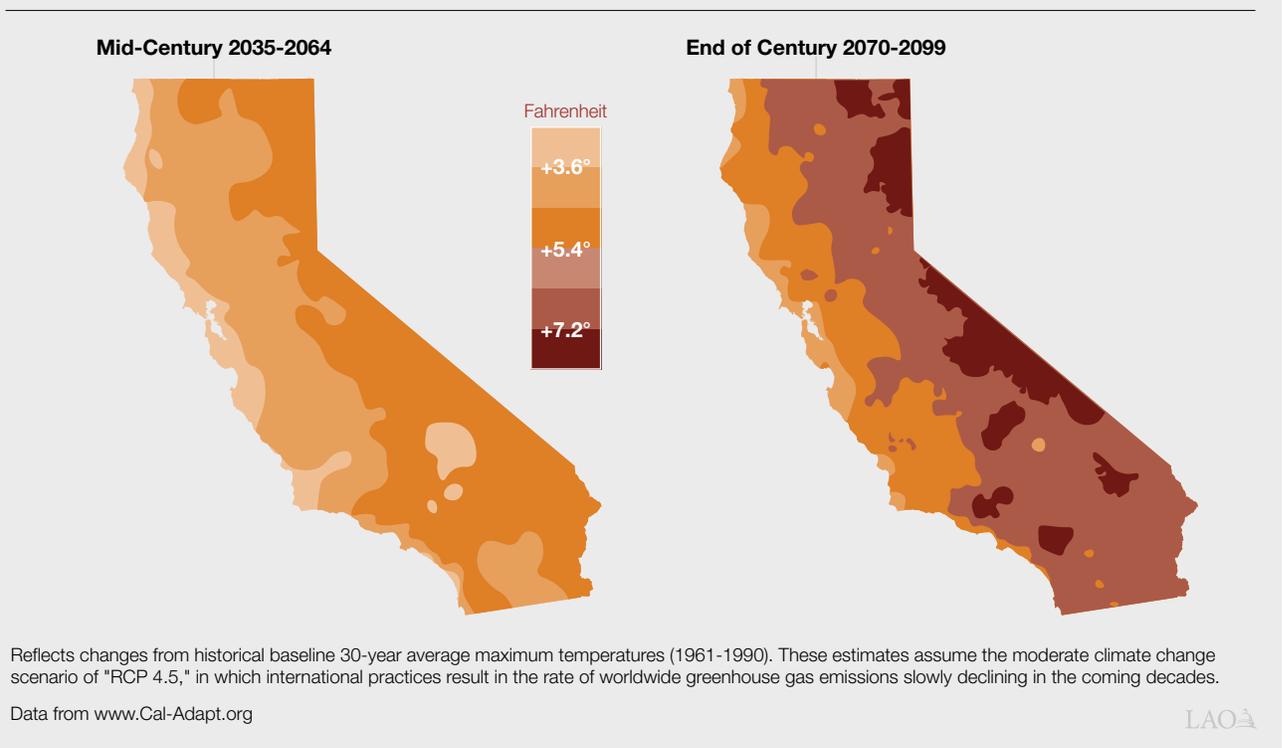
Figure 1

Impacts of Climate Change on Californians



Figure 2

Projected Increases in Statewide Average Maximum Temperatures



temperatures ever recorded in the state. Moreover, average summer temperatures in California were the hottest on record in 2021, breaking the previous June-through-August record set in 2017.

In addition to higher average temperatures, California also will experience more frequent, intense, and prolonged **heatwaves**. While this will be true statewide, the changes will be more substantial in certain regions. For example, between 1961 and 1990, Los Angeles and Sacramento Counties each experienced an average of four days of extreme heat per year (defined as days when the maximum temperature exceeded each county's respective 98th percentile historical temperature for a given date). Climate models project that by mid-century, Los Angeles County will experience an average of nine days of extreme heat per year, growing to 12 days per year by the final decades of the century. In contrast, Sacramento County is projected to experience 20 days per year of extreme heat by mid-century and 28 days annually by the end of the century. These trends will be even more severe in some inland counties. For example, in Fresno County, the historical trends of five days of extreme heat per year are projected to increase to 29 days annually between 2035 and 2064 and 43 days annually between 2070 and 2099.

As discussed in greater detail below, these prolonged periods of heat will have negative impacts on human health—such as by raising the risks of heat stroke and dehydration—as well as impair agricultural production and natural habitats.

More Frequent and Intense Droughts

Warmer temperatures also contribute to more frequent and intense droughts by leading to a decline in and faster melting of winter snowpack, greater rates of evaporation, and drier soils. These conditions *decrease* the amount of spring and early summer snowmelt runoff upon

which the state historically has depended for its annual water supply, at the same time that they *increase* the demand for irrigation water in both agricultural and urban settings. The period of 2012 through 2015 represents the state's four driest consecutive years on record in terms of statewide precipitation, and 2021 is the third driest single year. Moreover, 2022 already experienced the driest consecutive January and February in the Sierra Nevada, based on records dating back over 100 years. Droughts have widespread impacts across the state, including mandatory water use restrictions, reductions in agricultural crop production, over-pumping of groundwater—which damages infrastructure from land sinking and dries up domestic wells in some communities—and degraded habitats for fish and wildlife.

Increased Risk of Floods

Climate models predict that California will experience less frequent but more intense storm patterns in the coming decades, including the state's precipitation more frequently falling as rain rather than snow compared to historical trends. Additionally, the state's streams and rivers will swell more in some years from earlier and faster spring snowmelt caused by higher temperatures. Scientists suggest the combination of these factors could lead to a 50 percent increase in runoff in future years, challenging the capacity of the state's existing reservoirs, canals, levees, and other flood control systems, and increasing the risk of inland flooding. Floods cause significant risk to human life, and also damage roads, buildings, and other infrastructure. One recent **study** conducted by First Street Foundation suggests that by 2050, 1.5 million properties in California will face “substantial risk” of flooding, representing an increase of 60,000 compared to the number of properties currently meeting that characterization.

More Severe Wildfires

Warmer average temperatures and drier environments also create conditions that lead to extreme, high-severity wildfires. These conditions increasingly dry out vegetation and lengthen the wildfire season, which raise wildfire risks. Additionally, more frequent and intense droughts put stress on trees and make them more susceptible to pest infestations. This, in turn, can lead to more diseased, dying, and dead trees, which can exacerbate the severity of wildfires by providing more combustible fuels. According to the state's [Fourth Climate Change Assessment](#), by 2100, the frequency of extreme wildfires burning over 25,000 acres could increase by nearly 50 percent.

As with other climate hazards, the state already is beginning to experience an increase in severe wildfires. [Figure 3](#) shows how most of California's largest and most destructive wildfires have occurred in recent decades. This pattern has been particularly notable in the last few years, which have seen some of the worst wildfires in the state's recorded history. For example, the 2018 wildfire season included the Camp Fire in Butte County, which became the single most damaging wildfire in state history with nearly 19,000 structures destroyed and 85 fatalities, including the near-total destruction of the town of Paradise. Moreover, 5 of the 20 most destructive wildfires in the state's history occurred in 2020 alone, with an additional two in 2021.

Not only do high-severity wildfires take lives and level homes, businesses, and community infrastructure,

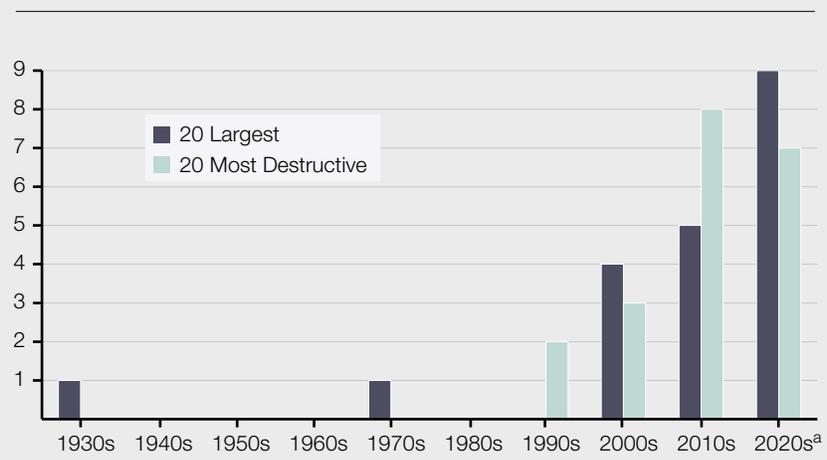
they also destroy fish and wildlife habitats. Moreover, intense wildfires can also impair air quality throughout the state. In recent years, smoke from wildfires has grown substantially and has been a major contributor to air pollution in the western United States—making up [roughly half](#) of small particulate matter in some regions, compared to less than 20 percent a decade ago. The degree to which climate change will impact particulate emissions in the future is subject to some uncertainty, but [researchers](#) have estimated that particulate matter in fire-prone areas could roughly double by the end of the century.

Coastal Flooding and Erosion From Rising Sea Levels

Sea levels along the California coast are projected to rise by about six inches by 2030 and as much as seven to ten feet by 2100 compared to 2000 levels, depending upon the degree of warming the planet experiences. These impacts will be compounded by periodic increases in sea levels caused by storm surges, exceptionally high “king tides,” or El Niño events. As shown in [Figure 4](#) on the next page, these

Figure 3

Most of the Largest and Most Destructive Wildfires Have Occurred in Recent Decades



^a Includes wildfires that occurred in 2020 and 2021.

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Figure 4

Sea-Level Rise Will Impact the California Coast in Multiple Ways

Flooding

Advancing seas and waves will cause both permanent and periodic flooding along the coast affecting buildings, infrastructure, and natural resources.



Erosion

Waves crashing further up the shore will erode sand away from beaches and coastal cliff walls.



Rising Groundwater

Higher ocean water levels could force up the water levels underneath the ground as well, leading to flooding, saltwater intrusion into fresh groundwater supplies, and toxic contamination by carrying hazardous materials to the surface.

changing conditions will impact the coast by leading to periodic and permanent flooding, eroding sand away from coastal cliff walls and beaches, and forcing groundwater levels to rise.

The impacts of sea-level rise along California's coast will be widespread, affecting public infrastructure, private property, vulnerable

communities, natural resources, and drinking and agricultural water supplies. For example, a 2015 **economic assessment** by the Risky Business Project estimated that if current global GHG emission trends continue, between \$8 billion and \$10 billion of existing property in California is likely to be underwater by 2050, with an additional \$6 billion to \$10 billion at risk during high tide.

Major Crosscutting Impacts on California

The climate hazards discussed above have a number of significant effects on residents, properties and infrastructure, and natural resources across the state.

Threats to People's Health and Well-Being

Changing Climate Brings Wide Range of Health Impacts. As shown in **Figure 5**, climate change has a variety of effects on human health. Some of the most direct impacts

Figure 5

Climate Change Has a Variety of Health Effects

Climate Change Impact	Examples of Health Effects
 <p>More frequent and severe extreme heat events.</p>	Heat-related illness and death, including heat stroke, dehydration, cardiovascular failure, and kidney disease.
 <p>Air pollution, including particulate matter, from wildfire smoke.</p>	Death and illnesses related to asthma, chronic obstructive pulmonary disease, and pneumonia.
 <p>More frequent and severe disasters, such as floods and wildfires.</p>	Injuries and fatalities from disasters, inability to operate certain medical equipment during Public Safety Power Shutoffs, and behavioral health impacts related to traumatic events.
 <p>Less secure water and food supply due to more frequent drought and warming temperatures.</p>	Higher incidence of malnutrition and diarrheal disease.
 <p>Reduced water quality due to runoff from extreme precipitation events and warming water temperatures.</p>	Increased prevalence of cholera and harmful algal blooms in rivers and lakes.
 <p>Changes in the climate conditions that support different diseases.</p>	Higher incidence of vector-borne diseases, such as Lyme disease and West Nile virus.

Source: Adapted from Centers for Disease Control and Prevention and Senate Office of Research.

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include injuries, illnesses, and deaths related to extreme heat; disaster events (such as floods and wildfires); air pollution from wildfire smoke; impaired water quality due to runoff from extreme precipitation events and warming temperatures; impacts on food and water supplies from more frequent droughts; and increasing prevalence of certain diseases.

Extreme Heat Among Most Significant Factors Impacting Mortality in California.

Temperature-related mortality (including from extreme heat) is **projected** to be among the most deadly and costly impacts of climate change in certain locations around the globe. Higher temperatures and extreme heat can lead to heat stroke and increase the risk of or exacerbate cardiovascular disease, respiratory disease, kidney failure, and preterm births. Under a moderate climate change scenario—which assumes that international practices result in the rate of worldwide GHG emissions slowly declining in the coming decades, somewhat constraining the magnitude of global temperature increases—higher temperatures are projected to cause 9 deaths per 100,000 people in California annually. By comparison, this is roughly equivalent to the 2019 annual mortality rate from automobile accidents in California.

Even though extreme heat will be more frequent and severe in hotter regions of the state, **one national study** estimates that temperature-related mortality is actually projected to be higher in cooler regions because they are less prepared for the heat (for example, fewer buildings have air conditioning). Significant differences in the projected number of heat-related deaths also exist *within* a particular region or city. For instance, urban areas with a large percentage of impervious surfaces and relatively little shade—also known as urban heat islands—tend to be hotter than surrounding areas. As discussed in more detail below, adverse health effects of hotter temperatures will be particularly significant in some locations and for certain populations.

Adverse Health Effects From Wildfire Smoke Also Are Substantial. Poor air quality also has been linked to a wide variety of adverse health effects, including increased risk of asthma, cardiovascular disease, cognitive impairment, and premature births. While overall health effects from wildfire smoke still are being studied, a rough estimate suggests wildfire smoke in 2020 caused about 20 deaths per 100,000 adults over the age of 65. **Researchers** suggest that particulate matter in fire-prone areas could roughly double by the end of the century, **and that** a 50 percent increase in wildfire smoke could increase deaths of older adults by an additional 9 to 20 per 100,000 people annually.

Damage to Private Property and Public Infrastructure

Wide Range of Structures and Facilities Face Threat of Damage. A changing climate and more frequent disasters will impact many existing buildings and structures across the state. This includes both private properties—such as houses and businesses—as well as infrastructure owned by the state and local governments—including roads and highways, schools, and water treatment and conveyance systems. For example, statewide transportation systems will experience a range of impacts, such as sea-level rise undermining coastal railways and bridges, intense storms causing mudslides and flooding of highways, and heatwaves causing buckling and rutting of roads. Moreover, many existing structures were built to different standards than are commonplace today, making them less resilient to the effects of climate change. For instance, many older homes were built with features—such as wood shake roofs, cedar siding, or single-paned windows—that make them more vulnerable to igniting during wildfires.

Evolving Conditions Are Changing Risk Exposure. Traditionally, land-use decisions—such as where to construct housing, locate public buildings such as schools, or build roads—were informed by historical trends, such as how

often an area had flooded in the past. Changing conditions make historical data less reliable for assessing current and future threats, meaning many existing structures now face greater risks in their current locations compared to when they were built. For example, in the San Francisco Bay Area alone, a recent [study](#) led by the Bay Conservation and Development Commission estimated that with an anticipated four feet of flooding in the region from sea-level rise over the next 40 to 100 years, 13,000 existing housing units and 104,000 existing job spaces will no longer be usable. Additional [research](#) suggests that 15 wastewater treatment plants in California will be exposed to flooding with three feet of sea-level rise, growing to 36 facilities with six feet of sea-level rise. Moreover, about 1 million structures currently are located in areas that the California Department of Forestry and Fire Protection classifies as being at very high risk of wildfires.

Some Existing Structures and Infrastructure Will Require Modification or Relocation to Remain Usable. Many existing buildings and infrastructure will need to be modified in order to avoid serious damage from climate change impacts. For instance, due to warmer average temperatures and more frequent heatwaves, school facilities in historically temperate regions may need to consider remodeling playgrounds with more heat-resistant materials and shade structures, or adding air conditioning systems. Some impacted roads, railways, bridges, and ports will need to be modified or relocated to remain accessible. Certain homes—particularly older homes—may also need to add features such as air conditioning, modern insulation, and air filtration to mitigate the effects of extreme heat and outdoor wildfire smoke.

More Intense Impacts for Certain Vulnerable Populations

Some Californians Are More Vulnerable to Negative Climate Change Impacts. Climate change impacts will not affect all Californians equally. Certain residents will be more vulnerable to experiencing negative impacts, based on their underlying health conditions, where they live, their jobs, and the level of economic resources upon which they can draw. For example, some of the most significant climate impacts—such as heat and wildfire smoke—disproportionately affect certain medically vulnerable groups, including: children and the elderly, populations that have underlying medical conditions (such as asthma and cardiovascular disease), and populations that spend a lot of time outdoors (such as homeless populations and outdoor workers).

Lower-Income Households and Communities Are Particularly Vulnerable. In general, low-income households and communities are expected to bear a disproportionate burden because they have fewer resources for adapting to various climate impacts. For example, low-income households have less money to purchase and operate air conditioning units during extreme heat events, air filters to moderate wildfire smoke, or back-up electricity generators to provide electricity during Public Safety Power Shutoff events. Low-income residents also are more likely to live in older housing that requires modifications—such as air conditioning or more fire-resistant exteriors—to adapt to increased risks. Notably, low-income residents also are more likely to live in rental housing, and thus more likely to be reliant on landlords to conduct modifications to their homes to mitigate the effects of climate change. For instance, while current state regulations require that landlords provide their tenants with heating facilities to maintain a minimum temperature of 70 degrees, there is no comparable requirement

for cooling mechanisms to avoid exceeding any maximum threshold, meaning renters could be at greater risk during periods of extreme heat.

Discriminatory Housing Policies Correspond to Increased Community Vulnerabilities.

Many neighborhoods facing disproportionate levels of risk from climate impacts also align with those that experienced historical housing discrimination policies. That is, historical housing policies may be directly responsible for some unequal exposure to current and growing climate risks. Specifically, recent research suggests that communities the federal government designated in the 1930s as “hazardous” for real estate investment through a process known as redlining tend to experience **hotter temperatures** and more **flood risk** than other areas. Similarly, rural communities that are at greater risk of experiencing water shortages due to droughts tend to be home to large proportions of households with residents of color and who earn lower incomes. This is due in part to historical discriminatory practices that restricted which racial groups could live and purchase homes in the communities that contained larger and more developed water systems.

Climate Change Impacts Pose Particular Risks for Workers in Certain Industries.

Greater climate risk is also aligned with particular occupations. Specifically, workers in industries where most of the work occurs outdoors—including agricultural production; forestry; commercial and residential construction; and the outdoor-based hospitality, services, and recreation industries—will be more affected by climate change based on their greater exposure to extreme heat and wildfire smoke. In general, these industries tend to pay low- and middle-wage salaries. More than 2 million Californians work in these jobs, representing about 10 percent of the state’s overall workforce. Furthermore, Latino workers make up a disproportionate share of the workforce in outdoor industries

that face greater exposure to extreme heat and wildfire smoke. Specifically, while Latino workers represent about 38 percent of the state’s overall workforce, they account for 60 percent of the workers in primarily outdoor-based industries.

More Frequent Disruptions and Instability

Climate Impacts Will Be Disruptive for California’s Residents and Economy.

More frequent extreme weather and climate-related emergencies often will be unpredictable and will include (1) short-term incidents, such as when wildfire smoke or extreme heat events make it unsafe to work or recreate outside; (2) longer-term impacts, such as when floods or fires damage homes, businesses, and infrastructure; and (3) permanent changes, such as higher sea levels or more prolonged droughts causing current activities to become impractical in certain regions.

For example, K-12 schools and child care providers will increasingly be impacted by disasters such as wildfires and floods interrupting their ability to offer in-person educational services. More frequent school closures will cause disruptions to instruction, school meals, and child care—leading to a greater risk of food insecurity, learning loss, and poorer academic outcomes for impacted students, as well as impairing their parents’ ability to work. These impacts are already occurring more regularly. As shown in **Figure 6**, from 2017-18 through 2019-20, the state averaged more than **1,600 schools** closed due to wildfires annually, compared to an annual average of about 70 schools from 2008-09 to 2016-17. These closures affected an average of about 950,000 students per year in 2017-18 through 2019-20. Schools and child care providers will need to plan for how they can maintain continuity of education and services—particularly for more vulnerable and impacted students—as climate change disruptions become more frequent.

Work in Some Industries May Also Become Less Stable. Changing climate patterns will also make work less stable and predictable for many industries and workers. In particular, incidents like extreme heat, fires, smoke, and severe storms will cause work interruptions and instability in primarily outdoor-based industries such as construction, tourism, recreation, agriculture, and logistics/goods movement. For example, work and economic activity will be disrupted by flooding of ports, docks, surrounding roadways, or adjacent railways through which goods are distributed—affecting deliveries of imports across the state, as well as exports such as Central Valley agricultural products that are shipped throughout the world. In addition to episodic disruptions, some of the most affected industries and regions may need to make long-term adjustments to remain viable, forcing some workers to relocate, train to adopt new industry practices, or shift to new types of work. For instance, higher

temperatures and more frequent severe droughts likely will make it difficult for existing levels and methods of agricultural operations in the Central Valley to remain **operationally or economically viable** in the coming years. A significant decrease in agricultural production could have considerable employment impacts in that region, such as fewer jobs overall and unpredictable changes to the nature of remaining jobs.

Loss of Biodiversity and Natural Resources

Increasing Temperatures and Severe Weather Events Threaten State's Fish and Wildlife, Ecosystems, and Native Plants.

A 2018 **state report** estimated that under current GHG emissions levels, between 45 percent to 56 percent of the natural vegetation in California will be climatically stressed by 2100. Some of these impacts already are evident. For example, an estimated **172 million trees** have died in

Figure 6

Students Have Experienced Increased School Closures Due to Wildfires

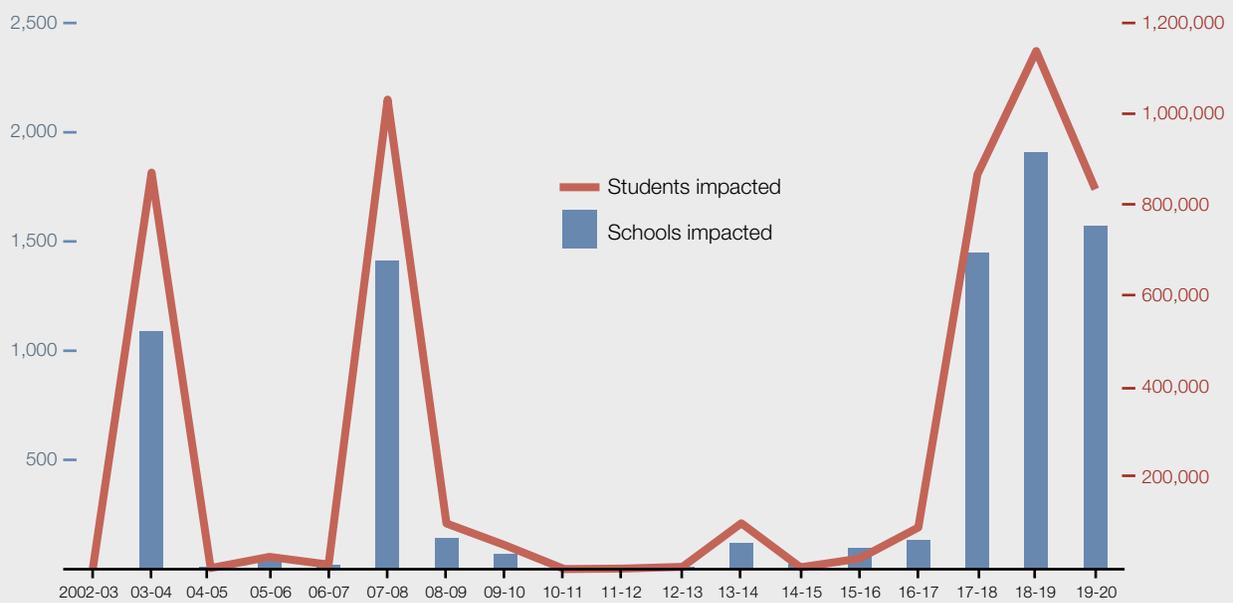


Figure adapted from data compiled by CalMatters in August 2020 (<https://calmatters.org/education/2020/08/wildfires-school-plans-students/>).

California's forests since 2010 due to multiple years of low moisture and drought conditions, high temperatures, and resulting bark beetle infestations. These dead trees provided fuel for and likely exacerbated the severe wildfires that have occurred over the past decade, which subsequently negatively impacted those forest habitats and the wildlife they contained.

Warmer temperatures and less water runoff during dry years also impair conditions for fish, aquatic wildlife, and migratory birds that depend on the state's rivers, streams, and wetlands. For example, lower and warmer water levels in the Sacramento River in the summers of 2014 and 2015 resulted in the death of 95 percent of the river's juvenile winter-run Chinook salmon in those years—practically eliminating two out of three existing cohorts of this endangered species. Similarly poor conditions replicated catastrophic outcomes for this species in the summer of 2021, when [state officials estimated](#) just 2 percent of migrating juveniles survived. Significant declines—or potential permanent extinctions—of the state's native fish species represent not just a loss of public trust natural resources, but also impair the state's fishing industry and economy, as well as dispossess some of California's Native American communities of essential elements of their tribal culture.

Sea-Level Rise Also Poses Threat to Ecological Resources. Inundation of coastal beaches, dunes, and wetlands threatens to impair or eliminate important habitats for fish, plants, marine mammals, and migratory birds. Higher sea levels also will cause salt water to encroach into—thereby degrading—coastal estuaries where fish and wildlife currently depend upon freshwater conditions. A 2018 [report](#) by the State Coastal Conservancy and The Nature Conservancy found that 55 percent of California's existing coastal habitats are highly vulnerable to five feet of sea-level rise, including 60 percent of

the state's iconic beaches and 58 percent of its marshes. Humans also are dependent on these coastal environments, both for the natural processes that they provide (such as providing protection from flooding and filtering stormwater runoff to improve water quality), as well as their recreational benefits. Millions of California residents visit the coast annually to fish, swim, surf, and enjoy nature, particularly along the one-third of the coastline owned by the State Parks system. A recent scientific [study](#) by United States Geological Survey researchers predicted that under scenarios of three feet to six feet of sea-level rise, up to two-thirds of Southern California beaches may become completely eroded by 2100. Such a loss would impact not only Californians' access to and enjoyment of key public resources, but also beach-dependent local economies.

Increased State, Local, and Private Costs

Adapting to the Impacts of Climate Change Will Be Costly. While California will not be able to avoid all of the effects of climate change, opportunities to reduce the magnitude of potential impacts do exist. Yet taking steps to prepare for, respond to, and recover from climate change impacts will be costly. Although the federal government may provide some funding for these activities, many of the costs will be borne by the state, local governments, and private businesses and residents. Some of these costs will be one time or limited term in nature—such as to develop plans or modify infrastructure—and some will be recurring and ongoing—such as increased operation of air conditioning units or clearing out regrowth of forest underbrush.

The State Will Incur Some Costs... Some of the costs of preparing for climate change impacts will fall on the state. For example, the costs associated with adapting the state transportation system to withstand the impacts of

climate change—including using new materials, responding to more frequent maintenance needs from more extreme conditions, and modifying or relocating certain infrastructure—likely will be higher than current expenditure levels. Additionally, as wildfires and other extreme climate events become more frequent, the state likely will need to fund an expanded workforce and more worker overtime to respond to these emergencies. The state likely also will incur costs from the need to expand its workforce in other areas to respond to climate change impacts—such as by hiring additional engineers and scientists to assess vulnerabilities, plan for adaptation strategies, and design and implement the state's responses to climate risks.

...As Will Local Governments... Like the state, local governments also will face costs associated with modifying and protecting their infrastructure and operations. For example, adaptation costs for schools might include higher utility bills from increased reliance on air conditioning during extremely hot days, making necessary facility modifications, and purchasing additional computers and technology upgrades to potentially allow for temporary shifts to remote learning when wildfires make air

quality unsafe to attend school. Costs for cities and counties might include adding drainage to roads to manage more intense rain events, or modifying water treatment plants located along the coast to accommodate higher sea levels.

...And Private Residents and Businesses.

Residents and businesses also will incur costs related to climate adaptation. For instance, as extreme weather events become more common, employers will have to implement adaptation measures to ensure worker safety and minimize the loss in labor productivity. These might include purchasing additional air filters and masks to protect workers from smoke, incurring higher utility costs from an increased need for air conditioning, changing traditional hours of operation, providing additional training to help prevent and identify heat-related illnesses, or modifying facilities to accommodate periodic flooding (such as by moving sensitive equipment to higher floors). Similarly, costs associated with modifying and maintaining existing homes—such as replacing roofs or siding to be more fire resistant, adding air conditioning and filtration for heat and smoke, or elevating to reduce flood risk—will fall largely on homeowners.

Significant Existing State-Level Efforts to Address Climate Impacts

Given that California is even now beginning to experience the effects of climate change, certain climate adaptation efforts are already underway at the local, regional, and state levels. Below, we highlight some of the most significant crosscutting state-level efforts and funding.

Significant Funding in 2021-22 Budget Package. As summarized in **Figure 7** on the next page, the 2021-22 budget package included \$9.3 billion over three years—primarily from

the General Fund—for a variety of activities to respond to climate impacts. This included funding targeted for activities responding to each of the five climate hazards California is experiencing. While some of this funding will be used for state-level activities, the majority will be allocated as grants to local governments and partners. Particularly within the climate resilience funding package, some of the funding categories are targeted specifically to assist vulnerable communities.

Figure 7

Climate Adaptation Funding Packages Included in 2021-22 Budget

(In Millions)

Package	Climate Hazard Focus	2021-22	2022-23	2023-24	Totals
Drought and Water Resilience	Droughts, floods	\$3,269	\$880	\$500	\$4,649
Wildfire and Forest Resilience	Wildfires	988	—	—	988
Climate Resilience	Sea-level rise, extreme heat, droughts	369	2,090	1,230	3,689
Totals		\$4,625	\$2,970	\$1,730	\$9,325

California Climate Adaptation Strategy.

In November 2021, the California Natural Resources Agency released a draft strategic plan establishing priorities and goals for building statewide resilience to the impacts of climate change. The document contains outcome-based priorities—many drawn from the hazard-specific plans listed below—and identifies success metrics and time lines for specific actions. The administration intends that it serve as a framework to guide climate adaptation activities across sectors and regions in California.

Local Planning Requirements and Resources.

The state has taken several steps to ensure that local governments plan for the impacts of climate change, including:

- Chapter 608 of 2015 (SB 379, Jackson) required that climate change adaptation and resilience be addressed in the safety elements of all general plans, and Chapters 202 (SB 99, Nielsen) and 681 (AB 747, Levine) of 2019 required that safety elements identify evacuation routes.
- Chapters 626 (SB 901, Dodd) and 641 (AB 2911, Friedman) of 2018 required that the state update its *Fire Hazard Planning Technical Advisory* in order to better assist local governments in developing effective policies, codes, standards, and programs aimed at mitigating fire hazards.

- Since 2013-14, the state has provided \$31 million in grants through the California Coastal Commission for local entities to update their local coastal plans. Additionally, Chapter 236 of 2021 (SB 1, Atkins) expanded existing coastal planning activities by local governments and the commission to include preparation for sea-level rise, and also established the California Sea Level Rise State and Regional Support Collaborative to provide information and support to local entities.
- The *California Adaptation Planning Guide*, updated by the Governor's Office of Emergency Services in 2020, is designed to help local entities integrate best practices and current science into their adaptation planning efforts.

Integrated Climate Adaptation and Resiliency Program (ICARP).

Established by Chapter 606 of 2015 (SB 246, Wieckowski), ICARP is housed at the Governor's Office of Planning and Research (OPR) and helps to coordinate the statewide response to climate change impacts. Major activities include developing and maintaining the **Adaptation Clearinghouse**, a searchable database of resources; regularly convening a **Technical Advisory Council** to improve interagency coordination and develop tools and guidance; and administering a new climate resilience planning and implementation grant program (initiated through the 2021-22 budget).

California Climate Change Assessments.

Beginning in 2006, the state has published a series of reports that summarize current climate science relevant to California, including strategies to adapt to climate change impacts. The fourth set of reports was published in 2018, and the 2021-22 budget package provided \$22 million for the next update. Chapter 136 of 2020 (SB 1320, Stern) requires the state to conduct an updated assessment every five years.

State Department Vulnerability Assessments and Plans. A 2015 executive order required that state agencies consider climate change in all of their planning activities, and in 2018, OPR published a guidebook to help in those efforts—*Planning and Investing for a Resilient California*. Various response efforts are underway across state government, with some agencies having made more progress than others. For example, in 2019, The California Department of Transportation (Caltrans) assessed the state highway system for climate change impacts, identifying segments of the system vulnerable to impacts such as precipitation, temperature, wildfire, storm surge, and sea-level rise. Using the findings from the vulnerability assessments, Caltrans evaluated the at-risk segments of the state highway system and studied the potential adaptation solutions. In contrast,

several agencies with substantial infrastructure under their control—including the University of California and the judicial branch—have not yet completed systemwide assessments of their vulnerability to climate change.

State-Level Hazard-Specific Planning Documents. The state has developed various planning documents in response to specific climate hazards facing the state, including:

- **Extreme Heat:** *Extreme Heat Action Plan* (Draft 2022).
- **Drought:** *Water Resilience Portfolio* (2020); *Report to the Legislature on the 2012-2016 Drought* (2021).
- **Flood:** *Central Valley Flood Protection Plan* (2017; update planned for 2022); *Delta Adapts Vulnerability Assessment* (2021).
- **Wildfire:** *California’s Wildfire and Forest Resilience Action Plan* (2021).
- **Sea-Level Rise:** *State of California Sea-Level Rise Guidance* (2018); *Critical Infrastructure at Risk; Sea Level Rise Planning Guidance for California’s Coastal Zone* (2021); *State Agency Sea-Level Rise Action Plan for California* (2022).

Issues for Legislative Consideration

Given the magnitude of climate change impacts that California already is beginning to experience, the Legislature will confront intensifying questions about how the state should respond. While the companion reports in this series highlight issues specific to different sectors, certain major themes are applicable across all policy areas. We summarize some of the key crosscutting questions the Legislature will face in the coming months and years in **Figure 8** on the next page and discuss them in more detail below.

How Can the State Avoid Exacerbating Climate Impacts?

Using a Climate Lens Can Help Avoid Increasing Future Risks. The significant potential for damage and danger that already exists from climate change reinforces the importance of ensuring that future policy decisions do not increase such risks. To avoid unintended consequences, the Legislature will want to use a climate lens in considering new policies and

projects that may have non-climate related objectives as their primary goals. Such an approach involves an explicit consideration of how climate change might impact the proposed activity, and avoiding adopting policies or undertaking projects that might inadvertently make it more difficult to effectively adapt to those impacts. For example, if the state were to explore using new road construction materials that rely on recycled materials to meet one set of sustainability objectives, it would want to ensure that such materials do not also significantly amplify heat and thereby worsen the local impacts of increasing temperatures.

Climate Change Should Inform the Location and Design of Housing and Infrastructure. Steps the Legislature could take include a new look at what role state policies should play in influencing *where* and *how* new homes and infrastructure are built to try to minimize their exposure to climate impacts. For example, the Legislature could consider requiring local governments to more fully incorporate climate change in the housing elements of their general plans, or adopting changes to statewide building codes to encourage new homes to be built with climate resilience in mind. As it considers these questions, the Legislature will face difficult choices about how to balance the trade-offs of potentially limiting construction of new homes in risky areas against other competing priorities, such as ensuring adequate housing is built across the state, housing affordability concerns, and preserving local control.

Figure 8

Crosscutting Climate Change Impacts: Key Issues for Legislative Consideration

- ✓ How can the state avoid exacerbating climate impacts?
- ✓ What is the appropriate role of the state in preparing for climate impacts?
- ✓ How can the state help protect the most vulnerable Californians?
- ✓ How should the state fund its climate change preparation and response efforts?
- ✓ How should the state prioritize among potential climate adaptation efforts?
- ✓ How do the costs and merits of taking action compare with the consequences of inaction?

Similarly, the Legislature will want to consider ways to ensure that future state transportation projects are resilient, long lasting, and a worthwhile investment of state funds. This will be particularly challenging given that the time frame for planning and implementing transportation infrastructure is quite lengthy and therefore not well suited to respond to unpredictable and evolving conditions.

What Is the Appropriate Role of the State in Preparing for Climate Impacts?

Important to Focus on Most Effective State-Level Actions. The magnitude and extent of climate change impacts across California make it unreasonable to expect that state government will be able to address them all by itself. Rather, effectively reducing and responding to the anticipated adverse effects will require a wide range of actions to be taken by both private and public actors across the state, including households, businesses, and local governments, as well as coordination with the federal government. Within this broader context of private and public adaptation actions, a key question for the Legislature will be what role *state* programs and policies can and should play in adapting to climate change, including

how they interact with local adaptation activities. Some key categories of state-level activities the Legislature could consider include:

- **Adopting Guidance and Standards.** Setting expectations at the state level will ensure important adaptation actions are implemented uniformly across California. This could include changes to state workplace safety standards, updated building code standards, regulations establishing a maximum heat threshold for rental properties (and associated cooling requirements), or clear guidelines on what temperature levels should shift school activities indoors.
- **Assessing and Addressing Data Gaps.** Additional information could help inform and guide adaptation actions at the state and local levels. The state can help identify what potentially helpful information currently is lacking, particularly in cases where state-level data collection and dissemination could help avoid inconsistencies or duplication of efforts across the state. Steps could include improving the state's ongoing monitoring of how climate change *currently* impacts health outcomes, researching the degree to which climate change is projected to impact *future* health outcomes, and assessing how changing conditions are affecting workplace safety.
- **Providing Support and Coordination.** The state is uniquely positioned to help facilitate and synchronize climate response efforts at the local level and across state government. Steps could include providing technical assistance and expertise, disseminating best practices, taking advantage of economies of scale to maintain and deploy key resources when needed, and requiring interagency consultation for the development and implementation of state programs.

- **Providing Targeted Fiscal Support.** State funding likely will be a critical component of climate preparation and response activities across the state, including for testing new strategies, providing “seed money” to spur investments from other sources, addressing the state's responsibilities (such as for state-owned infrastructure), and filling in gaps to ensure important statewide priorities are achieved.

How Can the State Help Protect the Most Vulnerable Californians?

State Programs Can Explicitly Focus on Supporting Vulnerable Populations.

As discussed above, certain populations—such as low-income households, medically sensitive populations, and workers in outdoor industries—generally are more vulnerable to the effects of climate change. The Legislature will want to consider how it can target state programs in ways that support these groups. Such a focus could help address some of the most significant adverse effects of climate change, as well as reduce the inequitable distribution of impacts. For example, to mitigate impacts on public health, the state could take steps such as establishing programs that provide free or low-cost air filters or masks to low-income populations, ensuring warnings about extreme heat and air quality are translated and targeted to reach medically and/or socially vulnerable populations, or strengthening Medi-Cal managed care plans' role in helping their members prepare for and navigate services during and after emergencies.

Legislature Could Target Policies and Assistance for Particularly Vulnerable Regions, Neighborhoods, and Workers.

Additionally, since past government actions—such as redlining—have exacerbated the disproportionate climate risks that some communities face, the Legislature may want to consider whether the state should take actions

such as targeting financial assistance to certain neighborhoods. The Legislature could also explore opportunities to incentivize landlords to modify their rental properties to mitigate the effects of heat and smoke on their tenants.

The Legislature also will want to consider which workers, industries, and regions will be disproportionately affected by climate change and how the state might want to help address those challenges. For example, given lower-wage workers are over-represented in outdoor-based industries, the state may want to focus its efforts on addressing the anticipated impacts on those groups. The state likely will need additional data to provide a clearer sense of whether existing state programs, such as unemployment insurance and workforce development programs, are equipped to address the needs of workers impacted by climate change.

How Should the State Fund Its Climate Change Preparation and Response Efforts?

Legislature Has Range of Funding Sources It Could Consider. As noted earlier, taking steps to prepare for, respond to, and recover from climate change impacts will generate costs for all levels of government, as well as private businesses and residents. The recent federal Infrastructure Investment and Jobs Act will provide some funding to California to assist with our adaptation efforts, but additional state funding likely also will be needed. Determining how to fund the state's share of climate adaptation activities will be a key decision point for the Legislature over the coming years. One important consideration in identifying the most appropriate fund source for specific activities will be whether they are one time or ongoing in nature. Some funding options the Legislature could consider include:

- **General Fund.** As shown in Figure 7 on page 14, the 2021-22 budget package took advantage of the historic state budget surplus to dedicate over \$9 billion—primarily from the General Fund—over three years for various climate response and adaptation activities. As the state's largest and most flexible fund, the General Fund likely will continue to be a key source to which the Legislature will turn for climate adaptation efforts. However, the General Fund also supports many other competing and ever-emerging priorities, and available funding could be constrained when the state next encounters tight fiscal times—which some economists believe could come in the next few years. As with all its decisions, the Legislature will have to balance climate response alongside its multiple other policy and budgetary priorities. In some instances, the Legislature could seek to meet existing General Fund requirements while also achieving some climate adaptation goals, such as by directing Proposition 98 funding for activities that increase schools' preparedness.
- **Proposition 2 Infrastructure Funds.** In addition to general purpose General Fund monies, the Legislature could potentially use future required Proposition 2 infrastructure funding for climate adaptation efforts. Under Proposition 2 (a constitutional amendment passed by voters in 2014), the state must spend a certain amount on infrastructure in years when the state's rainy day fund contains at least 10 percent of General Fund revenues. Because the reserve is estimated to reach that threshold in 2022-23, the state likely will need to meet these infrastructure spending requirements in upcoming budgets.
- **Special Funds.** The Legislature also could consider reprioritizing other funding sources—such as the Greenhouse Gas Reduction

Fund (GGRF) or state transportation funds—explicitly for climate adaptation activities and projects. Some of these existing revenue sources may become less reliable in future years, however. For example, the state’s cap-and-trade program—which generates GGRF revenue—is only authorized until 2030. Additionally, as vehicles become more efficient, gas tax revenues—which currently represent the primary source of state funds for transportation projects—may not provide as much funding for future efforts. As such, the Legislature may want to consider pursuing new sources of revenue to support expanded climate adaptation efforts in the coming years. For example, this could include road charges where drivers pay for road maintenance based on the miles they drive.

- **General Obligation Bonds.** Historically, the state has depended upon general obligation bonds to fund many infrastructure and natural resources projects. Requesting voter approval of new bonds remains an option for future efforts, although bonds create long-term obligations for the state to pay off both principal and additional interest costs. Moreover, bond funding often is somewhat restrictive in its uses—typically focused on capital outlay projects. While many climate adaptation efforts will consist of constructing capital projects, some initiatives—such as conducting research, operating cooling centers, or providing technical assistance—would not be as appropriate for bond funds.

State Appropriations Limit (SAL)

Consideration. The state budgeting process also is complicated by requirements related to the constitutional SAL, which can constrain how much General Fund the Legislature can allocate for certain types of activities. (We discuss the limit and its effect on the state budget in our post [The 2022-23 Budget: Initial Comments](#)

[on the State Appropriations Limit Proposal](#).)

However, because many climate adaptation efforts are capital outlay projects—which are exempt from the SAL—the Legislature might have more capacity for such activities, particularly in years where the limit is a consideration.

How Should the State Prioritize Among Potential Climate Adaptation Efforts?

Given Limited Funding, Legislature Will Want to Select Activities That Most Effectively Meet Its Goals. In addition to balancing how much funding to dedicate for climate adaptation *against* its many other statewide budgetary priorities, the Legislature also faces the challenge of prioritizing spending *among* various activities to prepare for and respond to climate impacts. Given that the costs for potential climate adaptation activities likely will far outstrip available state funding (even with potential new revenues), once it identifies fund sources, the Legislature will need to decide how to spend those dollars to maximize their effectiveness. Prioritization factors could include the immediacy of an expected climate impact, degree of state ownership and responsibility, number of Californians affected, potential fiscal and economic implications, threat to public safety, or the ability—or inability—of certain communities to adapt without state assistance. The Legislature could also consider prioritizing efforts in which providing seed money could help spur local adaptation efforts, such as for regional planning or community-based adaptation initiatives that are harder to implement without financial incentives. To better inform its prioritization decisions, the Legislature may need to seek additional research and information that explicitly assesses the relative cost-effectiveness of various climate adaptation strategies.

How Do the Costs and Merits of Taking Action Compare With the Consequences of Inaction?

Pre-Disaster Mitigation Is Often Less Costly Than Recovering. Climate adaptation projects can be expensive and difficult. In many cases, however, efforts that help to avoid future damages and costs could bring significant longer-term economic benefits for residents, regions, and the state compared to if they were not undertaken. For example, a national study found that \$1 of federal spending on pre-disaster mitigation projects for infrastructure yielded savings of \$6 in disaster recovery costs.

Important to Weigh Up-Front Costs of Adaptation Efforts Against Potential Long-Term Savings. Weighing the merits of undertaking certain climate adaptation activities against associated costs could be a difficult calculation for the Legislature in many cases, given that near-term costs could be significant and the expected benefits can be uncertain and may not materialize for many years. Despite these complications, however, conducting longer-term cost-benefit analyses is essential, given the magnitude of the potential out-year costs associated with climate impacts. Moreover, in assessing the merits of climate adaptation proposals, the Legislature will want to ensure it also considers the costs of *inaction* to climate change by comparing up-front costs against the potential savings that adaptation projects could achieve over time. For instance, such an analysis could compare the potential cumulative costs of repeatedly rebuilding an erosion-prone stretch of highway to those associated with relocating it to a more stable location. Similarly, over time, the costs of implementing new workplace safety standards for employers could be significantly less costly than potential losses in labor productivity and worker health benefits if current practices continue under increasingly hazardous conditions.

Consider Potential Co-Benefits of Climate Adaptation Activities. An additional consideration for the Legislature to factor into its decisions is whether some activities might yield co-benefits beyond just addressing certain climate impacts. For example, developing strategies and infrastructure to capture and store stormwater runoff could not only help with urban flood control, but also could increase local water supplies and build drought resilience. Similarly, planting trees and adding green spaces in certain urban settings could both reduce heat amplification as well as bring lifestyle and recreational benefits for local residents. Thinning forests can both help reduce the severity of wildfires and potentially have water supply benefits if the projects help shade and maintain snowpack on the ground rather than allowing it to evaporate from tree tops. As the Legislature considers the trade-offs associated with pursuing certain climate adaptation activities, it will want to be sure not to overlook potential secondary advantages.

Some Important Benefits May Be Hard to Quantify. In some cases, the benefits of mitigating climate impacts could be hard to quantify in a traditional cost-benefit analysis. These include the value to Californians associated with avoiding the extinction of native species, minimizing learning loss for students from school disruptions, protecting people from heat-related illnesses or deaths, or preserving public access to beaches that face the risk of erosion from sea-level rise. Despite inherent complications in assessing the indefinite costs associated with some potential climate impacts, such considerations will be important for the Legislature to take into account as it determines its priorities.

Conclusion

Addressing the widespread impacts of climate change represents a significant challenge for the state, and one that will increasingly occupy the Legislature's agenda and require substantial fiscal commitments in the coming years. Effectively responding will necessitate that actions be taken across state government. Therefore, limiting discussion, emphasis, and activities to just the departments and legislative committees that focus on environmental issues will not be sufficient to address the extensive impacts occurring across different policy areas. As discussed in this report, some issues cut across various sectors,

including the need for: coordination across and within different levels of government, additional information to help guide actions, prioritization of efforts, state-level technical and financial assistance, and a focus on the most vulnerable Californians. However, certain impacts will vary by sector and require more targeted actions. A critical step for the Legislature to help inform and focus its responses is to understand how a changing climate already is impacting and will continue to affect different sectors such as those discussed in this series of reports.

LAO Publications

This report was prepared by Rachel Ehlers and reviewed by Anthony Simbol. The Legislative Analyst's Office (LAO) is a nonpartisan office that provides fiscal and policy information and advice to the Legislature.

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