DRAFT REPORT

Safeguarding California Plan: 2017 Update

California's Climate Adaptation Strategy

CALIFORNIA natural resources AGENCY

May 2017

Participating Agencies and Departments

Although the **California Natural Resources Agency** serves as the coordinating body for *Safeguarding California,* this draft reflects the hard work of many individuals and groups. The following agencies and departments served as leads for each chapter of *Safeguarding California: 2017 Update:*

Coordination
California Natural Resources Agency

Agriculture
California Department of Food and Agriculture

Biodiversity
California Department of Fish and Wildlife

Emergency Management
Governor's Office of Emergency Services

Energy
California Energy Commission
California Public Utilities Commission

Forests
California Department of Forestry and Fire Protection

Land Use and Community Development
California Department of Housing and Community Development
Governor's Office of Planning and Research
California Strategic Growth Council

Ocean and Coast
Ocean Protection Council
California State Lands Commission
California State Coastal Conservancy
California Department of Fish and Wildlife
Bay Conservation and Development Commission
California Department of Parks and Recreation
California Coastal Commission
Delta Stewardship Council
State Water Resources Control Board
California Strategic Growth Council

Public Health
California Department of Public Health, Office of Health Equity

Transportation
California State Transportation Agency
California Department of Transportation
California High Speed Rail Authority

Water
Department of Water Resources
State Water Resources Control Board

"It’s time for **courage**, it's time for **creativity** and it's time for **boldness** to tackle climate change . . . The risk is real, the cost is huge and growing, and therefore taking a sequence of **realistic steps** just makes sense, and that's what we're going to do in **California**.”

– California Governor Edmund G. Brown Jr.

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Executive Summary

In 2017, one of the most severe droughts in California's recorded history was interrupted by one of the wettest seasons ever experienced. This dramatic swing highlights what research suggests will become a more common trend and underscores the need to bolster California's infrastructure and public services to withstand the effects of climate change. Extremes have always marked California's climate. Research tells us that climate change will exacerbate those natural swings. Already, we are experiencing rising average temperatures, shrinking mountain snowpack, warmer storms, and higher sea levels. If we do not adapt, climate change will threaten the state's public health and economic prosperity.

Government needs both a sound fiscal foundation and an aggressive commitment to action based on best available science to take on the permanence and magnitude of these changes. Governor Edmund G. Brown, Jr. and the California State Legislature have responded resolutely, balancing the budget from the worst economic recession of our time; enacting historic funding programs to buttress and modernize state water, transportation, and energy infrastructure; and funding a world-leading scientific understanding of how climate change will impact the state.

The Governor and the Legislature have also made climate change adaptation central to government planning, investment, and public outreach. Statutes and executive orders have launched multiple State-led efforts to foster change throughout state and local government. By mid-2018, these efforts will be supported by the most comprehensive and localized scientific understanding of climate change to date through the completion of the Fourth Climate Change Assessment and the over 50 different peer-reviewed studies it will contain.

This document, *Safeguarding California Plan: 2017 Update,* is a programmatic survey across state government of what California is doing to respond to climate change, what needs to be done, and how we will achieve those goals. The hundreds of actions and recommendations listed here were developed through the scientific and policy expertise of staff from 27 state agencies. The plan opens with overarching strategies recommended by the California Natural Resources Agency, the State's lead agency on climate change adaptation. The document then outlines ongoing actions and cost-effective and achievable next steps to make California more resilient to climate change across ten different policy areas. This roadmap also provides a transparent and accountable tool for the public to evaluate the State's progress.

The *2017 Update* should move California toward a state of preparedness in which:

- People and communities respond to changing conditions, shocks, and stresses in a manner that minimizes risks to public health and safety while maximizing equity and protection of the most vulnerable so that they can thrive despite climate change;
- Built infrastructure systems continue to provide critical services;
- Natural systems adjust and function in the midst of climate change; and
- Government managers at all levels take climate change adaptation into account in all aspects of their work.

Introduction

Globally, California leads in efforts to avoid the worst effects of climate change by reducing greenhouse gas emissions. The State has committed to fight climate change at the subnational level as a founder of the Under2 Coalition – a global pact among cities, states and countries to limit the increase in global average temperatures to below 2 degrees Celsius, the level of potentially catastrophic consequences. Under the leadership of Governor Brown, California established the most ambitious greenhouse gas emission reduction targets in North America and the nation's toughest restrictions on destructive super pollutants. These actions build on landmark legislation the Governor signed in October 2015 to generate half of the state's electricity from renewable sources by 2030 and double the rate of energy efficiency savings in California buildings. Governor Brown also has committed to reducing today's petroleum use in cars and trucks by up to 50 percent within the next 15 years; making heating and transportation fuels cleaner; and managing farm and rangelands, forests and wetlands to maximize carbon storage.

Still, the impacts of climate change are already being felt in California and are disproportionately impacting the state's most vulnerable populations. The accelerating rate of climate change in this century will likely exceed that experienced by California's native peoples over past millennia. Already these changes have rendered unreliable our 117 years of weather-related record-keeping as a state.

The California Natural Resources Agency has led the state's climate change adaptation strategy since 2008. The Agency's *2009 California Adaptation Strategy* was the first comprehensive document that clearly explained the state's vulnerabilities to climate change as well as hundreds of actions that state government should take to reduce those risks.

After five years of progress, the Natural Resources Agency released an update to the state's climate adaptation strategy with the 2014 document *Safeguarding California: Reducing Climate Risk*, also known as the *Safeguarding California Plan*. The 2014 plan provided more complex information and an updated high-level vision for how state government could aid adaptation across nine sectors. In 2016, the State released "Implementation Action Plans" that further detailed ongoing actions and next steps to carry out the 2014 *Safeguarding California Plan*.

This 2017 update to the *Safeguarding California Plan* is the latest step in the iterative process of adapting to climate change. Directed by Assembly Bill 1482 (Gordon, Statutes of 2015-16) to update the state's adaptation strategy every three years, the Natural Resources Agency has worked with dozens of state agencies to assemble a roadmap for adaptation action. This draft plan describes what the State has done and will do in the coming years to protect California from the impacts of climate change.

Eight Years of Safeguarding California

This public comment draft represents the continued evolution of California's comprehensive strategy for state government to address the impacts of climate change. Each plan has had different objectives and focuses, as seen below.

2009 California Adaptation Strategy

- Overview of climate science and statewide hazard-based climate assessment
- Four comprehensive statewide adaptation strategies
- Vulnerability assessments and adaptation strategies for seven sectors

2014 Safeguarding California: Reducing Climate Risk plan

- Update information on climate science
- New information on vulnerabilities and activities for nine sectors
- Update general policy recommendations

2016 Safeguarding California Implementation Action Plans

- High-level vulnerability assessments and overview of recommendations from 2014 plan
- Explanation of ongoing actions and next steps implementing 2014 recommendations
- Addition of "Land Use and Community Development" sector

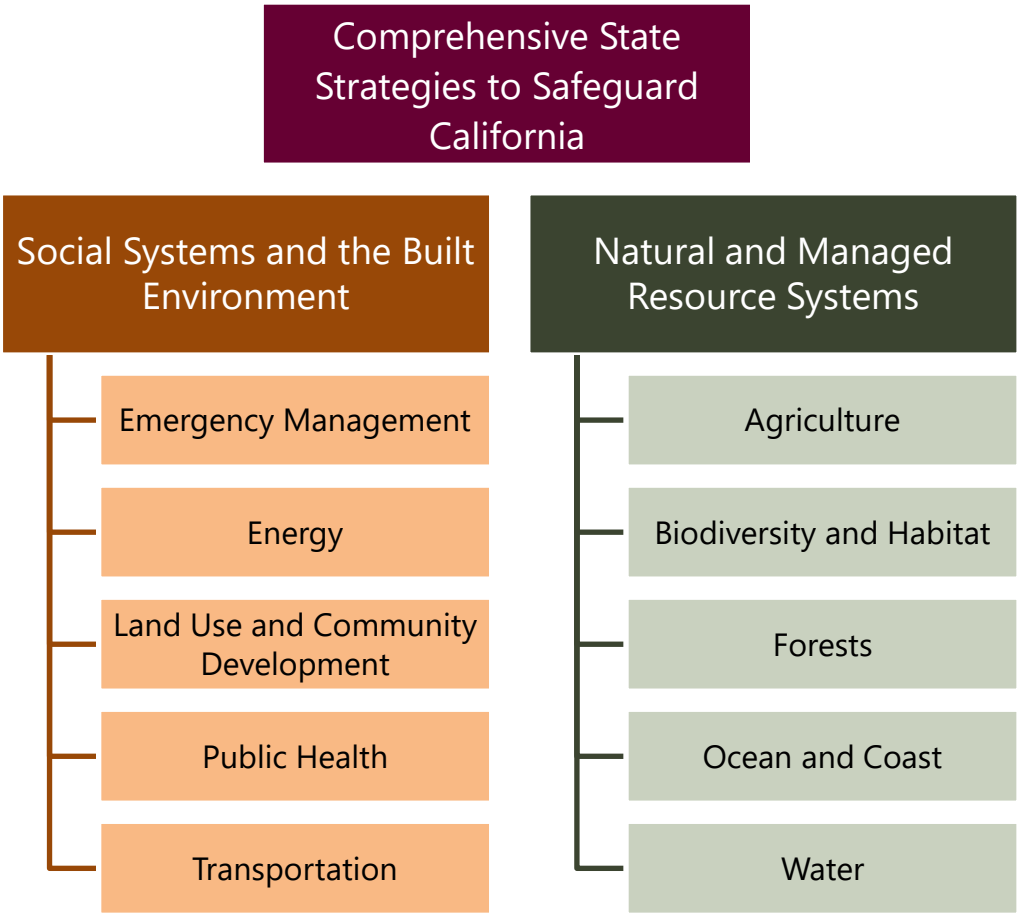
Safeguarding California Plan: 2017 Update

- Update of comprehensive statewide adaptation strategies and relevant implementation actions
- New framework to better integrate sectors and link ongoing research to state adaptation action
- Update high-level recommendations for all 10 sectors
- Outline annual reporting structure for next steps and adaptation actions
- Increase focus on vulnerable populations, environmental justice concerns, and equity
- Propose conceptual metrics to track and measure climate impacts and the adaptation responses of state government over time

Vision and Organization

The first chapter of this plan outlines ***Comprehensive State Strategies to Safeguard California***. These strategies span all levels of government and state agencies.

After, the plan is divided into two broad policy umbrellas: Social Systems and the Built Environment and Natural and Managed Resource Systems. Within each of these categories, there are five policy areas, for a total of 10 different sectors, as pictured below:



Each of the 10 Sector Plans follows a similar format. First, they present ***High-level Recommendations***, which are broad categories of goals to guide action within each sector. The ***Next Steps*** that follow each high-level recommendation lay out objectives and strategies needed to achieve the recommendation. Finally, each sector plan ends with ***Ongoing Actions***, a summary of climate adaptation projects and programs already being implemented.

California Uses Climate Science for Action

California is a global leader in using, investing in, and advancing scientific research to make proactive climate change policy. Its efforts to understand and communicate how climate change will affect our expansive and diverse state provide the foundation for state and local actions that make our communities safer from climate threats. The State is investing in the next generation of cutting-edge research that will inform the policies and actions in this report; as our climate continues to change, California will keep investing and utilizing the best available science to safeguard its people, environment, and economy.

In over a decade of state-sponsored climate research, California has developed critical methods to understand how climate change will impact different places in different ways, and to deliver that information to planners and decision makers. Residents living in Modoc County face very different challenges from climate change than those living in San Diego, so state government is providing resources, conducting research, and designing programs for climate conditions appropriate for individual communities through its Fourth Climate Change Assessment.

Recognizing the complexity and diversity of climate change impacts around the state, this *Safeguarding California Plan: 2017 Update* does not attempt to generalize this information. If you are interested in learning about the ways that California is already experiencing climate change, the "Indicators of Climate Change" report in California report from the Office of Health Hazard Assessment presents 36 trends impacting the state's climate, environment, and communities. To understand future impacts, the Cal-Adapt.org web portal is at the forefront of resources for specific communities to understand how climate change will raise temperatures and exacerbate extreme heat events, drought, snowpack loss, wildfire, and coastal flooding.

California is constantly improving and expanding the body of science that informs policy and action, so it also provides important guidance to local governments, state agencies, and communities on how to best take action on evolving and increasingly sophisticated projections. Operationalizing climate considerations in state government and planning for climate risks in local planning efforts is required by law, so now state and local government can implement adaptation with more clarity and consistency.

When California's Fourth Climate Change Assessment is published in the third quarter of 2018, it will take the state's cutting-edge accomplishments in climate research to a new level. Its peer-reviewed components will directly inform the hundreds of actions found in this document, as well as summarize new findings and key climate change information for regions around California.

Key Next Steps to Advance Climate Science:

- Continue to evaluate and update the Climate Change Research Plan, engaging a wide range of state agencies to scope research that will directly inform adaptation policy advances.
- Institutionalize and prepare for regular California Climate Change Assessments every four to five years.
- Secure dedicated funding and support for Cal-Adapt.org to keep it updated, comprehensive, and useful for decision-makers and planners.
- Ensure the use of common climate change projections for state and local government planning.

Comprehensive State Strategies to Safeguard California

How We Got Here

The comprehensive state adaptation strategies California state government has developed over time reflect the many holistic statewide initiatives promoting climate adaptation.
In the *2009 California Adaptation Strategy*, the Natural Resources Agency presented four Comprehensive State Adaptation Strategies to address across sectors:

1. Promote comprehensive state agency adaptation planning.
2. Integrate land use planning and climate adaptation planning.
3. Improve emergency preparedness and response capacity for climate change impacts.
4. Expand California's climate change research and science programs and expand public outreach of research to policy-makers and general public.

The *2014 Safeguarding California: Reducing Climate Risk* plan based its seven "Cross-sector Strategies" on the 2009 framework:

1. All core functions of government must make the risks Californians face from a changing climate an integral part of their activities.
2. Provide risk reduction measures for California's most vulnerable populations.
3. Identify significant and sustainable funding sources for investments that reduce climate risks, human loss, and disaster spending.
4. Support continued climate research and data tools to inform policy and risk reduction activities.
5. Maximize returns on investments by prioritizing projects that produce multiple benefits and promote sustainable stewardship of California's resources.
6. Prioritize climate risk communication, education, and outreach efforts to build understanding among all Californians.
7. Promote collaborative and iterative processes for crafting and refining climate risk management strategies.

These cross-sector strategies ultimately led to Governor Brown's April 2015 Executive Order B-30-15, which emphasized four related principles for the State's adaptation approach:

1. Priority should be given to actions that both build climate preparedness and reduce greenhouse gas emissions.
2. Where possible, flexible and adaptive approaches should be taken to prepare for uncertain climate impacts.
3. Actions should protect the state's most vulnerable populations.
4. Natural infrastructure solutions should be prioritized.

In light of the 2009 and 2014 strategies and the related principles in Executive Order B-30-15, this chapter will focus on six updated Comprehensive State Adaptation Strategies:

CA-1. Consider climate change in all core functions of government.

CA-2. Partner with California's most vulnerable populations to increase equity and resilience through investments, planning, research, and education.

CA-3. Support continued climate research and data tools.

CA-4. Identify significant and sustainable funding sources for investments that reduce climate risks, harm to people, and disaster spending.

CA-5. Prioritize natural infrastructure solutions, actions that both build climate preparedness and reduce greenhouse gas emissions, and projects that produce multiple benefits.

CA-6. Promote collaborative adaptation processes with local and regional government partners.

Recommendation CA-1: Consider climate change in all core functions of government.

Incorporating climate impacts into all core functions of government ensures we protect people, infrastructure, the economy, and nature from climate impacts and disrupting events. Preparation saves lives and money.

The 2009 and 2014 adaptation strategies recommended that all new development "consider project alternatives that avoid significant new development in areas that cannot be adequately protected (planning, permitting, development, and building) from flooding, wildfire and erosion due to climate change." The following executive and legislatively directed actions have been taken to ensure these recommendations are implemented.

Achievements, ongoing efforts, opportunities:

Executive Order B-30-15: Requiring State Agencies to Incorporate Climate Change Impacts into Planning and Infrastructure

Executive Order (EO) B-30-15, signed by Governor Brown in April 2015, identifies several steps for building a resilient California:

1. Preparation of Implementation Action Plans to identify the steps that will be taken to realize the goals in *Safeguarding California*.
2. Direction to all State agencies to consider climate change in all planning and investment, including infrastructure investment.
3. Using full life-cycle cost accounting tools to evaluate infrastructure investments.
4. Actions to protect the state's most vulnerable populations.
5. Direction to the Governor's Office of Planning and Research to establish a technical advisory group to provide state agencies with guidance on how to integrate climate change in planning and investment.

Technical Advisory Group and Guidance Document

The Technical Advisory Group was created to provide guidelines for state agencies to incorporate climate risks into policies, planning and investments. These guidelines outline planning and investment principles to promote integrated climate action, foster equity and community resilience in coordination with state, local, and regional agencies, and prioritize actions that utilize natural and green infrastructure solutions and enhance and protect natural resources. The group that created the guidelines was comprised of representatives from a majority of state agencies, departments, offices and commissions of the executive branch, in addition to members of the public, and representatives from local and regional governments, non-governmental organizations, and the private sector. The Technical Advisory Group worked to create the framework of the guidance document, while smaller groups were tasked with creating more focused guidance on life cycle cost accounting; local, regional and state collaboration; built and natural infrastructure; climate scenarios; equity and vulnerable communities; and metrics. The Technical Advisory Group Guidance Document provides guidance for achieving resiliency across all agencies while allowing each agency the flexibility to identify which processes and functions should be subject to this guidance and how the guidance should be best incorporated in ongoing decision making.

Climate Adaptation Legislation Signed into Law in 2015-16

- Assembly Bill 2800 (Quirk, Chapter 580, Statutes of 2015-16) requires the creation of a climate-safe infrastructure working group to examine how to integrate scientific data concerning projected climate change impacts into state infrastructure engineering, including oversight, investment, design, and construction.
- Assembly Bill 1482 (Gordon, Chapter 603, Statutes 2015-16) requires updating the state's adaptation strategy, *Safeguarding California*, every three years. It requires state agencies to maximize specified objectives, including, promoting the use of climate adaptation strategy to inform planning decisions and ensure that state investments consider climate change impacts, as well as promote the use of natural infrastructure, as defined, when developing physical infrastructure to address adaptation.
- Senate Bill 246 (Wieckowski, Chapter 606, Statutes 2015-16) creates the Integrated Climate Adaptation and Resilience Program led by OPR to provide a venue for State, local, and regional coordination on climate adaptation. This includes work on guidance, financing, and other implementation activities.
- Senate Bill 379 (Jackson, Chapter 608, Statutes of2015-16 requires cities and counties to include climate adaptation and resiliency strategies in the safety elements of their general plans.
- Senate Bill 1000 (Leyva, Chapter 587, Statutes of 2015-16) requires cities and counties to include an environmental justice element in their general plan that identifies disadvantaged communities within the areas covered by the general plan as well as policies and objectives to reduce health risks in those communities.

Recommendation CA-2: Partner with California's most vulnerable populations to increase equity and resilience through investments, planning, research, and education.

Climate change threatens the health and well-being of California's diverse population of nearly 40 million people. The communities most vulnerable to the impacts of climate change also experience systemic differences in health status that are preventable and unfair. These vulnerable communities include but are not limited to: women, racial or ethnic groups, low-income individuals and families, individuals who are incarcerated and those who have been incarcerated, individuals with disabilities, individuals with mental health conditions, children, youth and young adults, seniors, immigrants and refugees, individuals who are limited-English proficient (LEP), and lesbian, gay, bisexual, transgender, queer, and questioning communities, or combinations of these populations.

In many cases, vulnerability to climate change is the result of the inequitable distribution of power and resources, and resultant socio-economic and living conditions. Because of existing inequities, institutionalized racism or exclusion, people in these groups are often poor, and poverty equates to a lack of resources and economic and political power. Vulnerable populations also often experience higher rates of health issues and living conditions that may be affected by climate change, such as asthma or cardiovascular disease, poor housing quality, or residency in areas at high risk of harm from sea level rise, extreme heat, drought, wildfire, or poor air quality associated with climate change. Vulnerable populations often have less capacity to manage extreme weather events and adapt to a changing climate.

Reducing disparities in employment, income, wealth, housing conditions, and health, in addition to prioritizing resources and investment to vulnerable communities, will help reduce these communities' vulnerability to the impacts of climate change.

Decisions, plans and investments by agencies can help residents least able to cope with damage to their homes, communities, and physical and mental health. Prioritizing services, resources, training and jobs can improve living standards, build avenues for meaningful participation in decision-making and improve resiliency. Robust engagement of vulnerable communities pulls different perspectives into government decision-making, which leads to more responsive decisions, increased acceptance of decisions and support for implementation. It is essential to give people a voice and power over actions that affect their lives.

California Building Resilience Against Climate Effects (CalBRACE)
CalBRACE is a program funded by the U.S. Center for Disease Control and Prevention at the California Department of Public Health. It provides tools to help local health departments in California participate in planning for the impacts of climate change. CalBRACE seeks to improve living conditions in communities facing health inequities to reduce underlying vulnerability to climate change. The Project developed Climate Change and Health Profile Reports for all 58 California counties, forecasting climate impacts (i.e., extreme heat, sea level rise, wildfires, drought, and air quality) and health risks. It also developed vulnerability assessment reports for 11 counties, which identifies locations and communities vulnerable to climate impacts, to assist in prioritizing effective strategies for local and state climate resilience.

Senate Bill 1000 and Senate Bill 379 – General Plans: Safety and Environmental Justice
In September 2016, General Plan Guidelines were updated to provide guidance on how to incorporate environmental justice in local general plans. This includes incorporating either a standalone Environmental Justice Element or through the adoption of goals, policies and objectives in other elements of general plans. Senate Bill 1000 (Leyva), in coordination with Senate Bill 379 (Jackson), will help ensure that local governments build resilience in communities most vulnerable to health and economic impacts of climate change.

Senate Bill 350 – Low-Income Barriers Study
This study, mandated by Senate Bill 350 (De León), provides recommendations intended to improve access to clean energy investments for low-income customers and local small businesses in disadvantaged communities. The California Energy Commission adopted the final report from the study on December 14, 2016.

Recommendation CA-3: Support continued climate research and data tools.

Preparing for future climate change impacts requires solid, accessible, and user-friendly scientific findings. Decision makers, planners, and the public must be able to visualize and understand how the changing environment will impact communities. Greenhouse gas emissions will continue to determine the pace and scale of climate impacts, and direct observation of climate impacts will help refine and improve our modeled projections of climate risks. State strategies for reducing climate risk must adapt as new information emerges. Therefore, long-term planning processes need to adopt iterative approaches to incorporate the best available science. State programs should regularly incorporate new climate information and update management practices and goals accordingly.

California Fourth Climate Change Assessment

Research is underway through California's Fourth Climate Change Assessment to help us better understand and predict climate impacts. State agencies are coordinating and managing 52 separate research projects covering subjects from sea-level rise to carbon storage on natural and working lands as both a mitigation and adaptation strategy. The cutting edge research should be finalized in late 2018. In addition, foundational research has begun to improve the method for downscaling global climate scenarios in anticipation of a fifth climate change assessment for California.

Cal-Adapt 2.0

Cal-Adapt is an online, interactive, visualization tool created by state agencies that enables researchers, decision makers, and the general public to explore how climate change will impact specific regions in California. Cal-Adapt is specifically directed toward supporting local decision-makers and planners in identifying, understanding, and adapting to climate risks. Cal-Adapt was created as a result of a recommendation in the 2009 *California Adaptation Strategy*; the tool has since been updated with new sea-level rise, snowpack, streamflow, wildfire risk, and downscaled climate data and will continue to evolve with new scientific information.

Climate Change Research Plan for California

California's Climate Action Team – top state agency leaders who coordinate the state's mitigation and adaptation efforts – in 2015 approved a *Climate Change Research Plan for California*, the first such research plan developed by any state. The Research Plan identifies research gaps that should be tackled over the next three to five years and articulates near-term climate change research needs to ensure that the state stays on track to meet its climate goals. The Fourth Climate Change Assessment implements a substantial portion of the Climate Change Research Plan.

Recommendation CA-4: Identify significant and sustainable funding sources for investments that reduce climate risks, harm to people, and disaster spending.

Making adequate investments to prepare for near and longer-term climate risks now can help protect California's people, economy and natural resources over time. Although needed investments are substantial, spending now will defray later expenses. Existing infrastructure investments should be leveraged to maximize matching funds and climate benefits. Innovative risk sharing and financing mechanisms will also need to be considered and utilized. Investments must account for time frames needed to realize benefits, changing climate risks over time, and the anticipated functional life of any capital investments.

Central Valley Flood Protection Plan

In 2016, the California Department of Water Resources updated its Central Valley Flood Protection Plan (CVFPP), recommending $17 billion to $21 billion in actions and investments to improve flood protection and a conservation strategy to improve river and floodplain habitat. The CVFPP will integrate climate change projections into the prioritization of State, local, and federal flood protection investments, balancing traditional flood protection programs with multi-benefit projects that take advantage of flood project design and location to improve ecosystem function for endangered species and waterfowl.

Transportation Infrastructure and Maintenance Funding

In 2017, the Legislature approved and the Governor signed Senate Bill 1 (Beall), the Road Repair and Accountability Act of 2017 that invests $52.3 billion over the next decade for transportation infrastructure, maintenance, and public transit. Included in this package are dramatic increases in annual funding climate and environmental related programs – including $25 million per year for local growth planning, $20 million for regional transportation climate adaptation plans, and $35 million for advanced environmental mitigation -- as well as other policy changes that will drive community engagement towards system-wide air quality and environmentally focused transportation investments

Local Adaptation Funding Opportunities

In June 2016, voters in the nine counties ringing San Francisco Bay adopted Measure AA to provide $300 million in local bonds to protect natural open space lands, build wetlands and other natural infrastructure, and provide increased public access to parks and open space. In November 2016, Los Angeles County voters approved Measure A, which will generate nearly $100 million per year in parcel tax revenue for urban greening and open space conservation. Local funding sources like these could be leveraged with State and other funds to maximize adaptation efforts.

Recommendation CA-5: Prioritize natural infrastructure solutions, actions that both build climate preparedness and reduce greenhouse gas emissions, and projects that produce multiple benefits.

Wherever possible, California's efforts to adapt to climate change should bring multiple benefits. For example, a project to improve flood management might involve setting levees back from a river to boost its flood-flow capacity, but also serve to recharge groundwater and foster riverside habitat. Actions that reduce climate risks across multiple sectors and actions that address multiple climate risks should be prioritized. Restoration and conservation of natural systems such as forests, grasslands and shrublands, agricultural lands, and wetlands lend themselves to multiple benefits.

California WaterFix and EcoRestore
WaterFix is the State's plan to upgrade outdated water diversion infrastructure in the Sacramento-San Joaquin Delta to safeguard California's water supplies and restore more natural flow conditions in the Delta. California EcoRestore is a California Natural Resources Agency initiative implemented in coordination with State and federal agencies to advance the restoration of at least 30,000 acres of habitat in the Sacramento-San Joaquin Delta habitat by 2020. The types of habitat targeted include tidal wetlands, floodplain, upland, and riparian, and projects include fish passage improvements.

Watershed Improvement Program
The Sierra Nevada Conservancy and the U.S. Forest Service have partnered with other federal, state and local agencies and diverse stakeholders on the Watershed Improvement Program, which aims to quicken the pace and scale of science-based ecological restoration in the Sierra Nevada in order to help prevent large, uncharacteristic wildfires and further degradation of these ecosystems.

Community and Watershed Resilience Program
In January 2016, the U.S. Department of Housing and Urban Development awarded California over $70 million to develop the Community and Watershed Resilience Program. The program is designed to fulfill unmet recovery needs and build resilience in Tuolumne County, site of the 2013 Rim Fire. The program supports biomass removal, reforestation and restoration activities, including the creation of seven critical fire breaks and a biomass and wood products facility. The larger goal of the program is to link community resilience, economic development and watershed health.

Wetlands Restoration
In 2015, the California Department of Fish and Wildlife Wetlands Restoration for Greenhouse Gas Reduction Grant Program awarded $21 million in funding to restore or enhance approximately 2,500 acres of wetlands and mountain meadows for the purpose of greenhouse gas reduction. Wetlands restoration also enhances fish and wildlife habitat, protects and improves water quality and quantity and helps California adapt to climate change.

Forest Carbon Plan
Stressed by a five-year drought and bark beetle epidemic, an estimated 102 million trees are dead or dying in California forests, according to the U.S. Forest Service. Recent wildfires have been among the most destructive and expensive in state history. The California Forest Carbon Plan, now being finalized by state and federal forestry leaders in coordination with stakeholders, seeks to reverse these trends. The plan seeks to manage California's forests so that they serve as a long-term carbon sink, rather than a source of greenhouse gas and black carbon emissions.

Recommendation CA-6: Promote collaborative adaptation processes with local and regional government partners.

Successful climate adaptation requires close coordination among all levels of government and communities in order to leverage expertise, build capacity, raise awareness and maximize funding.

The Community and Watershed Resilience Program
As noted above, California was awarded $70.3 million in federal disaster resilience funding through the National Disaster Resilience Competition. The funds will support implementation of the Community and Watershed Resilience program, which is a partnership between Tuolumne County, the State, and US Forest Service. The program is designed to work across scales and jurisdictions and provide a replicable model for other rural mountain areas affected by fire.

Integrated Climate Adaptation and Resiliency Program
Senate Bill 246 (Wieckowski) created the Integrated Climate Adaptation and Resiliency Program to coordinate regional and local efforts with state climate adaptation strategies. The program is led by the Governor's Office of Planning and Research and consists of two key components:

- A Technical Advisory Council brings together local government, practitioners, scientists and community leaders to help coordinate activities that better prepare California for the impacts of a changing climate.
- The Adaptation Clearinghouse provides a centralized source of information and resources on climate adaptation, including the best available science and research, policy guidance and decision support tools and case studies, highlighting local implementation efforts across the state.

Ocean Protection Council Sea-Level Rise Guidance Document Update
As sea levels rise on California's coast, communities are already facing damage to development, ecosystems, water supplies, and infrastructure. The California Ocean Protection Council and the Natural Resources Agency, in collaboration with the Governor's Office of Planning and Research and the California Ocean Science Trust, are updating the State of California Sea-Level Rise Guidance Document. The document, initially adopted in 2010 and updated in 2013, provides guidance to state and local agencies for incorporating sea-level rise projections into planning, permitting, investment and other decisions. A robust public engagement process will inform the final guidance document update, planned for adoption by the California Ocean Protection Council in January 2018.

The Alliance of Regional Collaboratives for Climate Adaptation
The Alliance of Regional Collaboratives for Climate Adaptation was formed in early 2012 to address the emerging impacts of climate change, including extreme storm events, heat waves, droughts, and sea-level rise. The Alliance brings together regional collaboratives – from San Diego, Los Angeles, the San Francisco Bay Area, and Sacramento – that are coordinating and supporting local climate partners in projects to enhance public health, protect natural systems, build economies, and improve the quality of life in all communities. The Alliance enhances cooperation among regions and works with the State in its development of climate adaptation plans, policies and programs.

“State of the Science” Regional Assessments

The Fourth Climate Change Assessment will produce a localized look at climate impacts through a forthcoming “State of the Science” Regional Assessments that will make it easy for stakeholders to access the best available science by region. They will include information about warming, precipitation, wildfire, and area-specific sea-level rise and ocean acidification. The assessments will translate the science into clear and compelling stories of how climate change is altering our world. The regional assessments will include current adaptation projects and a “gaps analysis” to identify potential needs and opportunities for needed research.

Recommendation CA-7: Increase investment in climate change vulnerability assessments of critical built infrastructure systems.

Aging water, energy, transportation, and other built infrastructure systems must be retrofitted so that they can continue to provide critical services despite changing climate extremes. Vulnerability assessments are essential for understanding how essential infrastructure systems are exposed to, susceptible to, and able to withstand adverse climate impacts. They are the basis for developing risk mitigation strategies to protect critical infrastructure and making informed decisions about where to prioritize adaptation investments.

State agencies are supporting vulnerability assessments through existing funding for water, transportation, energy and other infrastructure systems. These assessments rely on regional priorities, thresholds of acceptable risk, and California's existing body of knowledge and data on climate change trends and projected impacts. There will be an ongoing need to develop and regularly update assessments for all critical infrastructure systems, and to study how disruptions in any one system affect interrelated systems.

Department of Water Resources Draft Climate Change Vulnerability Assessment
Numerous climate-driven hazards represent a threat to the Department of Water Resources (DWR) facilities, managed lands, operations, and staff activities. DWR is conducting a Climate Change Vulnerability Assessment as part of its Climate Action Plan to provide the first assessment of its kind for facilities owned and operated by the Department and the activities that DWR performs. Drawing from an extensive body of science and knowledge about climate change, the draft Climate Change Vulnerability Assessment describes, evaluates, and quantifies where possible DWR's vulnerabilities to expected increases in wildfire, extreme heat, and sea level rise, as well as to changes in hydrology and ecosystems. Once identified, these vulnerabilities will be prioritized and appropriate adaptation strategies will be developed to address them.

Vulnerability Assessment of the State Highway System
The California Department of Transportation (Caltrans) is using climate scenarios from California's Fourth Climate Change Assessment to inform a vulnerability assessment of the State Highway System. Climate stressors to the State Highway System include flooding, landslides, sea level rise, washouts, pavement deterioration, increased wildfires, and the buckling and rutting of roads due to extreme heat. The regional transportation assessments take into account the exposure of transportation assets to climate stressors as well as their criticality, or relative importance, based on use, stakeholder input, health and safety functions, and replacement costs. Caltrans recently completed a vulnerability assessment in District 1 (Humboldt, Mendocino, Del Norte, and Lake counties), and will assess eight out of the eleven remaining districts by 2017.

Energy Utilities
Four of the five large investor-owned facilities in California will be required to produce a vulnerability report and resilience plan as part of their participation in the U.S. Department of Energy's Partnership for Energy Sector Climate Resilience. The vulnerability assessments will help utilities determine which key assets and customers are vulnerable under which conditions. The reports will formalize internal risk assessment processes utilities have already been undertaking, and will allow energy agencies and utilities to understand where additional efforts are needed to better understand and address vulnerabilities. The California Public Utilities Commission encouraged California investor-owned facilities

to expand their vulnerability reports to include assessments of current and future generation and distribution assets, the entire supply chain for fuel and critical infrastructure, emergency management procedures, impacts to vulnerable communities, and institutional barriers to implementing resiliency plans.

California Fourth Climate Change Assessment Projects on Infrastructure Vulnerability

13 projects in the Fourth Climate Change Assessment will expand our understanding of vulnerabilities to critical water, power, and transportation infrastructure in California:

- Assessing Vulnerability and Improving Resilience of Critical Emergency Management Infrastructure in California in a Changing Climate
- Drought Planning and Climate Adaptation of Small Self-Sufficient Water Utilities
- Modeling the Impact of Wildfires on California's Transmission and Distribution Grid
- Distributed Evaluation & Assessment Program for California's Transportation Fuel Sector: Identifying Strategies for Reducing Vulnerability to Improve Resilience for Extreme Weather
- Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat
- The Adaption Blind Spot-Electrical Grid Teleconnected and Cascading Climate Change Impacts on Community Lifelines in Los Angeles
- Investigations on the Climate Vulnerability and Identification of Resilience Options for Regional Natural Gas and Electricity Systems
- Climate Scenario Development, Weather Forecasting, and Probabilistic Modeling for the Natural Gas and Electricity Sectors
- Visualizing Climate-Related Risks to the Electricity System Using Cal-Adapt
- Addressing Institutional Vulnerabilities to Climate Change: Drought as Stress Test for Water Allocation and Environmental Protection
- Advancing Hydro-Economic Optimization to Identify Vulnerabilities, Tradeoffs, and Adaptation Opportunities in California's Water System
- High Resolution Measurement of Levee Subsidence Related to Natural Gas Infrastructure in the Sacramento-San Joaquin Delta
- Investigations on the Impacts and Adaptation Options for Regional Electricity and Natural Gas Systems from Sea Level Rise

Social Systems and the Built Environment

Each community is unique and will experience climate change differently, depending upon its built and natural environments and social, economic and demographic factors. The terms “social systems” and “built environment” refer to the interrelationships among individuals, groups, and institutions, as well as the physical constructed environment around them.

Safeguarding the public requires a deep understanding of the way that climate change can impact people’s health and well-being, the critical infrastructure they rely on, their spatial environment, pre-existing inequities of power and resources that impact resilience, and the way these factors interact. Public health and resilience to disaster require reliable and durable roads, energy and water systems, health systems, housing, and other physical infrastructure crucial to maintain public safety under both acute and chronic effects caused by changing climatic conditions. In addition to stable physical infrastructure, public health and community climate resilience require strong social networks, viable safety nets and regulatory programs, and active engagement of communities in the decisions that affect their living conditions. Vibrant and prosperous communities must have the foresight to avoid emerging hazards while creating the social and physical foundations to rebound from systemic shocks, especially for those most vulnerable.

This chapter organizes dozens of recommendations and hundreds of ongoing actions that protect the public from the impacts of climate change around the following five policy areas:

- Emergency Management
- Energy
- Land Use and Community Development
- Public Health
- Transportation

The recommendations and ongoing actions of this chapter have essential linkages to the “Natural and Managed Resource Systems” chapter of this plan. Urban areas depend on ecosystem services from rural regions, and this connection is addressed throughout the document. Many issues straddle classifications of the built environment and natural and managed resources, such as drinking water and flood management infrastructure. This demonstrates the need for integrated and holistic approaches.

Emergency Management

According to the Intergovernmental Panel on Climate Change, the international body for assessing science related to climate change, climate change will continue to increase the frequency and severity of extreme weather events. The United Nation's Intergovernmental Panel on Climate Change defines Extreme weather as events, such as droughts or floods, that have historically occurred on average only once in 100 years and vary from "the norm" in severity or duration. The last few years in California have been marked by extreme weather and its effects. Drought gripped the state starting with a dry winter in 2011-12, including the driest four-year statewide precipitation on record (2012-2015) and the smallest and second smallest Sierra snowpack on record (2015 and 2014). The years 2014, 2015, and 2016 were warmest on average, statewide. In contrast, the water year that began October 1, 2016 in April became the wettest on record in the northern Sierra Nevada mountains. Wildfires continue to afflict California with increasing frequency, size, and devastation. Two of the three largest wildfires in California's history have occurred in the past four years, burning a total of 529,225 acres. In 2015 alone, two of the top ten most destructive wildfires in California's history occurred. Climate change is anticipated to increase and exacerbate these and other hazards, including extreme heat events, sea level rise, tsunamis, and flooding associated with atmospheric rivers, like those experienced in the 2017 winter storms, and resulted in federal disaster declarations. Climate change impacts all phases of emergency management; therefore it is critical to ensure community resilience against its effects.

The Governor's Office of Emergency Services (Cal OES) leads state disaster preparation, response, and recovery. Cal OES continues to incorporate climate change-associated risks into the State's Multi-Hazard Mitigation Plan and work with local stakeholders to increase awareness of future climate change impacts and incorporate associated countermeasures in their local plans, as directed by the Legislature with Senate Bill 379 (Jackson). Further, the Cal OES Office of Access and Function Needs works with public health partners to plan for climate change's impact on access and functional needs populations, such as people with physical, developmental, or intellectual disabilities; chronic conditions or injuries; limited English proficiency; or older adults, children, low-income residents and those who depend upon public transportation.

Disasters are inevitable, despite planning and mitigation. Therefore, Cal OES will work with local, state, federal, and private partners to incorporate climate change into longer-term resiliency strategies. Ultimately, Cal OES strives for an emergency management discipline-wide approach to adaptation, interlocking all efforts toward a more resilient and climate-ready California.

Preparing for the Worst as Extreme Weather Tests Dams

Most of California's major dams and reservoirs were built 50 to 100 years ago based on rain and snowfall records that are largely irrelevant, given climate change. California could not support its nearly $2 trillion economy without these dams blocking floods and storing water, as our precipitation is the most variable of any state. But climate change will test dams and their operators. As climate change drives up average temperatures in California, research shows that it is more likely that low-precipitation years will tip into drought and precipitation will fall as rain, not snow stored in the Sierra Nevada and Cascade mountains. This will change the timing of storm and snowmelt runoff. Most runoff now occurs in May and June. By the end of the century, most runoff will happen in January and February – which is also the time when dam operators will be managing storms.

The February 2017 failure of the gated flood control spillway at Oroville Dam, in the midst of the wettest year on record in the northern Sierra Nevada, illustrates the risk extreme conditions pose to California's aging water infrastructure. In response to the Oroville incident, Governor Brown announced a $437 million near-term investment in flood control and emergency response that includes proposed legislation to require the owners of all 1,250 dams regulated by the state to craft emergency action plans, including maps that show potential inundation areas in the event of dam failure. The Governor also proposes requiring the owners of all state-regulated dams to update these maps every 10 years to reflect changing conditions.

Recommendation EM-1: Employ research and deploy tools and data that demonstrate how climate change will affect all phases of emergency management and exacerbate the impacts of emergencies and disasters.

Research, data and modeling improve the ability of CalOES and partner agencies to manage risk and support sustainable insurance and disaster programs.

Next Steps

- **EM-1.1.** Review recent disasters and the extent to which they were exacerbated by climate change to better define appropriate countermeasures.
- **EM-1.2.** Review and incorporate necessary updates to the California Adaptation Planning Guide, as directed by Senate Bill 246 (Wieckowski). This may include development of an interactive web application to support the state's Adaptation Planning Guides.
- **EM-1.3.** Revise state guidance for Local Hazard Mitigation Plans to reflect climate adaptation requirements.
- **EM-1.4.** Pursue and support research to evaluate essential services and facilities, and their vulnerabilities to climate change impacts.
- **EM-1.5.** Leverage both pre- and post-disaster assistance programs to support resilient planning, mitigation, and reconstruction that take into account future climate conditions, including:
  - **EM-1.4a.** Hazard Mitigation Grant Program
  - **EM-1.4b.** California Disaster Assistance Act
- **EM-1.6.** Support risk-sharing mechanisms and advocate for climate-resilient development in areas vulnerable to hazards intensified by climate change (e.g. fire, drought, and flooding).

Ongoing Actions

- Continue to align Pre-Disaster Management and Flood Mitigation Assistance funding opportunities for projects that maximize whole community climate readiness and resilience.
- Continue to provide guidance to local communities on incorporating climate change risks and adaptation components into Local Hazard Mitigation Plans pursuant to legislation (Senate Bills 379 and 1000).

Recommendation EM-2: Enhance preparedness and coordination through ad hoc or recurring advisory bodies, to address climate change impacts and inform emergency management policy.

A fundamental component of emergency management is effective interagency coordination across sectors and disciplines before, during, and after disasters. Preparedness and coordination mitigate damage from disasters and emergencies, including those events exacerbated by climate change.

Next Steps

EM-2.1. Coordinate across agencies and levels of the emergency management sector to document mitigation efforts that achieve community and climate resilience.

EM-2.2. Develop novel mechanisms and pathways to increase climate awareness and investments in resilience in all areas of the emergency management sector.

EM-2.3. Train and credential emergency management personnel within Cal OES, state government, and across emergency management in California to ensure consistent and robust support to local emergency response efforts, bolster mutual aid, and provide for maximum surge capacity.

Ongoing Actions

- Cal OES' Climate Change Working Group maximizes interagency coordination and information across programs to ensure projects and planning take into account impacts of climate change.
- Convene and participate in advisory bodies to maximize external coordination; address emergency management and impacts of climate change; and ensure that planning, response strategies, and rebuilding efforts incorporate these considerations.
    - California Tree Mortality Task Force
    - Fire Service Task Force on Climate Impacts
    - California Climate Action Team
    - California Water Plan
    - State Hazard Mitigation Plan
- Improve integration of climate impacts and adaptation strategies into all phases of emergency management.
- Expand training opportunities to include courses that increase awareness, understanding, and competency about climate adaptation.

Recommendation EM-3: Incorporate climate considerations into emergency planning efforts at all levels.

Effective interaction between local, state, federal, tribal, and private partners will help ensure that consequences of extreme weather events are considered in whole community planning and mitigation.

Next Steps

EM-3.1 Consistent with other hazards such as earthquakes, integrate current and future climate projections into scenarios that inform emergency planning and investments including:

- **EM-3.1a.** Wildfire
- **EM-3.1b.** Inland flooding, including impacts on levee and dam failure
- **EM-3.1c.** Coastal flooding, including tsunami risk and impacts from more extreme storms
- **EM-3.1d.** Drought
- **EM-3.1e.** Secondary impacts to lifeline systems such as energy, transportation, and telecommunications during a climate change exacerbated disaster

EM-3.2 Examine feasibility of integrating climate projections and sea-level rise (SLR) scenarios into Cal OES' MyHazards and MyPlan tools.

Ongoing Actions

- The State Hazard Mitigation Plan addresses climate-related hazards and mitigation efforts.
- Many ongoing research projects under California's Fourth Climate Change Assessment will directly inform state agency actions in emergency management.
- Cal OES will continue to incorporate best available science on climate risks in all phases of emergency management through existing protocols, systems, and reports including: the Threat Hazard Identification Risk Analysis, the State Preparedness Report, and agreements with private partners such as the California Utilities Emergency Association.

Recommendation EM-4: Identify access and functional needs communities exposed to greater risks from climate impacts and work collaboratively to build community resilience.

Extreme weather emergencies have disproportionate effects on individuals with disabilities and persons with access and functional needs. Access and functional needs considerations before, during, and after extreme weather emergencies include: reliance on electricity to power durable medical equipment and assistive devices; accessible transportation to and from cooling centers and shelters; limited resources to obtain air conditioning, health coverage, and building/home modifications; and accessible and multi-lingual preparedness materials. The Cal OES Office of Access and Functional Needs will collaborate with partners at all levels to integrate access and functional needs considerations into planning and mitigation.

Next Steps

EM-4.1. Assess opportunities for inclusion of the Equity Checklist in the guidance "Planning and Investing for a Resilient California" in order to ensure compliance with Executive Order B-30-15.

EM-4.2. Explore integration and utilization of all state resources and planning capabilities to address, accommodate, and meet the environmental justice impacts of climate change.

EM-4.3. Ensure that the climate change-related impacts, which exacerbate risks to access and functional needs populations, are incorporated within all threat and hazard analysis conducted by the State.

Ongoing Actions

- Cal OES' Office of Access and Functional Needs (OAFN) will continue its collaborative approach and outreach efforts in increasing whole community preparedness, enhancing response, and encouraging local government agencies to partner together before disasters.
- OAFN will utilize existing climate change projections and datasets to determine the impacts on access and functional needs communities.
- OAFN will explore integration of access and functional needs demographic information within Cal-Adapt and other state agency resources and planning tools.

Energy

California's technology and environmental policies help power one of the world's largest economies. Supplying reliable and sustainable energy to this economic engine requires planning and policies underpinned by a commitment to utilization of the best available science.

California's energy infrastructure is designed to cope with the state's highly variable conditions and frequent disruptions from wildfires, storms and floods. But changing climate is expected to bring more frequent and intense natural disasters. Key climate parameters are starting to move outside of historically observed variability at a rate that makes historical data a poor predictor of future climate. For example, the warmest years on record in California occurred in 2014, 2015, and 2016. This year – 2016-17 – broke the record as the wettest ever recorded in the northern Sierra Nevada mountains.

Changes in temperatures, precipitation patterns, extreme events and sea-level rise have the potential to decrease the efficiency of thermal power plants and substations, decrease the capacity of transmission lines, render hydropower less reliable, spur an increase in electricity demand, and put energy infrastructure at risk of flooding.

The California Energy Commission (CEC) and the California Public Utilities Commission (CPUC) are not waiting to address the ripple effects of climate disruption on the energy sector. In line with Governor Brown's directive to develop and utilize the best available science for planning and investment, the CEC and CPUC have prioritized actionable research. The energy sector also is working with vulnerable communities to better understand how to partner and invest for more resilient outcomes.

The State's bold targets for renewable energy, renewable distributed generation, energy efficiency, and building retrofits all bolster and incorporate climate adaptation. These goals provide more sources of supply and reduce demand, improving system reliability.

The State's high-level recommendations and next steps presented here represent new cutting-edge commitments for integrated energy policy.

Reaching All Californians with Energy Programs

Most low-income Californians rent. They are 39 percent more likely to live in apartment buildings than the general population. For the managers of clean-energy programs, that is a vexing problem, because renters face little incentive to repair broken doors, roofs, or furnaces to block drafts and make a home more efficient, let alone install solar panels.

The Energy Commission recently assessed the many barriers to making sure all Californians have access to energy efficiency and weatherization services, as well as renewable energy generation and clean transportation options. The Commission held seven public workshops from East Los Angeles to Truckee. In a December 2016 "Low-Income Barriers Study," the Commission concluded that while some barriers are tied to poverty and difficult to eradicate, much can be done to better ensure public investments in clean energy reach all communities.

Among the Commission's many recommendations: Align and streamline eligibility requirements. Try pilot programs that address entire neighborhood, rather than individual buildings. Address asbestos, lead and mold removal, as well as structural maintenance, in conjunction with energy retrofit programs. Encourage investor-owned utilities to consider developing community solar installations in disadvantaged communities. Establish a green workforce fund to allow state-run clean energy and transportation programs so that workers in low-income communities can be hired and trained. And consider legislation that requires utilities to reach the same penetration in disadvantaged communities as elsewhere with programs such as those that install solar panels on the roofs of apartment buildings.

Recommendation E-1: Continue to support climate research for the energy sector to better inform climate adaptation and mitigation strategies.

Multiple lines of evidence clearly demonstrate that the energy system is more vulnerable to climate impacts than previously believed. For example, increased temperatures will decrease the efficiency of thermal power plants, transformers, and transmission and distribution lines and increase electricity demand. Since all of these detrimental effects are amplified and happen simultaneously during heat waves, the cumulative impacts on the energy system would be more significant without adaptation measures. Additional research is needed to better understand how efforts to reduce emissions and safeguard the energy sector align. The 2015 *Climate Change Research Plan for California* describes high-level research needs. An analysis of how the state is implementing the plan will be conducted in 2017.

Next Steps

- **E-1.1.** Develop research strategies to downscale statewide data to community impacts to prepare for California's Fifth Climate Change Assessment.
- **E-1.2.** Finalize the implementation report on accomplishments related to the *Climate Change Research Plan for California*.
- **E-1.3.** Continue the translation of key findings from the *Climate Change Research Plan* into action and results.
- **E-1.4.** Further advance research on adaptation and mitigation for the energy sector, ensuring that analyses are coordinated with interdependent sectors.
  - **E1.4a.** Analyze climate vulnerability of the petroleum sector.
  - **E1.4b.** Continue supporting adaptation research for the natural gas sector.
  - **E1.4c.** Support research on the water-energy nexus.

Ongoing Actions

- The CEC is leading energy sector adaptation research for California's Fourth Climate Change Assessment.
- The CEC sponsors online climate change data on the DataBasin platform to support the Desert Renewable Energy and Conservation Plan process, a multi-agency effort to protect desert ecosystems while identifying areas for renewable energy development.
- The CEC supports adaptation research for the natural gas sector via the Natural Gas Research and Development program.

Recommendation E-2: Use common climate scenarios in all energy research and planning, and work to help standardize climate scenarios across state government planning and investment.

The Energy Commission has been a key player in creating standardized climate scenarios for state government planning and investment. It participated in the Executive Order B-30-15 Technical Advisory Group that developed guidance for State agencies on how to determine which climate scenarios to plan for in the future, and how to approach planning and investment in an uncertain and changing future. It is expected that the guidance will point to the same scenarios as the CEC's 2016 Integrated Energy Policy Report and the Climate Action Team Research Working Group. The Technical Advisory Group guidance will identify CEC's Cal-Adapt website, which synthesizes California climate change scenarios and climate impact research, as a resource for exploring climate scenarios compatible with its recommendations. The Ocean Protection Council will issue updated guidance on sea-level rise in early 2018.

Next Steps

E-2.1. Ensure that state guidance to implement Executive Order B-30-15 is consistent with and supported by the best available science.

- **E-2.1a.** Work with the Government Operations Agency to incorporate reporting on the vulnerability of state facilities to climate impacts into sustainability roadmaps for state infrastructure.

E-2.2. Share and discuss the scenarios developed for California's Fourth Climate Change Assessment with other state agencies.

- **E-2.2a.** Assess the feasibility of making the climate scenarios used for the Fourth Climate Change Assessment more broadly accessible to the public.

Ongoing Actions

- By assisting with the development of the Ocean Protection Council sea-level rise guidance document, the CEC is able to more tightly link emerging science on sea-level projections to ongoing climate scenario development and coordination.
- CEC has worked with the Department of Water Resources' Climate Change Technical Advisory Group to integrate its work with both CEC's ongoing energy research and planning and the Fourth Climate Change Assessment.
- The California Water Commission used the CEC and Department of Water Resources' work on best available climate science to create guidance for analysis of projects applying for funding from Proposition 1, the 2014 $7.5 billion water bond.
- The CEC gave Caltrans the climate scenarios being used for the California's Fourth Climate Change Assessment to inform ongoing vulnerability assessments of the state highway system.

Recommendation E-3: Continue incorporating implications of climate change into all energy sector planning and decision-making.

The CEC and the CPUC are committed to accelerating efforts to incorporate climate science and adaptation into landscape level and infrastructure planning activities. Building off the climate adaptation strategy developed for the Desert Renewable Energy Conservation Plan, the CEC accelerated the incorporation of climate change scenarios and improved planning tools according to the four guiding principles of Executive Order B-30-15: Prioritize win-win solutions for emissions reduction and preparedness, promote flexible and adaptive approaches, protect the state's most vulnerable populations, and prioritize natural infrastructure solutions. Recent adaptation legislation (Assembly Bills 1482 and 2800, Senate Bills 246 and 379) creates legal mandates to continue the work identified in the Executive Order. AB 2800 also requires the Natural Resources Agency to set up a process with scientists and engineers to identify how engineering codes and standards should be reviewed and updated so that infrastructure is designed to withstand climate change impacts. A report to the Legislature is due by the summer of 2018.

Next Steps

E-3.1. Further investigate adaptation strategies through the CEC's 2017 Integrated Energy Policy Report.

- **E-3.1a.** The Energy Commission will continue to explore, in collaboration with CPUC and other energy entities, best practices for incorporating climate change and adaptation into the investor-owned utilities' and publicly owned utilities' planning processes.
- **E-3.1b.** The CEC will collaborate with the CPUC and other energy entities to incorporate the climate scenarios into energy planning. For example, the 2017 Integrated Energy Policy Report will identify climate parameters such as temperature extremes at specific locations and timeframes that can be drawn from the climate scenarios for energy planning purposes.

E-3.2. Support the implementation of Assembly Bill 2800 to promote climate-safe infrastructure, ensuring that its findings are also useful for the design of all energy-related infrastructure

E-3.3. Apply energy-related findings from the Fourth Climate Change Assessment to CEC and CPUC policy.

E-3.4. Complete and implement the 2017 Energy Adaptation Working Group action plan.

Ongoing Actions

- The Energy Adaptation Working Group was established to implement the March 2015 energy sector implementation action plan. Its successes include bolstering the U.S. Department of Energy's Partnership for Energy Sector Climate Resilience.
- The implementation of the Renewable Portfolio Standard, which requires electricity retailers to purchase at least 33 percent of their power from renewable sources by the end of 2020, is informed by the consideration of ongoing and inevitable climate impacts.
- The Energy Commission is making sure that Senate Bill 350 (De León) implementation takes climate change into account.
- The Department of General Services is directing the diversification of electricity supply to state-owned facilities.

Recommendation E-4: Support local adaptation planning efforts and increase outreach about available analytical tools.

The state operates several programs to promote clean energy generation and energy efficiency. In January 2016, the CPUC issued a guidance document to investor-owned utilities calling for robust vulnerability assessments and resilience plans as part of their obligations under the U.S. Department of Energy's Climate Resilience Partnership Memorandum of Understanding.

Next Steps

E-4.1. Work with privately and publicly owned utilities on resilience planning in concert with the U.S. Department of Energy under its Partnership for Energy Sector Climate Resilience initiative.

E-4.2. Work with California utilities to implement an initiative similar to the federal Partnership for Energy Sector Climate Resilience.

E-4.3. Encourage cooperation and collaboration between all utilities and the statewide network of local government commission led regional climate adaptation collaboratives that focus on specific regional needs.

Ongoing Actions

- Continue to inform regional climate adaptation collaboratives and local entities about the resources and analytical tools available for adaptation work in the energy sector (e.g., Cal-Adapt and the web application Climate Console). Seek input from such groups about their information and decision support needs.
- The CEC continues to support local implementation of energy resilience measures through ongoing efforts, including:
    - customer-side renewable distributed generation.
    - microgrid incentives and support.
    - the Self-Generation Incentive Program.
    - energy efficiency programs.
    - water efficiency programs.
    - demand response strategies.
    - energy storage programs.

Recommendation E-5: Investigate means to provide long-term support for Cal-Adapt advancement, maintenance, and expansion.

Cal-Adapt is an interactive web data portal initially developed under the CEC's Public Interest Energy Research program to make California climate science available and accessible to the public, utilities, and decision makers. Senate Bill 379 (Jackson) requires local hazard mitigation plans developed by cities and counties to address climate adaptation and resilience. The legislation explicitly names Cal-Adapt as a source of information to help cities and counties assess local vulnerabilities to climate change. To date, Cal-Adapt has been sporadically funded through research grants for system upgrades and incorporation of new data. Now that the website is operational, the state needs to commit continuous funding to keep it operating in support of local climate adaptation/hazard mitigation planning. Funding also is needed to incorporate data from other sectors, an effort which cannot be funded from public goods charges in the electricity or natural gas programs.

Next Steps

E-5.1. Provide peer-reviewed data from the Fourth Climate Change Assessment to the public through Cal-Adapt 2.0.

E-5.2. Seek ways to integrate all data and resources from the Natural Resources Agency portfolio of Fourth Climate Change Assessment projects into Cal-Adapt.

E-5.3. Support the development of tools based on the Cal-Adapt Application Program Interface to improve and enhance the capabilities and uses of Cal-Adapt while expanding its user base.

E-5.3a. Work with the Government Operations Agency and the California Department of Technology to help develop a tool that will provide relevant climate data for all state-owned facilities to inform management and sustainability.

Ongoing Actions

- The UC Berkeley Geospatial Innovation Facility has been enhancing Cal-Adapt and beta-testing the Cal-Adapt 2.0 site at beta.cal-adapt.org.

Recommendation E-6: Increase climate resiliency in low-income and disadvantaged communities.

Senate Bill 350 (De León) requires the Energy Commission to study barriers to and opportunities for low-income and disadvantaged communities to increase access to energy efficiency and renewable energy investments and programs. The Low-Income Barriers Study finalized in December 2016, recommends that the CEC's Electric Program Investment Charge Program should target 25 percent of technology demonstration and deployment funding for sites located in disadvantaged communities."

Next Steps

- **E-6.1.** Address equity issues identified in the Low-Income Barriers Study and link efforts related to its implementation to climate resilience.
- **E-6.2.** Address programmatic, funding, and financing barriers for energy/water efficiency retrofits for low-income households and small businesses.
- **E-6.3.** Investigate and address environmental justice issues around supporting community solar projects for low-income customers.
- **E-6.4.** Work to coordinate energy-related programs that target low-income communities with broader climate adaptation efforts.
  - **E-6.4a.** Assess opportunities with the Department of Community Services and Development to coordinate on low-income weatherization and solar programs.

Ongoing Actions

- The State is working with regional climate adaptation collaboratives and other organizations to ensure that the needs of low-income and disadvantaged communities are considered.
- The CEC released the Low-Income Barriers Study and committed to invest 25 percent of Electric Program Investment Charge technology and deployment funds for sites in disadvantaged communities.

Land Use and Community Development

In September 2016, the State released a multi-agency "Vibrant Communities and Landscapes" document that analyzes how development patterns, land conservation and protection, and land management practices connect to the State's long-term community health, environmental, and economic goals. "Vibrant Communities and Landscapes" envisions a California with 50 million residents in 2050 that has strengthened its diversity, grown in prosperity, and protected its natural bounty through deliberate and coordinated policy decisions. This future is dependent on considering climate change impacts in policy discussions and coordinating state, federal, and local jurisdictions with private landowners and stakeholders to address these issues. The land use and community development sector is an important locus for this coordination.

The Land Use and Community Development sector in *Safeguarding California* was first introduced in the package of Implementation Action Plans released in March 2016, and it represents part of the State's ongoing efforts to comprehensively integrate climate change, equity, social, environmental, and economic concerns in planning, guidance, and policy. The 2016 Implementation Action Plan presented the ongoing work and planned activities of three state entities leading activities to support resilience through land use and community development policies. The Governor's Office of Planning and Research (OPR), the Department of Housing and Community Development (HCD), and the Strategic Growth Council (SGC) are all undertaking approaches that reflect climate change adaptation as they work on their missions and facilitate implementation of state planning priorities.

OPR, HCD, and SGC, among other state agencies and departments, develop guidance, implement policies, and administer funding programs that support land use planning and community development in California. The work of each of these agencies is built on coordination with partners at the state, local, and federal levels. Integrating hazards, including those related to a changing climate, is an essential component of these efforts. As climate change exacerbates inland and coastal flooding, wildfires, droughts, extreme heat and other hazards, state government must partner with communities to make land use and community development decisions that prioritize long-term safety and resilience.

Conceptually, strategic growth and compact communities support resilience by helping people avoid hazards where possible and cope with those that are unavoidable. By helping to plan for cohesive and tightly-knit communities, state and local governments can help foster relationships among neighbors that lead to better outcomes before and during shocks to the system. With climate change already making sudden and prolonged shocks more severe and frequent, Californians will need to rely on each other more than ever, and community development and land use decisions can contribute to grassroots resilience. Partnering with communities to make better infrastructure planning and housing development decisions is a crucial part of smart growth and sustainable development.

Incorporating climate change and environmental justice considerations in local planning activity also provides an opportunity to build a community of practice around the best approaches to land use planning and community development. Ultimately, this document helps clarify the vision for how policies can lead to land use decisions and community development that help safeguard California from the effects of climate change. The seven recommendations described here each represent a key step for state government to ensure all Californians will live and thrive in resilient communities.

Preserving Land for Compact Communities and Ecological Benefits

In Marin County, 1.5 miles northeast of the Point Reyes Station and adjacent to the Golden Gate National Recreation Area, a fourth-generation ranching family turned to Marin Agricultural Land Trust instead of selling to an estate buyer. A $490,050 grant in 2015 from the state's Sustainable Agricultural Land Conservation Program (SALCP) to the Marin Agricultural Land Trust helped to protect the ranch through the purchase of an agricultural conservation easement. The SALCP funds were generated by California's cap-and-trade carbon market and will prevent development on the 330-acre property, which has been owned by the same family since the 1870's. Lagunitas Creek makes up the northern boundary of the property and is also a critical spawning area for the Coho salmon, steelhead trout, and other aquatic life. Surrounded by the Golden Gate National Recreation Area and MALT-protected Black Mountain Ranch, Gallagher Ranch joins a continuously protected landscape.

Photos by Michael Woolsey (above) and Paige Green courtesy of MALT.

Transit-Oriented Housing for Resilient Communities

In the central Los Angeles neighborhood of MacArthur Park, where metro rail lines converge, the state invested $5 million to help fund a five-story, 82-unit mixed use affordable housing development on top of the Metro Rail Westlake/MacArthur Park station. Residents will live steps away from rail connections extending north to the San Fernando and San Gabriel valleys, west to Santa Monica, east to El Monte and south all the way to Long Beach. The project includes a new elevator to give access to people with disabilities and an escalator that improves access from the east side of the neighborhood and shortens the pedestrian trip by two blocks.

Recommendation L-1: Develop innovative governance models and public engagement strategies to engage residents, especially vulnerable communities, to be sustainable, equitable, and adaptable.

All residents need to be provided with opportunities to effectively and genuinely participate in local planning processes and development decisions. It is essential to ensure that all Californians clearly understand how they can address their current needs and be included in conversations that anticipate their future risks. To build collective community support for climate adaptation, the State—in partnership with local governments—first needs to raise awareness of climate hazards and build capacities to empower participation of everyone in the decision-making process. Participatory community events, trainings, web-based surveys, public workshops, and other events can be used to engage residents in the community planning process.

It is especially important that partnerships include the most vulnerable communities. The State has made a commitment to protect the most vulnerable communities, and to prioritize resources and investments to disadvantaged communities. In many cases, these residents still live with the legacy of poor land use and development plans adopted in past years. The Office of Health Equity in the Department of Public Health uses three steps to make sure that the State engages with and consider residents living in vulnerable areas. Land use and planning entities should embrace this approach as well:

1. Identify communities and neighborhoods that can demonstrate that they are experiencing disadvantages or burdens, or geographic areas that the state has categorized as disadvantaged and eligible to receive state resources.
2. Seek out existing community-based organizations and institutions or agencies that focus on serving or organizing individuals in need to reach out and form collaborative relationships.
3. Collaborate to prioritize needs and develop joint activities aimed at designing and implementing programs, plans and policies to improve current conditions and anticipated complications.

Next Steps

L-1.1. Highlight and share case studies that demonstrate how the state is partnering with local governments, stakeholders and community leaders to successfully integrate climate preparation and readiness concepts into land use planning activities, resulting in neighborhoods that are engaged and intent on building a healthier and more resilient environment for its residents.

L-1.2. Require state grantees to incorporate appropriate community engagement strategies, including identifying and engaging the most vulnerable individuals in a planning or project area, in all relevant land use planning and community development grant applications.

L-1.3. Develop and share innovative practices for public engagement in the development of state grant guidelines, policies, and programs.

L-1.4. Explore opportunities to incorporate resident empowerment, leadership, and decision-making such as training programs, guided reviews of plans, neighborhood scans, and mapping activities as part of resident-led planning.

L-1.5. Assess policy options that reduce local government incentives to approve development in current and future hazard areas.

Ongoing Actions

- SGC engages local governments and diverse segments of neighborhoods and communities by leading extensive public outreach efforts and community workshops in order to gather input and integrate local perspectives into grant programs such as SGC's Transformative Climate Communities grant program.
- Community engagement is a scored component of SGC grant programs, including the Affordable Housing and Sustainable Communities grant, the Sustainable Communities Grant and Incentive Program, and prior grant programs such as rounds 2 and 3 of the Proposition 84 Sustainability Grants Program.
- The State is investing in social science research on overcoming governance and financing barriers to climate adaptation in the Fourth Climate Change Assessment, which will help spur new models that better address the needs of communities pertaining to the impacts of climate change.
- The State provides information on funding opportunities for climate change and sustainability work through the Air Resources Board's Cool California Funding Wizard and other publicly available resources, such as the Adaptation Clearinghouse hosted as a part of OPR's Integrated Climate Adaptation and Resiliency Program.

Recommendation L-2: Provide technical support, guidance, and capacity building to implement climate adaptation initiatives in local and regional governments and communities.

To advance local adaptation implementation, local governments, tribes, and community groups need the most up-to-date information and knowledge on both climate impacts and solutions. Under the umbrella of the Integrated Climate Adaptation and Resiliency Program, the State of California is organizing many ongoing initiatives that provide information, case studies, technical and analytical resources, and support to jurisdictions. This program, which includes an advisory council of local, regional, and State leaders, will take on the critical task of coordinating these initiatives with local partners to ensure State resources respond to local needs.

Next Steps

- **L-2.1.** Collect and organize information and outreach for coordinated State, regional, and local adaptation action through the Integrated Climate Adaptation and Resiliency Program.
  - **L-2.1a.** Develop the Adaptation Clearinghouse to compile and point to adaptation resources, including best available science and research, local implementation case studies, policy guidance, and links to funding and analytical resources.
  - **L-2.1b.** Work with local jurisdictions and communities using state adaptation resources to ensure that State efforts and investments respond to local information and resource needs.
  - **L-2.1c.** Develop new ways for communities to access technical support in implementing adaptation practices, prioritizing efforts to provide support to vulnerable communities.
  - **L-2.1d.** Utilize SGC's Sustainable Communities Planning Grant and Incentives Program to build a foundation that facilitates the adoption of best climate planning practices across the state, focusing particularly on disadvantaged and vulnerable communities.
- **L-2.2.** Support the update of the Adaptation Planning Guide, prepared by the California Emergency Management Agency (now the Office of Emergency Services) and the Natural Resources Agency, to reflect the best available science, best local adaptation practices, and current state policy.
- **L-2.3.** Update guidance included in OPR's General Plan Guidelines document on a regular basis to reflect industry practice and norms, case studies and other appropriate content for use by local governments in developing responses to climate change.
- **L-2.4.** Directly engage disadvantaged communities to participate in the development of state guidance documents and other resources.
- **L-2.5.** Continue to support the CivicSpark Governor's AmeriCorps Initiative to build local government capacity to address climate change and land use related challenges in line with State goals. The initiative places professionals in local governments around the state to build local capacity and support climate action.
- **L-2.6.** Promote local and regional performance targets for mitigation of the urban heat island effect and provide technical support for identification and implementation of urban greening, building and transportation policies, and programs to achieve it.
- **L-2.7.** Ensure that best available science continues to be available through Cal-Adapt.org.

Ongoing Actions

- HCD is currently indexing the location of potential future growth in context to potential impacts of climate change for consideration as land use policies are proposed at the state, regional and local level.
- SGC is developing a technical assistance program to support disadvantaged communities and provide assistance to enable these communities to develop competitive plans and applications for programs supported by the Greenhouse Gas Reduction Fund.
- Through the Integrated Climate Adaptation and Resiliency Program, OPR has convened a Technical Advisory Council that seeks to advance local implementation plans through coordination and communication.
- OPR supports CivicSpark, a Governor's AmeriCorps initiative, so that its services are aligned with State priorities.
- OPR is an ex-officio board member of the Alliance of Regional Collaboratives for Climate Adaptation, helping to connect climate priorities of major regions in California to State goals, policy initiatives and program efforts.
- The Sustainable Communities Grant and Incentive Program provides funding for local governments to develop and implement best practices that can be highlighted and transferred to jurisdictions around the state.
- The Fourth Climate Change Assessment has several ongoing projects that support local government climate actions through technical assistance, data, and tool development.

Recommendation L-3: Coordinate state guidelines and policies to promote climate resilience and hazard avoidance through local government general plans, zoning ordinances, subdivision regulations, and development incentives.

The State supports many aspects of local and regional planning. Integrating climate change considerations in local planning processes will be an ongoing and iterative process. This recommendation seeks to provide next steps for aligning state guidance and local practice for climate resilience.

In 2015, the State defined a resilient community in its application to the National Disaster Resilience Competition administered by the U.S. Department of Housing and Urban Development:

A resilient community is able to resist and rapidly recover from disasters or other shocks with minimal outside assistance. Reducing current and future risk is essential to the long-term vitality, economic well-being, and security of all communities. By identifying future risk and vulnerabilities, resilient recovery planning can maximize preparedness, save lives, and bring benefits to a community long after recovery projects are complete.

This vision for resilient communities drives both ongoing actions and next steps to boost resilience for Californians where they live.

Next Steps

- **L-3.1.** Track the utilization of OPR's General Plan Guidelines update that provides guidance on how to incorporate climate considerations (Senate Bill 379) and environmental justice (Senate Bill 1000) in local general plans.
  - **L-3.1a.** Track how Senate Bill 379 is realized on the ground through implementation tools such as zoning codes, grading ordinances, subdivision regulations, development incentives and other tools.
- **L-3.2.** Support engagement and outreach regarding changes in the California Environmental Quality Act guidelines that address long-term environmental impacts of projects.
- **L-3.3.** Develop and adopt guidance for how State agencies can support local government efforts on climate change.
  - **L-3.3a.** Support locally and regionally consistent adaptation planning via documents such as regional transportation plans, regional adaptation plans, local general plans, Local Agency Formation Commission municipal service reviews and other appropriate plans and programs.
- **L-3.4.** Ensure guidance across state government agencies addresses the need to consider climate change.
  - **L-3.4a.** Continue to assist making regional transportation plans and Sustainable Communities Strategies compliant with state requirements to incorporate climate change into all planning, investment, and operations.
- **L-3.5.** Assess opportunities to build on the work of the Assembly Bill 2800 Climate-Safe Infrastructure Working Group, which will assist in incorporating climate change in all state infrastructure engineering, in the context of State building codes and standards.
- **L-3.6.** Improve monitoring and evaluation of hazard areas with residential development.

Ongoing Actions

- OPR's Annual Planning Survey tracks on-the-ground progress that local governments are making in the areas of planning and climate action.
- Newly updated General Plan Guidelines incorporate climate change and environmental justice throughout the General Planning process.
- The Integrated Climate Adaptation and Resiliency Program, especially through its Technical Advisory Council, provides a collaborative forum for state, regional and local governments to identify and guide state policy with local climate resilience practice.
    - OPR's State Adaptation Clearinghouse provides resources to support local, regional and state planning for climate change adaptation.
    - The *Safeguarding California* Climate Action Team provides an internal State venue to align State, local, and regional.
- The Alliance for Regional Collaboratives for Climate Adaptation provides an external, less formal venue for conversations among state, regional and local entities.
- The Community Development Block Grant Program has been utilized to address pressing impacts like drought in flexible ways.
- The Community Development Block Grant Notice of Funding Availability already has been modified for disaster mitigation, demonstrating an ongoing integration of climate change.

Recommendation L-4: Integrate economic development initiatives with programs designed to bolster resilience.

Communities can support long-term, secure livelihoods for their residents through diverse economic development and employment opportunities. Business support, skills training programs, and access to finance can help people and businesses respond to natural disasters and economic challenges linked to climate change.

Next Steps

L-4.1. Actively identify and catalog opportunities to replicate or scale-up elements of the Community and Watershed Resilience Program being implemented to support post-Rim Fire recovery and resilience in Tuolumne County. (The Program is funded through a National Disaster Resilience Competition grant.)

L-4.2. Identify and develop innovative and equitable market-based strategies to support new approaches for implementing and financing resilience projects in communities and natural systems. This includes engaging with the insurance industry and piloting new methods such as environmental impact financing or pay-for-success approaches.

L-4.2a. Work to implement the recommendations from the Natural Resources Agency's Wood Products Working Group to address climate resilience and economic development.

L-4.3. Include metrics to track the progress of grantees in meeting workforce training, employment, and local business expansion goals under SGC's Transformative Climate Communities program.

L-4.4. Promote workforce training programs that accelerate the creation of green jobs in fields such as brownfield cleanup and redevelopment, installation and maintenance of green energy and technologies, energy efficiency weatherization and retrofitting, planting and maintenance of urban forestry and parks, habitat restoration, and sustainable timber harvesting and biomass utilization.

L-4.5. Look for transferability of elements from the SB 350 Low-Income Barriers Study to realize potential synergies between emissions reduction and economic development initiatives, especially in low-income communities.

L-4.6. Expand pathways to the CivicSpark Governor's AmeriCorps Initiative, California Conservation Corps, and associated workforce development programs that train and place Californians in professions that increase climate resilience.

Ongoing Actions

- The Natural Resources Agency is collaborating with a broad range of agencies on the implementation of Senate Bill 859 (Committee on Budget and Fiscal Review) through the development of recommendations by the Wood Products Working Group, which should lead to actions that tie economic development and resilience to climate impacts.
- The Community Development Block Grant Program provides investments for economic development in disadvantaged areas, and HCD has incorporated climate considerations into this program.
- HCD is administering over $70 million in funds from the National Disaster Resilience Competition to be invested in Tuolumne County in partnership with other state, federal, and local partners. The goal of this program is to support rural economic development and environmental resilience through community forestry and biomass utilization strategies.

Recommendation L-5: Ensure a coordinated and robust strategy is implemented across State and local governments to address environmental justice issues and the state's most vulnerable populations.

Climate change is already affecting California and it disproportionately affects the state's most vulnerable populations. The Governor and Legislature have indicated that protecting vulnerable populations is a guiding priority in all State climate adaptation plans, projects and investments. The following activities reflect the ongoing and future efforts tailored to achieve this outcome. Notably, many of these activities intentionally engage with vulnerable populations as partner stakeholders.

Next Steps

- **L-5.1.** Make equity a key consideration for State-funded research on and assessment of climate impacts.
  - **L-5.1a.** Use regional assessments that synthesize best available science as part of California's Fourth Climate Change Assessment to create baselines of knowledge about region-specific impacts to vulnerable communities.
- **L-5.2.** Work with the Office of Health Equity in the Department of Public Health to identify key strategies to link resilience efforts in public health, land use planning, and community development.
- **L-5.3.** Ensure that vulnerable community members in rural areas are included in State equity strategies.
- **L-5.4.** Make environmental justice in local planning a key connection to state activities around climate adaptation.
  - **L-5.4a.** Support local implementation of general plan statute requirements on environmental justice.
- **L-5.5.** Collaborate with foundations, non-profits, and community groups to foster greater engagement with State agencies on policy that can improve equity and grassroots resilience.
- **L-5.6.** Make equity a key part of best practices dissemination, including the Sustainable Communities Grant and Incentives Program and Integrated Climate Adaptation and Resiliency Program clearinghouse.
- **L-5.7.** Pilot the use of health and vulnerability screening tools to complement available tools for identifying disadvantaged communities.

Ongoing Actions

- The General Plan Guidelines outline how to meet new requirements for addressing environmental justice. OPR will conduct workshops throughout the state in 2017 and 2018 and provide ongoing technical support on meeting the new requirements.
- The Integrated Climate Adaptation and Resiliency Program Technical Advisory Council and Adaptation Clearinghouse will continue to support discussions, policy development and resources to continue progress in addressing environmental justice communities.
- The Department of Public Health is producing county climate health profiles that compile demographic and climate risk information as part of its California Building Resilience Against Climate Effects program.

Recommendation L-6: Provide financial support to promote infill development, affordable housing, transit-oriented development, smart planning and conservation to bolster grassroots resilience.

Grassroots resilience refers to a community's ability to withstand chronic and acute stressors into the future by building on foundations of trust and familiarity. The State is committed to investments that reduce vulnerability by incorporating climate risk into community infrastructure planning and systems and overcoming community development deficiencies. While other recommendations focus on building the knowledge and policy base for climate adaptation, this recommendation specifically encourages smart growth.

Next Steps

L-6.1. Analyze and assemble best practices that empower residents to stay and thrive in their communities while improving resilience to climate change.

- **L-6.1a** In appropriate programs, use anti-displacement language like that found in the Affordable Housing and Sustainable Communities Program so that individuals are not pushed out of climate-safe and supportive neighborhoods.

L-6.2. Explore innovative approaches to finance local adaptation and resilience planning and projects.

Ongoing Actions

- SGC makes anti-displacement strategies one consideration in administering its allocation of cap-and-trade dollars for the Affordable Housing and Sustainable Communities Program.
- The State has many ongoing grant programs that support the goals of this recommendation, including:
  - The Affordable Housing and Sustainable Communities Program (SGC)
  - The Transformative Climate Communities Program (SGC)
  - The Urban Greening Grant Program (Natural Resources Agency)
  - The Urban and Community Forestry Grant Program (CAL FIRE)
  - The Sustainable Agricultural Land Conservation Program, which provides funding for conserving prime agricultural lands to support compact development and sustainable communities (SGC/Department of Conservation)

Public Health

The task of public health is to promote and protect the health of communities where they live, work and play. While a doctor focuses primarily on treating individuals who are sick, the public health profession looks at the population level and concentrates on preventing people from becoming sick or injured in the first place. From conducting scientific research and monitoring diseases to educating the public and developing public policy that supports healthy behaviors and environments, the field of public health works to assure the conditions in which people can be healthy.

Climate change threatens public health, as it involves more extreme heat and other severe weather events, frequent wildfires, and droughts, a decline in air quality, and increases in allergens and communicable and other diseases. Climate change also threatens the basic human life support systems – our water, air quality, food, shelter, and security. The resulting human health impacts are varied and include increases in the risk and occurrence of asthma, allergies and other respiratory ailments, cardiovascular disease, vector-borne diseases, mental health impacts, civil conflicts and migrations, malnutrition, injuries, and heat-related illness and death. Climate change threatens the health and well-being of California's diverse population of nearly 40 million people and poses immense challenges for advancing health equity.

The individuals most vulnerable to the health impacts of climate change live in the same communities that experience health inequities, which are systemic differences in health status that are preventable. This includes low-income families, some communities of color, people with existing health conditions such as chronic diseases and mental health problems, children and seniors, people experiencing homelessness, outdoor workers (i.e. those involved in construction, landscaping, oil and gas extraction) and farmers, immigrants (especially those with undocumented status), tribal nations, and isolated people.

People experiencing health inequities face additional challenges, as they are likely to have fewer resources to prepare for, adapt to and recover from the health effects of climate change, whether that be sudden storms, fires, or changes to crop viability. The capacity for resilience in the face of climate change is significantly driven by living conditions and the forces that shape them (including wealth, education, housing, transportation, environmental quality) and access to resources and services, such as health care, healthy foods and safe spaces for physical activity. Thus, strategies such as alleviating poverty, improving living conditions, increasing access to opportunity, and reducing health and social inequities will result in more climate-resilient communities.

Identifying Public Health Challenges in Every One of California's 58 Counties

Climate change will put the health of Californians at risk in ways that vary by geography and economic circumstances. Working together, the federal Centers for Disease Control and the state Department of Public Health Office of Health Equity estimated distinct dangers and particular vulnerabilities in each of California's 58 counties through a program called CalBRACE – Californians Building Resilience Against Climate Effects.

The county-specific CalBRACE reports show, for example, that within 70 years, some parts of Yuba County will experience wildfire risk at four times the current level. Eastern Imperial County can expect on average 18 to 20 additional heat waves (five consecutive days over 100 degrees Fahrenheit) by 2100. In the same time frame in Los Angeles County, an additional 45 percent of the land will be vulnerable to floods so severe the annual chance of occurrence in 1-in-100. And in Humboldt County, home to some of the wettest places in California, rainfall is expected to decline by five to seven inches on average each year by 2050.

CalBRACE charted vulnerabilities, too. By 2100 in Alameda County, for example, the number of people at risk of inundation by a 100-year flood is expected to rise from 10,600 to approximately 96,000. In Kern County, nearly 49,000 residents work outdoor, at risk of heat illness, and 11 percent of households lack air conditioning. In Lake and Mendocino counties, 17 percent of adults report having been diagnosed with asthma, and nearly half of all adults report one more chronic health condition including heart disease, severe mental stress or high blood pressure. Localized assessments like these support local adaptation to climate change.

Recommendation P-1: Promote community resilience and health equity by improving underlying economic, environmental and social conditions.

Many actions to mitigate climate change also improve the health of families and communities and reduce health inequities. The capacity for climate resilience is significantly driven by living conditions and the forces that shape them, such as income, education, housing, transportation, environmental quality, and access to services. Public health engagement in climate change is essential to ensure that climate action strategies promote optimal health, well-being, and equity.

Next Steps

P-1.1. Target residential energy efficiency funding and programs to populations with relatively higher ambient air pollution and ambient noise.

P-1.2. Develop actions to help prepare for mental health impacts of climate change.

P-1.3. Combine funding of weatherization programs to the extent possible to improve housing conditions through a holistic "healthy homes" model.

Ongoing Actions

- The Office of Health Equity in the Department of Public Health is moving forward on the implementation of the California Statewide Plan to Promote Health and Mental Health Equity, which was finalized in 2015.
- The Department of Food and Agriculture's programs to strengthen local and regional food systems by supporting and creating incentives for establishment of urban and suburban agriculture, "farm to fork" programs, farmers' markets, and school and community gardens increase access to healthy foods and reduce food insecurity.
- The California Department of Community Services and Development (CSD) administers the federal Weatherization Assistance Program, designed to help low-income individuals and families increase the energy efficiency of their homes for rental or owned properties. The program also provides assistance in reducing the total cost of heating and cooling bills and helps to improve the health and safety of families (i.e. through sealing cracks and holes around windows, doors, and pipes; fixing or replacing windows; and ensuring proper insulation levels). The federal Low-Income Home Energy Assistance Program administered by CSD provides assistance to eligible low-income households to meet immediate residential heating and/or cooling needs.
- Through CSD's Solar for All California pilot program, more than 1,000 income-qualified California families installed photovoltaic solar systems on their homes at no cost.
- The California Public Utilities Commission offers the Energy Savings Assistance Program, which provides weatherization services at no cost to households who meet California Alternate Rates for Energy (CARE) income guidelines.
- The California Energy Commission's 2016 Existing Buildings Energy Efficiency Action Plan includes a strategy to establish deeper subsidies for full participation in energy efficiency upgrades by low-income households, including in multifamily rental units.

Recommendation P-2: Educate, empower and engage California residents, communities, organizations and businesses to take actions to reduce individual and community vulnerability to climate changes through mitigation and adaptation.

The State plays a crucial role in providing information to the public regarding climate change and its effects on health, particularly to climate vulnerable populations, that aids in the development of community awareness and resilience. Outreach provides critical information to individuals, communities, and public health professionals to take into consideration climate risks and actions. Outreach and education efforts can include information about the health impacts of climate change, prevention and management of climate-related illnesses, as well as promoting health equity and resilience.

Next Steps

P-2.1. Identify opportunities for engagement and capacity building with vulnerable populations. Strengthen the skills, knowledge, and abilities of communities to participate in and influence decision-making processes.

P-2.2. Create a curriculum for residents to prevent water intrusion and mold after extreme storm events through the Department of Public Health's Indoor Air Quality Program.

P-2.3. Support and strengthen community social networks and other assets to build climate resilience. For example, fund or solicit participation from schools, faith-based communities, neighborhood-based groups, health equity or environmental justice groups, and businesses in climate resilience planning.

P-2.4. Translate climate science to make it locally relevant and accessible for community members, and highlight health, climate, and equity impacts and opportunities.

P-2.5. Work with regional public health organizations, local health departments and other interested stakeholders, and integrate adaptation and resiliency components into climate change and health curricula as part of the Bay Area Regional Health Inequities Initiative, a coalition of 11 public health departments.

P-2.6. Refine and tailor existing educational and promotional materials for use by local health departments.

P-2.7. Conduct outreach to community health clinics, nonprofit organizations, community groups, local and state public health programs, mental health centers, and health navigators to encourage participation in climate planning.

P-2.8. Expand the OutsideIn SLO project—a partnership of San Luis Obispo County and the state—to additional counties and statewide.

Ongoing Actions

- The county-level vulnerability assessments and climate and health profile reports for the Department of Public Health's California Building Resilience Against Climate Effects program are part of a larger effort to engage and support county public health departments in their efforts to address climate change risks.
- The Department of Public Health seeks to support sea-level rise planning and adaptation planning in coordination with California Native American tribal governments.

Recommendation P-3: Identify, assess impacts, and promote mitigation and adaptation strategies with public health and equity co-benefits, and assure they do not have unintended consequences for health equity.

Public health actors must support climate change mitigation efforts because many of the strides being taken towards climate change adaptation may not be sufficient if climate impacts increase in frequency and severity. Many mitigation and adaptation strategies bring with them a variety of benefits, called health co-benefits, which protect people while combating climate change. These strategies include promoting mitigation and adaptation policies and planning that provide health co-benefits and adaptive capacity such as active transportation, urban greening, mixed-use zoning, affordable and energy-efficient housing, sustainable forestry, and consumption of locally-grown produce.

Next Steps

P-3.1. Take potential benefits and harm into account in transportation models used in local, regional, and state planning.

P-3.2. Provide mitigation for poor indoor air quality for new and existing buildings sited near major roadways.

P-3.3. Advocate to include climate considerations to the National Healthy Homes Checklist, a federal resource developed for the National Healthy Homes Training Center to assist families in creating healthier homes for children.

P-3.4. Integrate information from the vulnerability assessments for the Department of Public Health's California Building Resilience Against Climate Effects program into location-specific state government efforts in order to identify county-level climate change and health assets and risks.

P-3.5. Evaluate negative health consequences of possible adaptation strategies that may worsen public health outcomes by exacerbating pollen, gentrification and displacement, vector borne disease, or other impacts.

P-3.6. Identify populations with climate vulnerabilities or limited access to transportation to assist planning for climate-related emergency events.

P-3.7. Develop funding or evaluative mechanisms to ensure that energy efficiency upgrades are installed and operate as intended and do not adversely affect building ventilation or other indoor environmental quality factors and health consequences.

Ongoing Actions

- The Department of Public Health advocates for incorporating health in all policies, which can be seen through engagement on relevant climate adaptation and mitigation programs like:
  - Integrated Transportation and Health Impacts Model (ITHIM)
  - Green Building Action Plan
  - CALGreen (Green Building Code)
  - Urban Forestry Program

Recommendation P-4: Establish, improve, and maintain mechanisms for robust rapid surveillance of environmental conditions, climate-related illness, vulnerabilities, protective factors and adaptive capacities.

California scientists contribute immensely to the field of climate change mitigation and adaptation in terms of monitoring, mapping vulnerabilities, tracking vector-borne diseases and collecting epidemiological data. State agencies are implementing a number of surveillance mechanisms to provide support for state, regional, and local health agencies and partners to prepare their communities.

Next Steps

P-4.1. Identify surveillance and tracking opportunities for heat and wildfire-related health impacts.

P-4.2. Increase surveillance sampling of food commodities to avoid food-borne illness.

Ongoing Actions

- Important efforts related to rapid surveillance of conditions at the nexus of climate and health include:
  - Sea-Level Rise Interagency Mapping Development
  - Urban Heat Island Index Development
  - Community Assessment for Public Health Emergency Response (CASPER)
  - California Environmental Health Tracking Program
  - California Mosquito-Borne Virus Surveillance and Response Plan

Recommendation P-5: Improve public health preparedness and emergency response

The state Department of Public health, the Governor's Office of Emergency Services (Cal OES), local health departments, and other preparedness agencies frequently refine existing emergency preparedness plans and conduct exercises to augment preparedness for events likely to increase with climate change. Agencies also are developing plans for the anticipated impacts of sea-level rise, saline intrusion into drinking water, and increase in the frequency of severe heat events in areas where they have previously been infrequent. Furthermore, preparedness agencies are training communities on what to do before, during, and after an emergency.

Senate Bill 379 (Jackson), enacted by the Governor in October 2015, requires local jurisdictions to address climate adaptation and resiliency strategies as they revise local hazard mitigation plans (beginning in 2017) or in the safety element of the general plan (beginning in 2022, if the local jurisdiction has not adopted a local hazard mitigation plan). The law requires the update to include goals, policies, and objectives based on a vulnerability assessment identifying local climate change risks. The Department of Public Health and local health jurisdictions provide data on local health-related climate exposures and vulnerable populations.

Progress is being made to incorporate adaptation and mitigation measures in post-emergency responses to further increase communities' preparation as well as to reduce the impacts of subsequent climate change events. Such efforts include making provisions to provide healthcare through power outages and hospital closures and ensure access to medication and medical records. Social capital, also called social cohesion, can help ameliorate the mental health troubles associated with disasters, which include post-traumatic stress disorder, depression, nonspecific distress, and anxiety.

Next Steps

- **P-5.1.** Provide support to health care facilities to prepare and respond to climate change events and provide continuity of medical care following extreme events.
- **P-5.2.** Ensure that warning tools are multi-lingual and accessible to diverse communities.
- **P-5.3.** Partner emergency responders and local health departments to identify and reach vulnerable populations in need of access to cooling centers or personal cooling resources.
- **P-5.4.** Provide sample health equity language for climate change-related health impacts to local governments for updates of Local Hazard Mitigation Plans and general plan safety elements pursuant to Senate Bill 379 (Jackson).
- **P-5.5.** Solicit input from mental health professionals, consumers and advisory boards, regarding how to reduce the mental health impacts of climate change.
- **P-5.6.** Make resources available to support people suffering mental health consequences related to climate change.
- **P-5.7.** Encourage participation in climate resilience planning on the part of community health clinics, nonprofit organizations, community groups, local and state public health programs such as nutrition promotion programs, mental health centers, health navigators and others.

Ongoing Actions

- The Department of Public Health is providing guidance, resources, and support to local entities involved in public health and emergency response through efforts like:
    - the California Heat and Health Project
    - Public Health Emergency Preparedness Training Workshops
    - the Public Health and Emergency Preparedness Training Series for Latino Community-serving Organizations
    - the Binational Border Infectious Disease Epidemiology Program

Recommendation P-6: Collaborate with multiple agencies and organizations at local, state and federal levels.

Many agencies, individuals, organizations and businesses across California are implementing activities to prepare for climate change impacts. Collaboration is essential to create the necessary system-wide changes.

One such collaboration is the Health in All Policies Action Plan on Urban and Community Greening and Access to Green Spaces, created through a partnership of the Department of Public Health, Public Health Institute, and the Strategic Growth Council. The goal of the plan is three-fold: 1) Support the establishment of a baseline tree canopy, 2) develop and disseminate information about the health, environmental, and economic co-benefits of parks, urban forestry, and urban and community greening to non-traditional partners and 3) coordinate urban and community greening opportunities across other Health in All implementation activities and with other state agency work groups.

"Urban greening" involves establishing vegetated streetscapes and open spaces to create cleaner, healthier, safer, and more aesthetically pleasing neighborhoods. Urban greening promotes a complex system of trees and smaller plants, wildlife, and associated organisms, soil, water, and air in and around cities. Urban forests can mitigate the impacts of climate change by moderating climate, conserving energy use, reducing pollution and storm water run-off, and enhancing health. Additionally, urban greening has the potential to improve mental health by increasing community cohesion, therefore building social capital and decreasing feelings of isolation. Efforts to incorporate community greening should be based on information in Urban Heat Island maps from the California Environmental Protection Agency and on tree canopy cover and impervious surfaces maps and charts in forthcoming vulnerability assessments performed under the Department of Public Health's California Building Resilience Against Climate Effects program.

Next Steps

- **P-6.1.** Increase capacity at Department of Public Health and the Health and Human Services Agency to promote adaptation and resilience.
- **P-6.2.** Use the Health in All Policies Action Plan on Urban and Community Greening to increase parks, gardens, shade trees, and greening in disadvantaged communities, opting for low-allergen species.
- **P-6.3.** Deepen current partnerships, such as those within the Department of Public Health's chronic disease and nutrition programs, to better integrate health and adaptation activities.
- **P-6.4.** Connect the Department of Community Services and Development to a local health department to launch a pilot program whereby vulnerable populations are prioritized for housing improvements such as weatherization, energy assistance, or appliance upgrades.
- **P-6.5.** Convene or join inter-agency work group on extreme heat to discuss collaboration and interventions.
- **P-6.6.** Incorporate a climate adaptation perspective into program guidance and documents of the Department of Public Health's California Breathing Asthma Program.

Ongoing Actions

- In addition to the Health in All Policies Action Plan on Urban and Community Greening and Access to Green Spaces, the Department of Public Health supports action plans on the focus areas of: Healthy Food; Healthy Housing and Indoor Spaces; Parks, Urban Greening, and Places to Be Active; Community Safety through Violence Prevention; and Healthy Public Policy. The intersection of climate change and health must be considered holistically where relevant.
- The Public Health Working Group of the Climate Action Team supports coordination of public health and climate change policies with state government. In addition to the Public Health Working Group, the Department of Public Health works on additional working groups focused on forestry, oceans and coastal issues, and climate research to provide a health equity perspective on climate adaptation as resources allow.

Recommendation P-7: Conduct research and promote access to best available data to enable enhanced promotion and protection of human health and equity in light of climate change.

We need more research in order to best protect the public health of Californians in light of climate change impacts. Research topics that would help the State develop programs to protect public health include:

- The evaluation of the efficacy of early heat warning systems and cooling centers in reaching the most vulnerable people and preventing heat illness and death;
- Evaluating the past, current, and likely future impacts of climate change effects on the mental health of Californians;
- Understanding algal blooms in the Pacific Ocean and in local bodies of water, and their impact on shellfish, marine life, other plants and animals, and human health.

Lack of air conditioning increases risk of illness or death in extreme heat events, which poses the greatest risk to the elderly; people with mental illness, chronic conditions, or low incomes; people who are homeless or incarcerated; and those experiencing social or health-related vulnerabilities. Urban heat islands disproportionately impact low-income communities of color. To reduce inequities, it is imperative to plan to keep vulnerable populations cool and safe in heat events. Yet operating air conditioning increases greenhouse gas emissions, increases heat immediately outside artificially cooled buildings, can fail if peak demand causes power outages, and can be too costly for people with limited incomes. Research is needed to provide methods of cooling that eliminate the need for increased air conditioning. Effective techniques include urban greening, where (non-allergenic) trees provide shade and evaporative cooling, while greenery replaces pavement to reduce the urban heat island effect.

Green or living roofs and cool or light-colored roofs also help significantly lower temperatures. Buildings can be made more resistant to heat waves with weatherization and energy-efficiency upgrades.

The Center for the Built Environment at the University of California at Berkeley is researching development of "personal comfort systems" that use small amounts of energy to keep people comfortable. However, these technologies are likely far from mass distribution. There may be a need to develop highly-efficient and inexpensive air conditioning units for distribution to low-income housing and senior housing in combination with other passive cooling techniques to decrease heat-related deaths and illness.

Next Steps

P-7.1. Research low-carbon or net-zero emissions strategies for keeping people cool in extreme heat events.

P-7.2. Research the health and climate change adaptation and mitigation co-benefits of energy efficiency policies and building standards and "net-zero" energy and energy-efficient buildings.

P-7.3. Identify a research agenda for climate adaptation and health equity for the California Energy Commission, which oversees climate research.

P-7.4. Work with researchers at the University of California, Los Angeles on ongoing research on equity in local health department planning for climate adaptation.

Ongoing Actions

- The Department of Public Health supports many research efforts focused on climate and health in addition to those already cited in this report, including epidemiologic studies on heat, life cycle assessment and co-benefits of cool pavements, and health impacts of wildfire smoke exposure.
- The 2013 report "Indicators of Climate Change in California" from the Office of Health Hazard Assessment includes a companion document that addresses equity and environmental justice indicators. This perspective will be integrated and expanded in the forthcoming 2017 update to that report.

Recommendation P-8: Implement policy changes at local, state and national levels.

California is a leader in adopting policies that both reduce greenhouse gases and help communities prepare for, cope with and recover from climate change impacts. Many innovative and effective policies begin at the local level, such as ordinance in the City of Los Angeles requiring installation of cool roofs (light-colored reflective roofing material) on all new buildings to reduce the urban heat island effect. California also plays an important role on the world stage as leader and innovator in preparing for the effects of climate change, including health equity impacts.

Next Steps

P-8.1. Support implementation of California Energy Commission's Existing Buildings Energy Efficiency Action Plan in improving the performance and energy efficiency of existing residential, commercial, and public buildings.

P-8.2. Support incorporation of health considerations in general plans, environmental impact assessments, climate action planning, and other planning processes.

P-8.3. Collaborate with State agencies focused on green buildings and energy efficiency to include climate adaptation and health and equity considerations into State initiatives, planning, and policies, including updates to the California Building Code and California Energy Efficiency Standards.

Ongoing Actions

- The Department of Public Health is examining state grant guidelines to promote active transportation and health equity.
- The Office of Health Equity in the Department of Public Health participated in a technical advisory group that created a guidance to assist state agencies as they undertake the implementation of Executive Order B-30-15.

Recommendation P-9: Identify, develop, and maintain adequate funding for implementation of a public health climate adaptation strategy.

There is a need to prioritize implementation of adaptation strategies within the public health system, and build institutional capacity and mobilization through dedicated staff and resources within lead California Health and Human Services Agency departments. The Department of Public Health will continue conversations with Agency leadership to identify resources for staff to coordinate adaptation implementation, identify gaps and opportunities to inform strategic planning, and facilitate cross-sector collaboration and learning.

Next Steps

P-9.1. Prioritize community greening funding based on information from the California Environmental Protection Agency's Urban Heat Island maps and California Building Resilience Against Climate Effects' impervious surfaces maps.

P-9.2. Develop a plan to provide dedicated funding to local health departments to lead community preparation for health impacts of climate change.

P-9.3. Continue implementation of recommendations in Preparing California for Extreme Heat, a 2013 multi-agency state guidance document.

P-9.4. Review climate mitigation and adaptation state funding opportunities for inclusion of public health, equity, and resilience components or criteria.

P-9.5. Consider a mechanism to fund community-based organizations to prepare for health impacts of climate change.

P-9.6. Explore partnerships that combine funding for energy efficiency, indoor air improvements, and health improvement.

Ongoing Action

- The California Building Resilience Against Climate Effects (CalBRACE) Project created partnerships with many local public health departments that could serve as the basis for ongoing funding for statewide implementation of a public health climate adaptation strategy for California.

Transportation

California's extensive, multi-modal transportation system is depended on by millions of people and thousands of communities and businesses. The State's transportation infrastructure is a global gateway for products entering and leaving the United States. It includes highways and roads, railways, seaports, airports, transit, and walking and biking networks. Besides providing access to destinations, the transportation sector is critical to emergency response, provides significant employment, and is essential to the state and the nation for the delivery of goods and services.

The State Department of Transportation (Caltrans) owns and operates more than 51,000 miles along 265 highways, as well as three of the busiest passenger rail lines in the nation. The High-Speed Rail Authority (HSRA) has started construction on an 800-mile system that will serve as the backbone of an integrated rail network. High-speed rail service along the initial operating segment will begin serving passengers in 2025 and linking major metropolitan regions by 2029. The statewide transportation system also includes 140,000 miles of roads, 500 transit systems, 27 commercial service and 217 general aviation airports, 359 hospital and emergency services heliports, and 11 seaports—all owned, operated, and maintained by local and regional governments and special districts. Bicycle and pedestrian networks provide travel options, reduce vehicle congestion, and improve access and livability. Supporting the transportation infrastructure, there are also interdependent systems including fuel pipelines, utility and communication lines, and levees.

Planning, designing, constructing, operating, and maintaining this complex system is the shared responsibility of state agencies, federal agencies, metropolitan planning organizations, regional transportation agencies, transit authorities, local governments, special districts, and private entities. Transportation planning requires continuous and frequent coordination across sectors and different levels of government.

Climate change impacts from sea-level rise, storm surge, and coastal erosion have been identified as imminent threats to highways, roads, bridge supports, airports at or near sea level, seaports, and some transit system and rail lines. Shifting precipitation patterns, higher temperatures, wildfire, and an increased frequency of extreme weather events threaten transportation assets at varying locations across the state. Temperature extremes and increased precipitation can increase the risk of road and railroad track failure, decrease transportation safety, and create higher maintenance costs.

As climate changes occur over time, the choices for the State and all the transportation partners are to build protection against the threat (defend), redesign the infrastructure (accommodate), or abandon and relocate (retreat). The economic cost associated with such fortification, alteration, or relocation of existing infrastructure has yet to be fully estimated but is it likely to be billions of dollars. Impending climate impacts have implications not only for the siting of new transportation infrastructure, but also maintenance and operation, design features of transportation systems, and emergency planning and response for extreme climate events.

This Transportation Sector update builds upon the foundation provided by the previous strategies and plans. The information from former strategies and plans is still pertinent, and this update represents a continuation and expansion of those concepts and strategies. The focus continues to be on identifying climate-related vulnerabilities in the transportation infrastructure, developing adaptation plans to

define types of actions, and working to prioritize those actions to make the most of limited funds for capital investments.

Ecological Resilience and Climate-Safe Roads

Heavily-commuted Highway 17 bisects undeveloped, wildlife-rich land in the Santa Cruz Mountains between Santa Cruz and San Jose. One stretch known as Laurel Curve is especially dangerous for human drivers and deer, fox, mountain lion, and other creatures moving from one stretch of redwood forest to another. As the climate changes, different species have begun to move to new areas with climate more suited to their historical preferences; incorporating safe passage for wildlife is a key strategy for making ecological resilience a consideration in our built environment.

For years, state, local, and non-profit officials have been working toward acquisition of land necessary to create a tunnel passage for wildlife under the highway. In April 2017, Caltrans and the California Department of Fish and Wildlife announced an agreement to use the Laurel Curve project as a pilot effort to sell advanced mitigation credits for wildlife highway crossings. Under the agreement, credits can be used to mitigate for impacts to wildlife movement for future transportation projects. The credits are calculated using a first-of-its-kind methodology which takes into account the length of highway to be improved in lane miles or the project footprint in acres and the total cost of the project.

The 10-year, $52 billion funding package enacted in April 2017 by the Legislature and Governor includes $30 million for advanced mitigation strategies like the Highway 17 wildlife corridor, which will not only help safeguard motorists and wild creatures in the Santa Cruz Mountains, but also enable habitat connections elsewhere along California's roads.

Highway 17, Courtesy of Stan Shebs (Creative Commons)

Recommendation T-1: Understand climate trends that impact transportation.

As the climate in California continues to change, infrastructure within the state, including transportation, faces the threat of damage that may cause short-term disruptions or require complete reconstruction. To prepare for these potential impacts, it is imperative that transportation agencies continue to work toward a better understanding of statewide climate trends, and how they may impact the multi-modal transportation system. Moving forward, state government should enhance collaboration across agencies in furthering our understanding of climate science and trends to ensure a coordinated response to potential impacts.

Next Steps

T-1.1. Work with Cal-Adapt, the State's portal to data about how climate change might affect local communities, to further identify and refine climate metrics and projections that affect transportation system assets, including highways, rail, transit, bicycle, and pedestrian infrastructure.

T-1.2. Study potential locations of land subsidence and impacts to the transportation system, with the California High-Speed Rail Authority as lead.

Ongoing Actions

- Caltrans is studying climate changes that may impact the state highway system.
- The High Speed Rail Authority is studying climate trends that may impact the high-speed rail system.
- Caltrans is continuing to study the locations and impacts of urban heat islands to transportation infrastructure.

Recommendation T-2: Complete analysis of vulnerability assessments, and prepare adaptation plans to address identified vulnerabilities.

Vulnerability assessments are a critical element in understanding the potential climate change impacts and identifying specific locations that are likely to be affected. More climate data is becoming available to help state agencies develop their vulnerability assessments. Vulnerability assessments provide agencies with an understanding of their assets at risk, the scale, and the location of potential damage. They are essential in the development of climate adaptation plans. All levels of government should share data and information developed in vulnerability assessments when possible to help build a comprehensive picture of all transportation vulnerabilities.

When vulnerable segments of the transportation system are identified, steps should be taken to protect infrastructure. The first step in this process is the development of adaptation plans. Adaptation means anticipating the adverse effects of climate change and taking action to minimize or prevent damage. Depending upon the function of the various transportation systems, adaptation measures should be identified that protect infrastructure now and in the future. Well-planned early adaptation measures save money, resources, and lives.

Next Steps

T-2.1. Use climate change projections to analyze the vulnerability of transportation assets to climate change impacts.

T-2.2. Review and refine the outputs of vulnerability assessments with asset-specific information from departmental design, construction, maintenance, and survey engineers, professionals, and databases.

T-2.3. Create adaptation plans to address vulnerabilities identified in assessments.

T-2.4. Coordinate and integrate (wherever feasible) local, regional, and state adaptation plans.

Ongoing Actions

- Caltrans is conducting vulnerability assessments for the state highway system, using projections of climate change/trends.
- SB 1 (Beale, Statutes of 2017) provided $20 million in annual funding for regional transportation adaptation plans.

Recommendation T-3: Inform the transportation decision-making processes.

Based on an understanding of climate projections and trends, completed vulnerability assessments and adaptation plans lay the groundwork for transportation agencies to successfully inform and change the transportation decision-making process. Updating this process is imperative in ensuring climate change is included throughout the decision-making process at transportation agencies. Climate change and resilience should be considered early in the planning process and carried through the project-delivery process. In some cases, existing design and construction practices do not sufficiently consider climate change impacts and may not be capable of protecting transportation infrastructure in the long term. Therefore, climate change vulnerabilities and adaptation measures should be incorporated beyond the planning process into project design, funding, materials, contracting, and construction. By doing so, climate change policies and strategies will be incorporated into existing transportation and investment decisions.

Next Steps

- **T-3.1.** Assess current policies, processes, and procedures to identify key entry points where climate change adaptation is or should be considered and incorporated.
- **T-3.2.** Develop economic assessment strategies for evaluating impacts of climate change on the state's transportation system.
- **T-3.3.** Support and implement the recommendations of the Assembly Bill 2800 (Quirk) Climate-Safe Infrastructure Working Group to integrate consideration of climate impacts into all engineering, design, planning, and investment. The working group will address:
  - **T-3.2a.** The current informational and institutional barriers to integrating projected climate change impacts into state infrastructure design.
  - **T-3.2b.** The critical information that engineers responsible for infrastructure design and construction need to address climate change impacts.
  - **T-3.2c.** How to select an appropriate engineering design for a range of future climate scenarios as related to infrastructure planning and investment.
- **T-3.4.** Ensure that all state plans, grants, investments, design, and maintenance takes into account the current and future impacts of climate change in accordance with Public Resources Code 71155(a).

Ongoing Actions

- Caltrans is ensuring the consideration and incorporation of climate change and vulnerabilities across divisions.
- Caltrans is ensuring that California's zero-emission vehicle (ZEV) future is integrated into ongoing investments and is committed to supporting the Governor's ZEV Action Plan with its own Caltrans Zero-Emission Vehicle Action Plan.
- The California Transportation Commission included non-binding recommendations and information in the Regional Transportation Plan Guidelines to support incorporation of climate adaptation.

Recommendation T-4: Improve transportation system resiliency.

A resilient transportation system is one that is able to continue to provide essential mobility options during extreme weather caused by climate change. In order to create a more resilient system, transportation agencies must identify and implement adaptation strategies that protect the system from short- and long-term climate change impacts. New and innovative designs, materials, and maintenance practices will be necessary to increase the resiliency of the system as the climate continues to change. State transportation agencies should coordinate and collaborate with local, regional, and federal partners to create consistent solutions that increase the resiliency of the multi-modal transportation network and the communities they serve.

Next Steps

T-4.1. Identify, promote, and incorporate successful adaptation strategies, designs, and building practices that can increase the transportation system's ability to address identified vulnerabilities.

T-4.2. Increase asset monitoring capabilities to identify climate-related changes to transportation infrastructure in order to direct maintenance to assets that require preventative maintenance.

T-4.3. Use innovative materials and infrastructure design to optimize transportation resilience and extend design life of assets.

T-4.4. Use both structural and natural infrastructure solutions such as wetland restoration and creation, as well as rock revetments and seawalls, to protect transportation assets. Investigate methods to blend the structural and natural solution techniques to accomplish preservation of water quality beneficial uses and protection of transportation facilities.

T-4.5. Support and develop multimodal transportation routes to provide a variety of travel options in the case that a route is damaged.

T-4.6. In the transit sector, provide service to cooling centers in easily accessible locations, encourage public transit design decisions that lower urban heat island, and use passive cooling where possible at transit stops.

T-4.7. Educate those who use active transportation (bicycle and pedestrian) about heat illness prevention and treatment. Along pedestrian facilities with high-heat days, provide shade sidewalks/paths, and public water fountains to prevent heat illness. Where possible, use pervious pavement for bicycle and pedestrian pathways to increase water infiltration.

T-4.8. Implement adaptation plans (see T-2.3) in order to reduce/eliminate vulnerabilities, as funding allows.

T-4.9. Provide information to the Governor's Office of Emergency Services about segments of the transportation system that are expect to be impacted by future climate events in order to enhance emergency preparedness.

Ongoing Actions

- Caltrans is supporting adaptation research and pilot projects including a study of State Route 37 in the San Francisco Bay, a green infrastructure study on State Route 1 at Elkhorn Slough in Monterey, and adaptation plans in Humboldt County for Highway 1.
- Caltrans' emergency management team works with the Office of Emergency Services to protect the public and prepare the transportation system for climate events.

- Build high-speed rail to provide reliable access to urban centers across the state with increased public transit and active transportation opportunities around stations
- Build the statewide rail network as outlined in the 2018 State Rail Plan, including high-speed rail phase 1 and 2 in order to provide connectivity and multi-modal mobility options on every major corridor.
- Caltrans' 2018 State Rail Plan identifies priority rail corridors and supports electrification of these corridors to increase the reliability and efficiency of the rail network, thus providing needed resiliency should climate-related emergencies compromise alternative routes.
- Caltrans projects incorporate "Complete Streets" elements that provide transit, biking, and walking throughout the transportation system. These alternative transportation routes connect communities, and provide equitable access to evacuation routes.
- Caltrans is installing electric and hydrogen fueling infrastructure to support the expansion of alternative fuel vehicles that reduce fuel dependency.

Recommendation T-5: Maintain and enhance information sharing and education.

Providing outreach, education, and information sharing is essential in advancing the knowledge base on climate change and adaptation. Information sharing among transportation agencies, academia, and private entities is necessary to build a resilient system that can serve all California residents with vital transportation options. Transportation agencies should continue to conduct and support research, and provide education on the growing science behind climate change and the innovative resiliency measures being implemented. State agencies should take the lead in encouraging communication and collaboration among local, regional, federal agencies, the private sector, the public, and other stakeholders.

Next Steps

T-5.1. Encourage collaboration and integration among state, regional, and local adaptation efforts.

T-5.2. Analyze and compare data and methodologies used for infrastructure vulnerability assessments in the Fourth Climate Change Assessment, Department of Water Resources' vulnerability assessment, Department of Transportation vulnerability assessment, and other relevant assessment products to understand best practices and opportunities for coordination.

T-5.2a. Utilize the Research Working Group for the Climate Action Team to coordinate and scope all future initiatives that involve climate science.

T-5.3. Engage public organizations and individuals to discuss the expected impacts of climate change on the transportation system, and to identify adaptation solutions that protect nearby communities.

Ongoing Actions

- Caltrans convenes and participates in climate adaptation workshops with local, regional, and federal partners, academia, and other transportation stakeholders.
- Caltrans and the California Coastal Commission created an Integrated Planning Team to coordinate policy implementation between the agencies.

Research to Safeguard Social Systems and Built Infrastructure

The thirty high-level recommendations in the Social Systems and Built Infrastructure section represent a broad and interlinked strategy to protect California's people and infrastructure from climate change. The State's investments in research through the Fourth Climate Change Assessment are designed to directly inform this comprehensive adaptation approach. This table shows how ongoing research helps to solidify the existing adaptation framework while spurring new action to safeguard California.

Project Title	Informing Recommended Actions
The Impact of Changing Wildfire Risk on the California Homeowners' Insurance Market	**EM-1, EM-4, L-2**
Assessing and Communicating the Impacts of Climate Change on the California Coast	**EM-1, E-3, E-4, L-1, L-3, P-2, T-1**
Preparing Public Health Officials for Climate Change: A Decision Support Tool	**EM-4, E-4, E-6, L-2, L-5, P-1, P-3, P-4, P-6**
Drought Planning and Climate Adaptation of Small Self-Sufficient Water Utilities	**EM-1, EM-4, L-2, L-5, P-1, P-6, P-7**
Assessing Vulnerability and Improving Resilience of Critical Emergency Management Infrastructure in California in a Changing Climate	**EM-1, EM-3, L-2, P-5, T-2**
Overcoming Financial and Institutional Barriers to Implementing Local Government Adaptation Strategies	**EM-4, E-4, L-1, L-2, L-3**
Improving Hydrological Snowpack Forecasting for Hydropower Generation Using Intelligent Information	**E-1, E-2, E-3**
Modeling the Impact of Wildfires on California's Transmission and Distribution Grid	**EM-1, E-1, E-2, E-3**
Monitoring the Urban Heat Island Effect and the Efficacy of Future Countermeasures	**EM-3, E-1, E-2, E-3, L-2, P-1, P-3**
Distributed Evaluation and Assessment Program for California's Transportation Fuel Sector: Identifying Strategies for Reducing Vulnerability to Improve Resilience for Extreme Weather	**EM-1, E-1, E-2, E-3, T-2, T-3, T-4**
Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat	**EM-3, E-1, E-2, E-3, E-4, L-2, P-1, P-3, T-2**
The Adaption Blind Spot-Electrical Grid Teleconnected and Cascading Climate Change Impacts on Community Lifelines in Los Angeles	**EM-1, EM-3, E-1, E-2, E-3, E-4, L-2, P-1, P-3, P-5, T-2**
Investigations on the Climate Vulnerability and Identification of Resilience Options for Regional Natural Gas and Electricity Systems	**E-1, E-2, E-3**
Climate Scenario Development, Weather Forecasting, and Probabilistic Modeling for the Natural Gas and Electricity Sectors	**EM-1, EM-3, E-1, E-2, E-3**
Risk Modeling and Cognitive Science Characterization of Barriers to Climate Change Adaptation in California's Power Sector	**EM-1, E-1, E-2, E-3, E-4**
Visualizing Climate-Related Risks to the Electricity System Using Cal-Adapt	**EM-1, E-1, E-2, E-3, E-5, L-2, L-6, P-1, P-3, P-7, T-3, T-5**

Natural and Managed Resource Systems

Climate change will affect the productivity of California agriculture and rangelands, the health and biodiversity of terrestrial, coastal, and marine ecosystems, and the function of our water systems in complex and interconnected ways. These natural and managed systems provide goods and services—including food, water, energy, climate regulation, carbon sequestration, protection from floods and natural disasters, disease and pest regulation, and cultural resources—that are vital to the social and economic well-being of the entire state.

Safeguarding these goods and services will require ecosystem and landscape-level management. This section organizes these needs across the following five program area sectors within the umbrella of "Natural and Managed Resource Systems":

- Agriculture
- Biodiversity and Habitat
- Forests
- Ocean and Coasts
- Water

This section links directly to the prior section, "Social Systems and the Built Environment." Investment priorities for and around rural, tribal, and coastal communities support natural and managed systems while providing public health, infrastructure, and community development benefits. Strategies to safeguard oceans and coasts also support emergency management, land use, and community development strategies, protecting communities within coastal, San Francisco Bay, and Sacramento-San Joaquin Delta counties that host over 75 percent of California's population. Measures to protect forests, agricultural lands, and rangelands and to foster sustainable development align with land use planning strategies outlined in the "Social Systems and the Built Environment" section.

This section presents high-level recommendations and metrics to help evaluate climate impacts and related government responses. It shows how ongoing state-funded research is supporting and informing adaptation policy and action, then details each sector's ongoing actions and next steps for every high-level recommendation. This structure is also intended to link directly with the "Natural and Managed Resources and Systems, and Their Uses" chapter in the International Panel on Climate Change's Fifth Assessment Report. California's alignment with local, regional, national, and international efforts is part of its global efforts to lead climate action and make policy based on the best available science.

Agriculture

Successful agricultural production is closely tied to climate change. Water availability and changing temperatures, as well as changes in the prevalence of pests, pollinator life cycles, diseases, and beneficial species directly impact crop development and livestock production. Changes in climate can create or exacerbate other environmental concerns such as decline in water quality, groundwater security, and soil health.

The climate change impacts on agriculture are complex and variable. A reduction of chill hours could be harmful to many high-value crops such as fruits and nuts. Some crop yields may increase with warming, while others may decrease due to changing average, minimum, and maximum temperatures. As the climate changes, the State will need to assist farmers in assessing what crops can be grown in which regions in California. The diversity of California agriculture and the state's micro-climates offers a suite of potential measures to improve resiliency. The State can support the efforts of farmers and ranchers to adapt by developing tools, providing outreach, and incentivizing practices that offer increased resiliency.

Smarter Water Use on the Farm

In the summer of 2014, midway through a severe five-year drought, the California Department of Food and Agriculture began investing across the state's diverse farmlands to put water to more efficient use. With dozens of separate grants of a few tens of thousands of dollars each, the Department used greenhouse gas reduction funds to help farmers and ranchers convert irrigation systems from furrow flooding to drip irrigation, install soil moisture sensors and flow meters, connect irrigation systems with weather stations and sensors, convert the diesel motors on irrigation wells to electric motors, and switch from open ditch irrigation systems to pipelines.

The drought ended in 2017, but the State Water Efficiency and Enhancement Program, or SWEEP, continues. Projects on more than 200 farms and ranches have been funded with $34 million, more than a third in disadvantaged communities. Millions of gallons of water have been saved, which in turn reduces energy costs and greenhouse gas emissions.

Recommendation A-1: Build soil organic matter on farms and ranches to achieve multiple benefits.

Soils provide a foundation for the flow of nutrients and water to plants. The United Nations declared 2015 the International Year of Soils and recognized the importance of sustainable soil management to future food security and reducing the magnitude of climate change impacts. Continuing the momentum, California launched its own Healthy Soils Initiative, an interagency effort to increase soil organic matter (carbon sequestration) and reap other potential co-benefits of healthy soils such as improved plant health, enhanced biodiversity, dust prevention and mitigation, increased water retention of soils and improved water and air quality. These benefits extend off-farm and benefit communities and the environment holistically. The California Department of Food and Agriculture (CDFA) leads the Healthy Soils Initiative, promoting management practices with soil health benefits to the agricultural community.

Next Steps

A-1.1. Collaborate with partner agencies to customize or develop tools that quantify the greenhouse gas benefits of various farm and ranch management practices.

A-1.2. Identify a process for identifying co-benefits to water and air quality at a community level.

A-1.3. Announce a request for applications for the Healthy Soils Incentive Program to provide grants to agricultural operations to employ management practices that increase carbon storage in the soil.

A-1.4. Fund demonstration projects to showcase the multiple benefits that can be achieved through practices designed to enhance soil organic matter.

A-1.5. Scale incentive programs to farms of all sizes, being inclusive of all crops, demographics, and regions.

Ongoing Actions

- The Department of Food and Agriculture provides information on the Healthy Soils Initiative to the public through outreach events such as State Board of Food Agriculture meetings, a Healthy Soils Summit co-hosted by the U.S. Department of Agriculture, Natural Resource Conservation Service, and at meetings of the Environmental Farming Act Science Advisory Panel.
- The Department of Food and Agriculture is gathering stakeholder input on the Healthy Soils Incentive Program.
- The Department of Food and Agriculture continues to collaborate with the U.S. Department of Agriculture and other state agencies to investigate existing research and tools to estimate carbon benefits of soil management.

Recommendation A-2: Advance Water Management and Energy Efficiency in Agricultural Operations.

California's Mediterranean climate makes it a unique and unparalleled food production region for the world, but the short precipitation season makes irrigation a necessity much of the year. California irrigation infrastructure includes snowpack, reservoirs and rivers, lengthy conveyance canals and pumping stations, and groundwater aquifers. The movement of water throughout the state requires energy input. The agriculture sector has been making strides in water and energy efficiency. By converting to lower carbon-emitting energy sources and by reducing the water applied, agriculture is reducing its overall water/energy footprint.

Next Steps

A-2.1. Announce awards for the 2017 State Water Efficiency and Enhancement Program, which provides grants for installation of irrigation systems that reduce greenhouse gas emissions and reduce water use.

A-2.2. Award funding for a project(s) that combines improvements to water conveyance with on-farm water conservation techniques through the 2017 CDFA and Department of Water Resources Joint Agricultural Water Use Efficiency & State Water Efficiency and Enhancement Program.

Ongoing Actions

- The Department of Food and Agriculture is using stakeholder input to improve the State Water Efficiency and Enhancement Program.
- The Department of Food and Agriculture is working to draft a joint request for proposals and receive public input for a pilot program that uses Proposition 1 funds dedicated to agricultural water use efficiency and the Greenhouse Gas Reduction Fund (State Water Efficiency and Enhancement Program) to provide a range of benefits for those programs.
- The U.S. Department of Agriculture and the California Air Resources Board are working with the Department of Food and Agriculture to investigate existing research and tools to estimate the water and greenhouse gas emission benefits of irrigation system improvements.
- The State provides grants to farmers to advance irrigation practices through the State Water Efficiency and Enhancement Program.
- The Department of Food and Agriculture works to help bring farmers together with technical experts and conservation practitioners.

Recommendation A-3: Support Dairies in Climate Smart Management Practices.

California's dairy sector has achieved extremely high levels of production efficiency over the last 20 years, increasing the milk produced per cow by 50 percent, effectively reducing greenhouse gas emissions per volume of milk. Nevertheless, dairies have been identified as a critical industry for reducing methane emissions to combat climate change. Dairy operators say they need flexibility to implement greenhouse gas reduction solutions suited to their particular circumstances. The state can meet this need for flexibility by providing incentive programs focused on producing multiple benefits to continue to increase production efficiency while providing greenhouse gas emissions reductions. The potential for synergies in renewable energy and soil health make dairies a key participant in climate resilience in California agriculture.

Next Steps

A-3.1. Finalize a Request for Proposals for the California Department of Food and Agriculture's Dairy Digester Research and Development Program.

A-3.2. Hold grant application workshops to provide information to dairy operators and digester operators regarding the Request for Proposals.

A-3.3. Seek input from communities with dairy-dependent economies regarding the benefits and drawbacks of different dairy management practices.

A-3.4. In collaboration with partner agencies and stakeholders, develop and implement an incentive program for manure management practices (non-digester practices) that reduce greenhouse gas emissions and have co-benefits for dairies.

A-3.5. Encourage dairy operators to take advantage of other Department of Food and Agriculture incentive programs such as the Healthy Soils Incentive Program and State Water Efficiency and Enhancement Program.

Ongoing Actions

- Grants for dairy digesters, reduce methane emissions, address Senate Bill 1383 (Lara) implementation, and produce renewable energy through the Dairy Digester Research and Development Program.
- The Department of Food and Agriculture is convening a group of researchers and dairy industry representatives to provide recommendations on how to achieve greenhouse gas emission reductions on dairies and to identify opportunities for synergies with soil health and renewable energy.

Recommendation A-4: Increase farmland conservation.

California agricultural land faces the threat of increasing population and urban growth. California's farmland offers multiple benefits in addition to agricultural production, such as carbon sequestration and wildlife habitat. Securing farmland easements to ensure that farmland remains farmed also boosts continued landowner investment in agricultural productivity.

Next Steps

A-4.1. Continue funding for the Department of Conservation's Sustainable Agricultural Lands Conservation Program and California Farmland Conservancy Program.

A-4.2. Continue working with land owners and local governments to support Williamson Act participation, identifying opportunities to improve implementation.

A-4.3. Finalize the 2017 update to OPR's General Plan Guidelines, which include new sections on protecting open space, including agricultural land.

Ongoing Actions

- The Department of Conservation is leading the implementation of the Sustainable Agricultural Lands Conservation Program for the Strategic Growth Council.
- The Governor's Office of Planning and Research has released a General Plan Guidelines Update including consideration of Open Space and Agricultural Land Conservation.
- The research plan of the Climate Action Team includes investigation of the climate benefits of farmland conservation in the research agenda for the next five years.
- *Vibrant Communities and Landscapes: A Vision for California in 2050*, a document prepared collaboratively by many state agencies, focuses on the objectives of conservation and sustainable development.

Recommendation A-5: Grow the Climate Smart Agriculture Outreach Platform.

Often, climate-smart farming practices are most efficiently and effectively shared farmer to farmer. The California Department of Food and Agriculture encourages farmer-to-farmer communication at the local and even international level.

Next Steps

A-5.1. Continue collaborations with research institutions and international partners to share experience and knowledge.

A-5.2. Expand the utility of the California Department of Food and Agriculture Climate Smart Agriculture webpage for discussion of research and practical applications.

Ongoing Actions

- The Department of Food and Agriculture has developed a Climate Smart Agriculture webinar series to explore various climate resiliency efforts on an international level.
- Leadership at the Department of Food and Agriculture uses international visits to share insights on climate change adaptation.

Biodiversity and Habitat

Species and ecosystems in California are valued both for their intrinsic worth and for the services they provide to society. Air purification, water filtration, flood attenuation, food provision, recreational opportunities such as fishing, hunting, wildlife viewing, and more are all services provided by ecosystems. These services can only be maintained as long as ecosystems are healthy and robust, and continue to function properly under the impacts of climate change. A recent study examined the vulnerability of all vegetation communities statewide in California and found that 16 of 29 were highly or nearly highly vulnerable to climate change, including Western North American freshwater marsh, Rocky Mountain subalpine and high montane conifer forest, North American Pacific coastal salt marsh, and more. Vegetation serves as the underlying support providing habitat for wildlife, so this projection, indicates both the vulnerabilities of individual species and the magnitude of changes to come.

The 2009 *California Climate Adaptation Strategy* and the follow-up 2014 *Safeguarding California* Plan described the expected impacts of climate change on biological diversity and habitat in California, and outlined strategies to minimize these impacts. In this 2017 update, we expand upon that information to identify metrics for measuring and regularly evaluating observed climate impacts to species and ecosystems, and government actions to prepare for or minimize these impacts.

While the biodiversity and habitat sector content is focused on climate adaptation, it should be noted that ecosystems in California also provide a means to mitigate climate change via natural sequestration and storage of carbon. This topic is explored in depth in both the Natural Resources Agency's Forest Carbon Plan and the Natural and Working Lands section of California's forthcoming 2014 Scoping Plan Update to meet 2030 greenhouse gas targets. Natural lands carbon sequestration is therefore not addressed in detail in this document. However, it is important to note that adaptation and mitigation efforts are intertwined, and many of the activities described throughout this chapter may also support the State's efforts to reduce greenhouse gases.

Many of the advancements to date in this sector can be attributed to strong partnerships with non-state organizations. These include partnerships with local governments, federal agencies, other state agencies, non-governmental organizations, and tribes, as well as collaboratives such as the Landscape Conservation Cooperatives, the Bay Area Ecosystem Climate Change Consortium, the Climate Science Alliance - South Coast, the San Diego Climate Collaborative, and many more. Further, the work of this sector is underpinned by the use of best available science which to date has been supported by the U.S. Department of Interior Climate Science Centers, U.S. Department of Agriculture Climate Hubs, and other entities. The collaboration among partners and the transfer of information—both scientific data and practical experience—will help to ensure that common pitfalls are avoided, and that we collectively maximize benefits to species and habitats while balancing the needs of humans and wildlife.

Recommendation B-1: Strengthen the climate adaptation component of conservation planning efforts at multiple scales.

State agencies must continue to incorporate the latest climate science, projected and observed impact information for fish and wildlife, and adaptation principles into conservation planning efforts to ensure climate-smart actions are taken at the local, regional and state-wide scales.

Candidates for this type of work include planning efforts such as Natural Community Conservation Plans (NCCPs), Habitat Conservation Plans , Joint-Venture Implementation Plans, Endangered Species Recovery Plans, regional advance mitigation planning, and other joint conservation plans and long-term planning frameworks developed through partnerships in which state agencies participate, such as the 2017 Delta Conservation Framework. Many of these conservation planning exercises are aimed at preserving biodiversity, protecting federally or state listed species, aiding in species recovery, promoting habitat connectivity, and finding multi-benefit conservation solutions through integration with agriculture and working landscapes. Incorporating climate change will only strengthen each plan's ability to achieve these goals in the long-term.

Next Steps

B-1.1. Utilize opportunities to ensure climate change is well represented in all upcoming planning efforts, including the development of NCCPs, new Conceptual Area Protection Plans (CAPP), updates to State Wildlife Conservation Board Strategic Plan, and updates to the State Wildlife Action Plan.

B-1.2. Identify the best available climate science and develop specific guidance on how to use it in various conservation planning applications.

B-1.3. Engage and support local and tribal communities in their planning processes where significant ecological resources are concerned.

Ongoing Actions

- Climate change adaptation is addressed in several NCCPs that are either completed or in progress.
- The California Department of Fish and Wildlife developed general guidance for incorporating climate change into NCCPs, available on a website.
- A number of city and county general plan and regional sustainable community strategies integrate climate change into their guidance.
- California Department of Parks and Recreation continues to refine tools that will enable the department to integrate climate change adaptation into general plans and other planning documents.
- Climate change was thoroughly integrated into the Department of Fish and Wildlife's 2015 State Wildlife Action Plan update process, final document and associated Companion Plans.
- Climate change adaptation is integrated in the Department of Fish and Wildlife's 2017-2050 Delta Conservation Framework that lays out goals and strategies with focus on the long-term conservation of ecosystem processes in the Sacramento-San Joaquin Delta to protect, restore or enhance ecological function.
- The Climate Science Alliance – South Coast is developing a "State of the Science" project to explore the vulnerability of diverse Southern California ecosystems to climate change. The project aims to determine what conservation planning methods will best suit Southern

California species in the face of a changing climate. The final report will be part of the State's Fourth Climate Assessment.

Resilient Mountain Meadows Also Store Carbon

In the Sierra Nevada peaks where the Yuba River begins, scientists are testing the ability of mountain meadows to lock up atmospheric carbon. Three degraded meadows will be restored and monitored, with results compared to three other reference meadows in the Tahoe National Forest. The hope is that by halting erosion and channelization and reconnecting streams to meadows, plant biomass will increase above and below ground, increase soil organic matter and thereby improve the capacity of the soil to capture carbon.

The work is made possible through a grant of greenhouse gas reduction funds from the Department of Fish and Wildlife to the South Yuba River Citizens League. The primary goal is to learn more about how mountain meadow restoration alters carbon sequestration and greenhouse gas emissions, but the incidental benefits are significant: expanded wildlife habitat, delayed peak flows, improved water quality and quantity, and the fostering of the aspen groves and floodplains that can help multiple species cope with a changing climate.

Recommendation B-2: Enhance habitat connectivity and protect climate refugia through strategic acquisition and protection activities.

A well-connected system of habitat reserves is essential to protect species as current habitats change and new habitats develop. In the terrestrial environment, connectivity can provide stable pathways for native species and increase overall permeability of the landscape, which is increasingly important in the face of habitat fragmentation and other barriers to species movement. Connectivity is equally important in the aquatic environment, especially establishing linkages between areas of cold water refugia, where species can survive through habitat disruptions. Acquisitions through fee title and conservation easements are tools that can be used to preserve critical wildlife corridors and areas of potential refuge in the face of climate change.

Connectivity is already a basic consideration in most land acquisition efforts, and habitat connectivity in California has been mapped at the state-wide scale, such as the California Essential Habitat Connectivity Project mapped by the Department of Fish and Wildlife and Caltrans, and at finer scales in some regions of the state. This recommendation is intended to move beyond business-as-usual connectivity planning and promote the development of connectivity and reserve designs that might be different in the context of climate change and as land uses change over time. In general, striving for diversity in corridor attributes and redundancy in corridor placement (i.e. expanding the area covered by corridors) may be necessary tactics.

Enhancing connectivity, especially when informed by climate change information, will allow for dynamic changes on the landscape and will likely benefit a multitude of species. This is one of the most foundational and potentially most beneficial adaptation strategies we can undertake to address climate change in the biodiversity and habitat sector.

Next Steps

B-2.1. Develop maps of potential climate change refugia in California.

B-2.2. Identify and prioritize climate-smart corridors at multiple scales for incorporation into land acquisition decisions.

B-2.3. Determine how best to define and evaluate connectivity at various scales, so that it may be monitored over time.

Ongoing Actions

- A state assessment on climate connectivity is being carried out by UC Berkeley as part of the state's Fourth Climate Change Assessment.
- The Sierra Nevada Foothills Connectivity Project, a regional connectivity analysis, was completed in 2015.
- Connectivity to existing protected habitat and to other lands proposed for conservation is an existing consideration in the guidance and format for land acquisition proposals.
- A robust and innovative scientific methodology is being developed to evaluate and plan for current and future landscape connectivity under projected climate and land use conditions in the South Coast. This project was designed collaboratively by Department of Fish and Wildlife Region 5 staff and local scientists from San Diego State University as part of the Climate Science Alliance-South Coast.
- In 2016, the Department of Fish and Wildlife created a new Regional Conservation Investment Strategies Program) in response to Assembly Bill 2087 (Levine). The program went into effect on

January 1, 2017 and encourages a voluntary, non-regulatory regional planning process intended to result in higher-quality conservation outcomes and includes an advance mitigation tool. The Program uses a science-based approach to identify conservation and enhancement opportunities that, if implemented, will help California's declining and vulnerable species by protecting, creating, restoring, and reconnecting habitat and may contribute to species climate change adaptation and resiliency.

Recommendation B-3: Increase restoration and enhancement activities to increase climate resiliency of the natural landscape.

Restoration and enhancement can be used to increase resilience of degraded systems and reduce vulnerability to climate change. Restoration refers to activities to re-establish critical ecosystem functions, and enhancement refers to activities to improve degraded ecosystems. Restoring lost and degraded habitats can improve their capacity to support a diversity of species assemblages and re-establish or improve ecological processes (e.g. sediment deposition, water filtration, etc.). Restoration and enhancement can also support wildlife corridor usage as restored systems may better support wildlife movement, and provide food, water, and cover.

We can better utilize the abundance of climate vulnerability information that has been generated for fish, wildlife, and plants in California to help target some of our restoration and enhancement efforts. Activities such as invasive species detection and removal can help to reduce existing non-climate stressors to support ecosystem function and structure and reduce potential vulnerabilities to climate change.

State agencies should continue to work with partner organizations and the broader conservation community to clearly define climate-smart restoration and enhancement, describe what it looks like in various ecosystem types, and differentiate between climate-smart restoration and business-as-usual restoration.

Next Steps

B-3.1. Support the development of climate-smart restoration/enhancement tools and training for state agency staff.

B-3.2. Prioritize restoration or enhancement of areas with highly or moderately vulnerable ecosystems and with appropriate species and genetic stock to increase the likelihood of population persistence into the future.

B-3.3. Develop standards and processes for determining success of restoration efforts in relation to climate adaptation (e.g. have our actions have increased resiliency?).

Ongoing Actions

- The Watershed Restoration Grants Branch at the Department of Fish and Wildlife funded 44 restoration planning and implementation projects through Proposition 1 funding in fiscal year 2016-2017, supporting California's EcoRestore initiative. These projects included both aquatic and terrestrial habitat restoration. CDFW plans to release the next Prop 1 solicitation in late spring or early summer 2017.
- All State departments that were provided with funds under the "Protecting Rivers, Lakes, Streams, Coastal Waters, and Watersheds" chapter of Proposition 1 are coordinating to provide ecosystem benefits at the watershed and regional level.

Recommendation B-4: Increase biodiversity monitoring efforts to better understand baseline conditions and make possible the early detection of climate impacts.

Monitoring current conditions on the landscape is necessary for being able to identify climate impacts to fish, wildlife and plants, and their responses to those impacts. Examples of information that could be monitored include population data, such as distribution and abundance data for species in aquatic, terrestrial, and marine ecosystems; behavioral observations such as changes in geographic distribution or migration patterns; wildlife health such as disease occurrence and impact; and other factors such as impacts to food availability and habitat alteration or degradation.

This recommendation is aimed at continuing and expanding existing efforts to map and monitor species in California, as well as determining whether or not observed changes such as those in species populations, behavioral patterns, and disease events are tied to changes in climate (e.g. changes in precipitation, temperature, sea level rise, altered hydrologic regimes, etc.). Species and ecosystems can be impacted by a number of different factors, but understanding when, where, and to what extent climate is the cause of those changes will help state agencies determine how best to respond.

Monitoring every species across California is not reasonable or resource-efficient; instead, identifying areas or specific locations that might exhibit early signs of change, or even key species that might be harbingers of change would be a pragmatic way to monitor and detect climate-related impacts to fish, wildlife, and plants (i.e. key indicator species). In particular, vegetation mapping and monitoring can be extremely useful, as vegetation is often considered to be the best single surrogate for habitats and ecosystems. Fine-resolution vegetation data and mapping can inform not only conservation efforts, but also infrastructure and land-use planning. This may be a strategic place to focus initial expansion of monitoring efforts and attempts to discover connections to climate change.

Next Steps

- **B-4.1.** Continue fine-scale vegetation mapping efforts for California.
- **B-4.2.** Select previously mapped areas of vegetation that could be re-visited and monitored to detect whether any changes have occurred.
- **B-4.3.** Identify indicator species and appropriate metrics to monitor (e.g. the most critical flora and fauna, keystone species, etc.).
- **B-4.4.** Expand the Department of Fish and Wildlife Resource Assessment Program to include additional at-risk ecoregions and species.

Ongoing Actions

- Continue statewide fine-resolution vegetation mapping in compliance with the Department of Fish and Wildlife's Survey of California Vegetation standards.
- The Department of Fish and Wildlife has begun time-series monitoring that will yield importance climate change adaptation information on a few key species.

Recommendation B-5: Continue incorporating climate considerations into state investment decision processes related to fish and wildlife conservation.

Explicitly including climate change language in grant program priorities and project solicitations can achieve multiple benefits such as communicating climate-related expectations to project proponents and emphasizing the importance of the climate component; increasing the probability of receiving high quality proposals from the climate perspective; increasing the likelihood that the proposed project will contain forward-looking actions to benefit fish and wildlife; and reducing the likelihood that the project benefits to fish and wildlife and the investment itself will be overturned by climate impacts in the future. This recommendation also extends to investments in science and the allocation of funds to climate impact or vulnerability studies for fish, wildlife, and ecosystems.

State agencies have already made significant strides in accordance with Assembly Bill 1482 (Gordon, 2015), which requires consideration of climate impacts and use of climate adaptation strategies to inform State planning and investments, but need to continue making progress. For any state grant programs that do not yet consider climate change, language should be added to reflect climate impacts to fish and wildlife as appropriate. Grant programs or project solicitations that already include a climate component could be re-visited to see how climate was incorporated and if there is room for improvement in order to maximize climate co-benefits. Critical gaps in climate science related to biodiversity should be identified and filled.

Next Steps

B-5.1. Develop guidelines for grant programs to include impactful climate adaptation criteria.

B-5.2. Revisit grant programs that already include climate considerations and evaluate the significance of the inclusion (i.e. is the climate component meaningful? What impact does it have to the funding decision, if any?).

B-5.3. Develop and provide training to likely authors of land acquisition planning documents on how to address climate change.

B-5.4. Identify, and direct funds to fill, gaps in scientific knowledge related to climate impacts to fish, wildlife, and habitat.

Ongoing Actions

- Climate change adaptation is included in many state agency grant programs, including those at the Natural Resources Agency, Wildlife Conservation Board, Department of Fish and Wildlife and all state conservancies.
- Climate change is represented in several state agency strategic plans, including the Tahoe Conservancy, Sierra Nevada Conservancy, and Coastal Conservancy.
- Department of Fish and Wildlife staff are working to strengthen the climate component in the guidance document used by authors of land acquisition proposals.
- The Department of Fish and Wildlife recently funded two climate science projects:
    - A climate vulnerability assessment for vegetation communities statewide, carried out by researchers at UC Davis as part of the 2015 State Wildlife Action Plan revision.
    - A climate vulnerability assessment for a subset of mammals in California, also being conducted by researchers at UC Davis.

Recommendation B-6: Provide educational opportunities to the public and state agency staff regarding climate impacts and adaptation options for ecosystems, fish, wildlife, and plants.

Disseminating climate science, adaptation, and biodiversity impact information to the public furthers an understanding of why it is necessary to safeguard species and natural resources in California, thereby garnering necessary support from constituents.

Resource managers and conservation practitioners need easy access to adaptation strategies for planning purposes and climate-smart restoration techniques and tools to apply. Existing efforts to make this sort of information available include California Climate Commons and Point Blue Conservation Science's Climate-Smart Restoration Toolkit.

State agencies need to ensure that these resources are being utilized by staff where appropriate. Agencies should focus on sharing resources that are easily digestible and can be directly assimilated into state agency projects and programs. Where possible, agencies should identify and track how strategies can be applied across various ecosystem and project types. Encouraging feedback from state agency staff on information delivery and potential information gaps is also essential.

Next Steps

B-6.1. Continue existing climate education initiatives such as Climate Science Alliance South-Coast Climate Kids initiative and the Department of Fish and Wildlife's internal Climate Course for its employees.

B-6.2. Promote, support, or develop opportunities for on-the-ground climate action courses for State agency staff.

B-6.3. Develop an ongoing informational component related to climate risks to species and ecosystems in the Department of Fish and Wildlife's Office of Communications, Education, and Outreach program.

Ongoing Actions

- In 2016, 73 Department of Fish and Wildlife employees completed an internal Climate Course that includes materials designed by UC Davis faculty.
- Climate Kids, an initiative of the Climate Science Alliance – South Coast, is working with partners across the region and in Baja to engage students on climate change through art, storytelling, and science. To date, the program has reached more than 5,000 students in San Diego County and 4,000 students in Baja including opportunities for bi-national exchange events and field trips to coastal areas.
- In fall of 2016, the Department of Fish and Wildlife updated its climate change website. This website is the main tool for communicating with the public on the department's climate science and adaptation work. The website now includes more up-to-date information and improved resources.

Forests

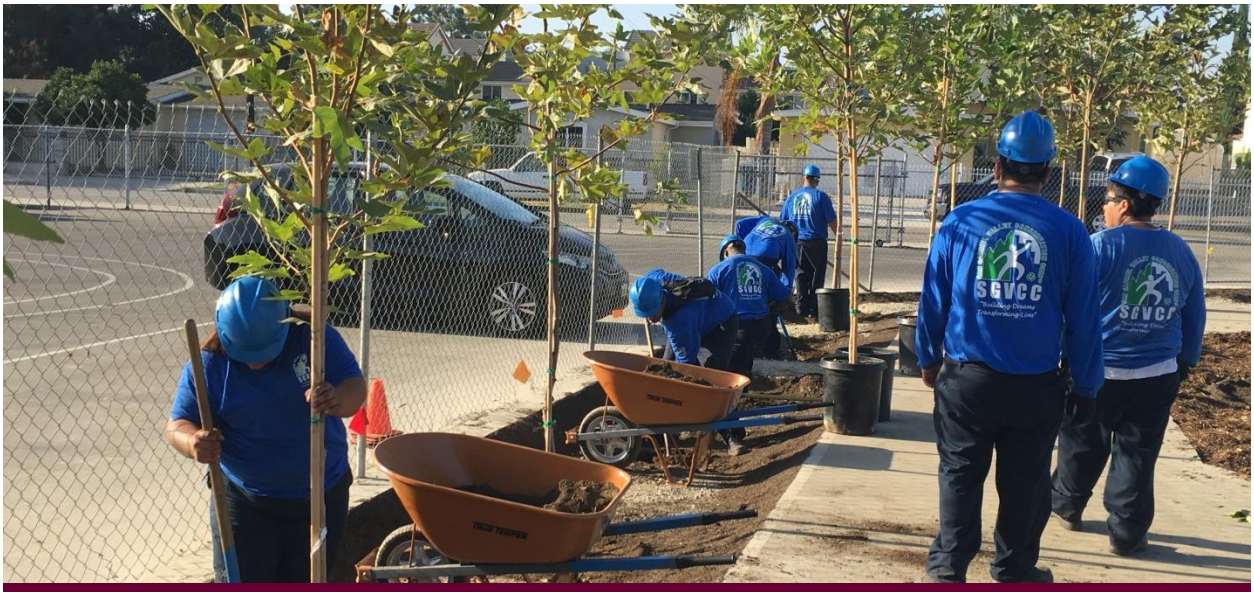
Forested lands make up roughly one third of our state, covering nearly 32 million acres. Their ecosystems provide essential habitat for native wildlife, while forest products and forest-based recreation support rural communities and the state economy. Nearly two-thirds of Californians receive water from streams and rivers originating in the forests of the Southern Cascades and Sierra Nevada mountain regions, tying healthy forests closely to the well-being of the majority of the state's population, over 25 million residents. In addition to wildland forests, the urban tree canopy covers 15 percent of California's urban areas, providing green space and public health benefits to the 95 percent of Californians who live in cities.

Climate change already affects tree survival and growth, forest composition, the range and distribution of tree species, and forest health and productivity.

In order to improve forest health and resilience, investments must be made to improve the social and economic resilience of forested communities, and their capacity to carry out forest management activities. Building rural and tribal restoration economies for achieving forest health outcomes will entail creating jobs to manage forests, harvest biomass, and manufacture wood products. It will also involve programs targeted to smaller landowners to improve forest management for public benefits, as these owners are typically less responsive to market forces. In urban areas, landscaping and urban forestry jobs will be needed to expand and maintain a healthy urban tree canopy and green spaces.

Given the variety of forest ecosystems and land ownership patterns in California, there is no panacea for restoring resiliency in forested landscapes. California forests host an exceptional diversity of species because of the broad variety of climatic zones, soils, elevations, and other environmental factors across the state. Further, while management of the state's forests is divided between the federal government (58 percent), state and local governments (3.4 percent), and private landowners (39 percent), disturbances such as pest outbreaks and wildfires do not adhere to ownership boundaries. This chapter creates a framework for improving forest resiliency in a changing climate, focusing on the need for regional strategies that work across state, federal, tribal, nonprofit, and private management partners and are tailored to address ecosystem conditions.

The proposed actions align with the recommendations laid out in the Forest Carbon Plan, a state-wide strategy to manage our forest landscapes as a sink of carbon. These actions highlight the roles that healthy forests, fuels reduction, protection of large landscapes, commercial timber harvest including biomass utilization, urban forestry, and improved research and monitoring can play in climate adaptation strategies, and entail an investment in forest ecosystems that more fully captures the vital services they provide. While improving forest health and resilience, these management steps will also enhance economic, cultural, and recreational opportunities for communities across the state.



Rebuilding an Urban Forest

In the biggest, most popular park in the San Gabriel Valley city of South El Monte, hundreds of trees have been killed recently by a boring beetle species that carries a fungus deadly to trees. More than 200 mature park trees will be removed in 2017. The loss of shade only worsens the heat-island effect in South El Monte, where temperatures often stay above 90 degrees for days. With the help of grants from CAL FIRE and the Natural Resources Agency, a local non-profit group, Amigos de los Rios, has begun replacing the lost trees – and then some. Over the next several planting seasons, volunteers and local conservation corps crews will plant 1,100 trees, including coast live oak, valley oak, and western sycamore. Besides shading park visitors, the trees will sequester carbon and help offset greenhouse gas emissions from traffic on the many nearby freeways.

Photos courtesy of CAL FIRE (top) and Amigos de los Rios (bottom).

Recommendation F-1: Enhance forest health through fuel reduction, thinning, and managed and managed fire treatments.

While forests naturally experience fire in regular cycles, called "fire return intervals," forests have missed fire cycles due to fire suppression in the past several decades. Without fire, dead material has built up in the forests, fire-adverse species have moved in, and forests have become dominated by smaller trees. Simultaneously, logging has removed larger older growth trees, further increasing the homogeneity of forests, increasing competition amongst trees for sunlight and water, accelerating the spread of pest and diseases, and reducing the amount of carbon to only a fraction of a forest regime of larger trees. When fire does return to many of these forests, it is increasingly severe, compared to historic levels.

Without significant efforts to restore forest structure and function, the accelerated climate stresses of warmer temperatures and more frequent drought will continue to increase the vulnerability of California's forests to disturbance such as large wildfires and pest outbreaks. By 2085, most of the forested areas in Northern California are predicted to experience a growth in burned area of over 100 percent above 1975 reference levels.

No single activity is going to solve the wide range of threats to California's forests. Given the certainty of an uncertain future climate, it is important to deploy a balanced approach of a wide range of management activities, and to adapt management strategies to changing ecological conditions.

Next Steps

- **F-1.1.** Increase the pace and scale of management activities on federal forestlands through national landscape conservation networks, landscape mitigation strategies, native seed rehabilitation and restoration, and vegetation treatments.
  - **F-1.1a.** Develop and advance cooperative state and federal projects to thin overstocked forests on federal lands.
- **F-1.2.** Increase the pace and scale of fuel treatments on non-federal forestlands including mechanical thinning and prescribed burning.
- **F-1.3.** Increase partnerships between the U.S. Forest Service and U.S. Bureau of Land Management, state agencies and conservancies, local and tribal governments, nongovernmental organizations, and private landowners to manage forests at the landscape and watershed level that maximize the benefits for water, wildlife, and people.
  - **F1.3a.** Support regional implementation of the Forest Carbon Plan, led by regional conservancies where they exist; empower alternative leadership capacity in areas not encompassed by state conservancies.
  - **F1.3b.** Identify sources of funding to support regional forest management actions, and provide state policy support for implementation through activities such as streamlining permitting for certain restoration activities and reducing small landowners' financial barriers to land management.
- **F-1.4.** Partner with Native American tribes to benefit from traditional knowledge of prescribed fire and forest management.
- **F-1.5.** Increase education and forestry assistance efforts for non-industrialized private forest land owners; connect landowners to funding sources and cost-share programs to facilitate these efforts

F-1.6. Promote the increased use of prescribed and managed fire to restore natural fire regimes and forest health. Facilitate cooperative efforts among private, state, tribal, and federal entities to apply prescribed and managed fire at an ecologically meaningful scale.

F-1.7. Develop agreements between state and federal air quality regulatory agencies to facilitate an increase in the use of prescribed fire.

F-1.8. Work with the California Department of Fish and Wildlife to expand acres of high priority forest habitat by five percent from 2015 acres. This target may be adjusted as the department's State Wildlife Action Plan is periodically updated.

Ongoing Actions

- The State Forest Carbon Plan presents actions for managing our forest landscapes in a changing climate, and sets the state for implementation at the landscape level.
- The federal and state Forest Stewardship Programs and CAL FIRE's Forest Improvement Program offer cost-share opportunities to assist individual landowners with land management planning, conservation practices to enhance wildlife habitat, and practices to enhance the productivity of the land.
- The Natural Resources Conservation Service provides funding to assist landowners in employing conservation practices.
- The U.S. Forest Service provides funding for management on National Forest System Lands in California.
- CAL FIRE's State Responsibility Area Fire Prevention and Tree Mortality Grant Program supports local efforts to remove dead and dying trees that pose a threat to public health and safety and for projects that reduce the wildfire threat to habitable structures within State Responsibility Areas, where the State is financially responsible for the prevention and suppression of wildfires.
- The Brown Administration's Tree Mortality Task Force coordinates response to the current tree mortality crisis with agencies, utilities, and other stakeholders.
- The state Greenhouse Gas Reduction Fund finances projects to proactively restore forest health for multiple benefits through CAL FIRE Forest Health Grants.
- The forest management chapter within the Department of Water Resources' California Water Plan Update provides guidance on actions to improve forest health for healthy watersheds.
- The Natural Resources Agency's Timber Regulation and Forest Restoration Program works with state agencies and industry to increase efficiencies and effectiveness for timber harvest planning and permitting processes and forest restoration.

Recommendation F-2: Increase protection of forested lands, reduce conversion to non-forest uses, and facilitate reforestation opportunities to result in a more stable forested land base.

California's forestland base has been relatively stable over the past three decades at approximately 32 million acres of forestland. However, due to regional development pressures, some forests are being fragmented or fully converted to other commercial land uses, such as vineyards, marijuana farms, and residential development. Development can deforest and fragment forest lands, degrade forest health, disrupt wildlife habitat, and increase risk of wildfire, even if the development footprint itself is small relative to total forest acreage. Regardless of disturbance impacts on natural landscapes, large tracts of contiguous wildlands will maintain ecological function in some form. Conversion to non-forest land uses however, is usually irreversible, and is arguably the biggest threat to forest lands in California today.

CAL FIRE estimated in 2010 that 2.3 million acres of California's forested lands are high priority for restoration due to wildfire impacts – a number that will likely increase due to the current tree mortality crisis that is estimated to impact 7.7 million acres statewide. Progress has been made to reestablish new forests, yet, given the effects of each year's new fires, over 270,000 acres of planned reforestation treatments have not been implemented.

In the absence of reforestation, natural succession in areas impacted by high intensity wildfire may result in an effective type conversion from forest lands to chaparral or shrub dominated communities. These communities are capable of storing much less carbon than mature forests, and typically have much more frequent fire return intervals. Accumulating evidence that climate change is resulting in warmer and drier condition in the West promises to exacerbate this trend, and makes it imperative to eliminate the current backlog of reforestation in wildfire areas.

Land protection should be targeted to conserve large, relatively intact forests that can provide essential ecosystem services.

Next Steps

F-2.1. Eliminate the current U.S. Forest Service reforestation backlog and sustain future treatments at a level where annual additions are matched by treatments.

F-2.2. Increase the area of non-federal lands reforested with a diverse mix of native species.

F-2.3. Incentivize voluntary landowner measures, such as conservation easements, in areas of high risk for conversion to non-forest land uses. These easements should be paired with stewardship plans.

F-2.4. Incentivize working forests that can return revenue from timber harvesting to allow small forest landowners to cover taxes and other expenses of maintaining forest lands, thereby preventing land fragmentation and conversion to non-forest land uses.

F-2.5. Promote the adoption of regional transportation and development plans that prioritize infill and compact development and consider the climate change impacts of land use and management in jurisdictions with substantial forest resources.

F-2.6. Provide support and technical assistance for counties, cities and regions to integrate forest resource conservation priorities into plans, drawing from existing Natural Community Conservation Plans, habitat conservation plans, the State Wildlife Action Plan, and critical agricultural lands where those plans already exist.

F-2.7. Provide funding to support, maintain, and expand seed banks and revive state tree nurseries and support programs for collection, propagation, and dissemination of tree species and genotypes that are better adapted to the changing regional environmental conditions.

Ongoing Actions

- The federal Forest Legacy Program and California Forest Legacy Program help incentivize conservation easements to protect environmentally important private forestlands.
- The Wildlife Conservation Board's land acquisition program acquires real property or rights in real property on behalf of the California Department of Fish and Wildlife for protection and restoration of wildlife habitat.
- The Natural Resources Conservation Service's Agricultural Conservation Easement Program provides incentives for easements in eligible private forestland.
- USDA Forest Service State and Private Forestry Grants provide technical and financial assistance to landowners and resource managers to help sustain the nation's forests.
- Grants for watershed reforestation and restoration are funded through the state Greenhouse Gas Reduction Fund.
- Seedbank and nursery support is provided through the Los Angeles Moran Reforestation Center, which catalogues and stores approximately 42,000 pounds of primarily native conifer seeds available for replanting forest stands after fires, insect or disease outbreaks, or other catastrophic events.

Recommendation F-3: Continue investing in urban forestry to enhance the health of current urban forests and expand urban tree canopy statewide

Covering over 791,725 acres of California, the urban tree canopy occupies approximately 15 percent of all urban areas. While census-defined urban areas represent only about five percent of the state's land area, almost 95 percent of the state's population, or over 35 million residents, are located in urban areas. The stocking rate of urban forests is just over a third of its potential statewide. The density and extent of canopy cover has room to grow, and would provide a variety of benefits if expanded. Meanwhile, existing urban forests are being impacted by climate change, drought, and pest outbreaks. Management steps must be taken to equip communities with the necessary resources to manage their urban forests for the long-term.

Urban heat islands are created by the concentration of dark pavement and roofing that absorb heat, engines and generators that produce heat, and the absence of vegetation in urban areas. The urban heat island effect can lead to daytime temperatures in urban areas on average one to six degrees Fahrenheit higher than in rural areas, and nighttime temperatures as much as 22 degrees Fahrenheit higher as the heat is gradually released from buildings and pavement. Expanding urban tree canopy cover and using vegetation where feasible can help reduce heat island effects by providing natural cooling. Reduced energy use from canopy shading by urban forests saves $568 million annually.

In addition to cooling benefits to counteract urban heat islands, urban forests offer a variety of other co-benefits that enhance climate resilience. They function to mitigate public health impacts of criteria air pollution in urban areas. Trees and vegetation benefit water infrastructure through rainfall interception, reduced water pollution, and reduced flood risk. Additionally, urban greenspace provides public health and community benefits such as strengthened social cohesion, support for cognitive functioning and place attachment, and increased physical activity. Trees in gardens, orchards, farms, and schools provide food for communities. Urban forests offer economic benefits, generating over $3 billion in direct revenues in 2009 and nearly 60,000 jobs.

Next Steps

F-3.1. Establish local tree canopy cover goals (locally and regionally) and work towards the Forest Carbon Plan's objective of increasing total urban tree canopy statewide by one-third above current levels, to 20 percent coverage of urban areas by 2030.

F-3.2. Assist local governments and others in assessing their urban forest resources and best management practices using basic urban forest assessment standards such as percentage of tree canopy cover, tree inventory, and management plans.

F-3.3. Obtain and share tree canopy coverage data with local governments on a periodic basis and support adoption of long-term comprehensive urban forest management plans, including relevant tree inventories.

F-3.4. Help local governments identify optimal locations for green infrastructure and increased tree canopy cover in the 372 communities identified in CAL FIRE's 2010 Forest and Rangeland Assessment as high-priority areas for urban tree planting in order to conserve energy and improve air quality.

F-3.5. Develop urban forestry protocols to ensure that communities are engaged in site choice and project development from the onset of planning.

F-3.6. Support the creation of jobs, training programs, and workforce development in urban forest management, tree planting, and green infrastructure development to provide

sustained economic benefit and ensure long-term capacity for maintenance in these communities.

F-3.7. Fund urban tree planting and green infrastructure projects where they yield multiple benefits such as reducing energy use, capturing storm water, and improving water and air quality.

F-3.8. Provide resources and technical assistance to local governments as they assess urban forestry and green infrastructure policies and regulations.

F-3.9. Create incentives for the use of best management practices, including tree maintenance and preservation, by local governments and others to protect large, established trees and increase the short-term and long-term tree canopy.

F-3.10. Improve and expand highest and best use of urban biomass to avoid traditional waste streams.

Ongoing Actions

- The Urban and Community Forestry Grant Program has funded projects for urban forest expansion, improvement, and management as well as urban wood and biomass utilization through the Greenhouse Gas Reduction Fund.
- CAL FIRE Regional Urban Forestry Advisors offer technical assistance on urban forest management.
- The California Natural Resources Agency announced an open solicitation for the Urban Greening Grant Program in March 2017. Funded through the Greenhouse Gas Reduction Fund, these grants will help to preserve, enhance, increase or establish community green areas such as urban forests, open spaces, parks and other community spaces.

Recommendation F-4: Promote rural and tribal economic development by expanding wood products markets, biomass utilization, and outdoor recreation.

California imports over 75 percent of its wood for consumption despite being the third largest producer of timber in the nation, providing a significant opportunity to increase in-state utilization of California timber products. Increased production of timber and wood products can support forest management goals outlined in other recommendations in this chapter while providing rural economic development opportunities.

Material generated by commercial forestry as well as forest health, restoration, and hazard treatments should be utilized productively or disposed of in a manner that minimizes net greenhouse gas and particulate matter emissions. Although there is ample raw material from overstocked forests, in many regions landowners struggle to find financially sustainable demand and the workforce capacity to remove small-diameter trees, dead trees, and biomass. The lack of capacity to manage the biomass and trees for higher value products, such as durable wood products, compost and other soil amendments, results in this wood being left in the forest, where it can increase the risk of wildfire, or in many cases, is open-pile burned. Both of these activities undermine the objectives of greenhouse gas emission reduction goals, and can have negative implications for human health.

Regions should be empowered to choose the appropriate biomass utilization strategies from restoration activities that match local capacity and markets so that the economic benefits of biomass harvesting are retained within the community. Community engagement and a full consideration of the local health and economic impacts of projects could help better ensure that projects match regional needs.

In addition to biomass utilization, forests can support rural economic development through recreation and tourism. The outdoor tourism industry generates $122.5 billion in direct travel spending and $9.9 billion in state and local taxes. In the Sierra Nevada region alone, forests support over 50 million recreational visitor-days annually. Recreation and tourism benefits provide support for forest conservation efforts while supporting regional economies: one of the strongest predictive factors that determine public support of forest projects is whether the project is perceived to improve access to recreational opportunities.

Next Steps

- **F-4.1.** Expand wood products manufacturing in California, focusing on industries with sustainable long-term supply and market viability.
  - **F4.1a.** Identify potential for expanded and new markets for products such as cross-laminated timber and other engineered mass timber, biochar, and other soil amendments, and liquid biofuels that can be made from traditionally low-value biomass. Encourage the siting of complementary wood products manufacturing facilities near small-scale bioenergy businesses to create regional economic hubs.
- **F-4.2.** Provide financial and technical assistance to rural communities and Native American Tribes near forested areas to increase capacity for biomass utilization.
  - **F4.2a.** Invest in long-term workforce development in forest-dependent areas to ensure that economic benefits of biomass utilization support the communities from which forest products derive.

F-4.3. Provide community representation in decision-making for biomass facility siting and ensure that air quality impacts to local communities are considered in project siting and development.

F-4.4. Increase the total volume of carbon stored in long-lived wood products from California forests, particularly in buildings; ensure that the California Green Building Standards Code supports this objective.

F-4.5. Develop and support the generation of and markets for compost from forest biomass for agricultural, rangeland, municipal, and residential soil amendments.

F-4.6. Work with Native American tribes to protect tribal access to non-timber forest products and traditional activities such as cultural burns and activities related to subsistence in forests such as hunting, fishing, and trapping. Work across agencies to ensure that forests continue to provide an abundance of outdoor recreational and tourism opportunities.

Ongoing Actions

- The Natural Resources Agency's Wood Products Working Group established through Senate Bill 859 (Committee on Budget and Fiscal Review) is developing recommendations to expand wood products markets in California.
- In 2016, the California Energy Commission released an Electric Program Investment Charge solicitation for efficient, sustainable and lower-cost bioenergy projects. Awards for six projects totaling more than $16 million were announced in March 2017.
- The National Disaster Resilience Competition funded a $22 million grant for a biomass facility and wood products campus in Tuolumne County through the California Department of Housing and Community Development.
- The California Energy commission continues to support research into the potential for conversion of woody biomass to transportation fuels both statewide and regionally.
- Contracts approved by the Public Utility Commission to fulfill mandates for biomass energy provided by statute through Senate Bill 1122 (Rubio, 2012)or Governor Executive Order 10-30-2015 will continue to be implemented.

Recommendation F-5: Implement sustainable forest management and working forests for the overall health and protection of forested watersheds.

Investments in forest health help provide high-quality water downstream. Nearly two-thirds of the State's developed water supply originates from the forested lands of the Southern Cascades and Sierra Nevada mountain regions. While the region's snowpack provides water storage, its forests and meadows regulate water quality and timing. Forests help anchor soil and absorb rain and snowmelt and help lessen the severity of flooding and landslides. In addition, forests help regulate the timing and magnitude of water runoff and water flows. Healthy forested ecosystems can improve the quality and supply of these water resources, and delay and buffer the timing of spring melt.

Additionally, meadows cover approximately 191,000 acres in the Sierra Nevada, but approximately half are known or likely to be degraded. Eroded meadows lose their capacity to store groundwater, an ecosystem service that will be more important under warmer and dryer climate scenarios. Restoration activities can improve meadow habitat and hydrologic function. Improving meadow and forest management to protect watershed health will be increasingly important as climate change continues to reduce snowpack and cause temporal changes in snowmelt and spring runoff that can lead to longer dry periods in summer months, reducing available moisture for forest plants.

Soil loss following high severity fire negatively affects tree growth and carbon sequestration, and can be detrimental to watershed health. High sediment loads, conveyed during the high-flow events typical of California's precipitation regime, typically follow large, high-severity fires for a number of years. This sediment and debris can reduce reservoir capacity, increase water turbidity, interfere with other critical infrastructure, and negatively affect riparian habitat. Post-fire reforestation and forest health activities, such as commercial timber harvesting and thinning, can improve watershed health and benefit water resources. Forest management helps to reduce the need to remove silt and debris from reservoirs and recharge basins, make more space for water supply storage and hydropower generation capacity, and increase the economic value of these activities.

Next Steps

- **F-5.1.** Account for the value of healthy watersheds and their ecosystem services and consider the avoided costs of investing in protecting and restoring these services in decision-making; better communicate these services to stakeholders outside of forested regions.
  - **F-5.1a.** Explore new financing mechanisms that recognize the multiple benefits and beneficiaries of healthy watersheds.
- **F-5.2.** Prioritize forest health and fuels reduction activities for water supply watersheds.
- **F-5.3.** Restore 10,000 acres of mountain meadow habitat on non-federal lands in key locations; work with the U.S. Forest Service to restore mountain meadow habitat on federally managed lands.
- **F-5.4.** Use science and outreach to draw connections between statewide beneficiaries and forest restoration actions in upper forest watersheds. Encourage investments in maintenance of forested watersheds by downstream commercial water users such as drinking water suppliers, breweries, canneries, etc.
- **F-5.5.** Support watershed-level collaboratives for forest management through multi-party funding mechanisms and existing cost-share programs that engage federal agencies, state conservancies, local governments, Native American tribes, nongovernmental organizations, and private landowners.

F-5.6. Ensure rehabilitation of fire control lines that have the potential to alter runoff patterns and become sources of sediment. Install proper drainage structures on firelines and roads, and remove soil from emergency stream crossings built when constructing firelines with bulldozers.

Ongoing Actions

- The *Mokelumne Watershed Avoided Cost Analysis*, conducted by the Sierra Nevada Conservancy in coordination with the USDA Forest Service and The Nature Conservancy, evaluates the benefits and avoided costs of increased fuels reduction treatments in the Mokelumne Watershed. This analysis is intended to inform future watershed planning, as well as public and private investment.
- A chapter on Forest Management within the Department of Water Resources' California Water Plan Update provides guidance on actions to improve forest health.
- State Board of Forestry regulations guide protection of the beneficial uses of water and riparian functions.
- Assembly Bill 2480 (Bloom) identifies watersheds as part of California's water infrastructure.
- Greenhouse Gas Reduction Funds provide funding for forest-related watershed reforestation and restoration projects.
- Large-scale collaborative efforts such as the Sierra Nevada Conservancy's Watershed Improvement Program bring stakeholders together.
- Proposition 1 Restoration Grant Programs fund watershed protection and ecosystem restoration projects of statewide importance outside of the Sacramento-San Joaquin Delta.

Recommendation F-6: Foster fire-adapted communities through local planning and fire preparedness.

Although natural wildfire supports and is critical to forest ecosystem health, ongoing research predicts that climate change will exacerbate the risk of uncharacteristically large wildfires that put many forested communities in danger. Additionally, while adaptation strategies within the previous recommendations will help enhance forest health and reduce the risk of catastrophic wildfire, it is inevitable that some fires will continue to escape control efforts. As a result, we must prepare homes and communities to withstand and recover from fires, develop policies and procedures to promote public safety, and educate the public the natural role of wildfire in California's landscape. Engaging individual landowners, homeowners, and communities in fire protection responsibilities with federal, state, and local fire protection agencies is becoming an ever-increasingly important climate adaptation strategy.

Communities within California's 6.7-million-acre wildland urban interface, the geographic transition zone between human-inhabited structures and wildland, are especially susceptible to damage catastrophic wildfire. Development and population growth in this zone puts human lives and homes at risk during wildfires and degrades and fragments wildlife habitat. Creating fire-adapted communities will require the integration of local land use planning with fire suppression and pre-disaster planning activities and resource management to proactively improve forest resilience.

Next Steps

F-6.1. Integrate climate change considerations in the update to the Strategic Fire Plan for California drafted by CAL FIRE and the Board of Forestry, which is the state's roadmap for reducing wildfire risk.

F-6.2. Increase actions implemented by landowners, Native American tribes, public agencies, and communities to reduce human loss and property damage from wildland fires, such as fuel breaks, fire safe landscaping, removal of hazardous vegetation, inspections for fire safe clearance around homes, forest health treatment, fire prevention, and fire safe building standards.

F-6.3. Further support landowner-initiated hazardous fuels reduction through grants, cost-share agreements, and other programs, and work to remove regulatory barriers that limit hazardous fuels reduction activities.

F-6.4. Increase public education on fire risks and the increasing importance of forest thinning, prescribed fire, managed fire, and other fuels treatment projects. Educate landowners, residents, business owners, and fire safe councils about responsibilities of living in the wildland and necessary prevention measures.

F-6.5. Ensure that ongoing, proactive fire prevention through forest management remains a priority for CAL FIRE hand crews and other CAL FIRE resources despite fire suppression costs.

F-6.6. Support efforts to reduce risk factors and vulnerability of existing structures. Improve monitoring of fire safety regulations, increase the number and effectiveness of defensible space inspections, and promote an increasing level of compliance with defensible space laws. Apply building standards for fire safety uniformly.

F-6.7. Create land-use and community-based wildland fire protection plans and decision support tools that are informed by climate projections and an ongoing understanding of wildfire risk.

F-6.7a. Assist governmental bodies in developing a comprehensive set of wildland and wildland urban interface protection policies for inclusion in each county general plan and other relevant planning documents.

F-6.7b. Encourage local land use planning efforts to conduct thorough risk assessments if considering development within the wildland-urban interface.

F-6.7c. Develop county and regional fire readiness plans with community-based groups such as fire safe councils, fire and land management agencies; engage individual community and tribal members these efforts.

F-6.8. Identify and evaluate the risks wildland fire hazards pose to life, property, and natural resources, and use science-based approaches to understand how climate change will affect these risks.

F6.8a. Maintain consistent, detailed, and regularly updated vegetation and fuels maps and CAL FIRE Very High Fire Hazard Severity Zone maps; improve sharing of all maps and analyses across ownerships to ensure communities understand local fire risks.

F6.8b. Engage local stakeholder entities such as fire safe councils to validate and prioritize the assets at risk and to update data for values and assets at risk.

F-6.9. Create provisions for local emergency plans to ensure public safety when wildfires occur.

F6.9a. Initiate and maintain cooperative fire protection agreements with local, state, and federal partners to create an integrated regional fire protection system and deliver a cost effective and efficient emergency response.

F-6.10. Address post-fire responsibilities for community revival and natural resource recovery.

F-6.10a. Conduct rapid post-fire assessments and project implementation to minimize flooding, protect water quality, limit sediment flows, and reduce other risks on lands impacted by wildfire.

F-6.10b. Engage landowners and land management agencies in designing and implementing salvage and reforestation activities and vegetation treatment plans to restore ecosystem function to burned areas. Refine best management practices by assessing the effects of pre- and post- fire treatments.

F-6.10c. Investigate all wildland fires to understand their causes; analyze trends of causes and focus community prevention and education efforts based on findings.

Ongoing Actions

- The 2010 Strategic Fire Plan for California, a cooperative effort to reduce firefighting costs and property losses, increase firefighter safety, and to contribute to ecosystem health, is being updated.
- CAL FIRE conducts monitoring of vegetation clearing in the wildland urban interface and defensible space inspections in State Responsibility Area communities across the state.
- The California State Board of Forestry and Fire Protection's Vegetation Treatment Program aims to lower the risk of catastrophic wildfires on nonfederal lands through hazardous fuels reduction.
- CAL FIRE Fire Prevention Education reaches audiences statewide through a new mobile app, social media campaigns, school programs, fair exhibits, posters, flyers and thousands of other printed materials, radio and television spots, internet communications, community meetings, and one-on-one contacts with those who live, work and recreate in wildland areas.

Recommendation F-7: Support key research, data management, and monitoring needs in the forestry sector and apply findings through adaptive management

The forestry sector has a long tradition of applied research. Given recent trends of climate change, drought, wildfire occurrence and tree mortality, however, there is a need to revisit key research priorities to ensure the continual employment of science-based, cost-effective strategies for forest management and monitoring. This should include collaboration between federal, State and private funding entities to identify a comprehensive set of research priorities. Studies in progress include a resource economics study underway by UC Berkeley for the Forest Climate Action Team; research to support the Natural Resources Agency's Fourth Climate Change Assessment; and research by Lawrence Berkeley National Laboratory for the natural and working lands component of the Air Resources Board's 2030 Target Scoping Plan.

Research and development on forest biomass and forest management activities also is supported by several programs of the California Energy Commission. In summer 2016, the commission released a new bioenergy solicitation to support technologies that use forest residue and thinning from sustainable forest management and fire-hazard reduction to generate electricity. The commission's Alternative and Renewable Fuel and Vehicle Technology Program released a recent open solicitation, Community-Scale and Commercial-Scale Advanced Biofuels Production Facilities, to fund facilities that could process woody biomass into fuels. The same program also funded applied research conducted by the U.S. Forest Service for providing tools to evaluate and prescribe sustainable harvest and utilization of forest biomass in California.

Linked to research activities, ongoing monitoring of forest conditions will provide baseline information for adaptive management and understanding the effects of climate change on forest ecosystems. The Board of Forestry and Fire Protection will report monitoring of the carbon stored in forests for Air Resources Board's Natural and Working Lands Inventory. Other databases that track and report on management and conservation activities include CalMAPPER, which CAL FIRE uses as a database and for certain information contained in timber harvesting plans, forest improvement projects, and fuels reduction. The California Department of Fish and Wildlife uses the California Environmental Data Exchange Network, EcoAtlas, and Miradi for various project types and programs. Grant-specific information associated with bond initiatives are maintained in Natural Resources Agency databases, and regional and national databases used by the U.S. Forest Service report on forest activities. However, these databases vary in level of detail and are not fully compatible.

Next Steps

F-7.1. Create an interdisciplinary committee consisting of researchers and funding entities to develop a priority climate and forest research agenda. Coordinate with the University of California, the California State University system, and other research entities to identify and fill knowledge gaps related to climate adaptation in forest and forest biomass utilization.

F-7.2. Enhance the predictive capacity of forest carbon models and invest in tools and databases to improve forest monitoring, planning, policymaking, and investment.

- **F7.3a.** The Air Resources Board, in consultation with the Natural Resources Agency and CAL FIRE should engage in a comprehensive review and complete a standardized greenhouse gas inventory for working lands by the end of 2018.

F7.3b. Sharpen forest carbon accounting methods by improving forest inventory data collection and incorporating remote sensing where possible.

F7.3c. The Natural Resources Agency should seek resources to develop and implement a centralized database or other information management system to track implementation activities identified in this plan and the Forest Carbon Plan by December 30, 2018.

F7.3d. Using federal, state and academic research forests, develop effective transects of climate monitoring stations across the state.

F-7.3. Research forest restoration and protection best practices and apply them in an adaptive management context. Initiate and continue research relating to appropriate restoration efforts in areas affected by uncharacteristic wildfire or tree mortality or both, including incorporation of climate change modeling.

F-7.3a. Develop best management practices consisting of silvicultural systems that are likely to create optimal forest structure and composition over a wide range of as-yet unknown future climate situations

F-7.3b. Continue research into the long-term impacts of forest management practices on habitat, site productivity and resilience.

F-7.3c. Gain a better understanding of genetic and species selection of tree planting stock that can best thrive under changing climate conditions.

F-7.3d. Research the effects of actions taken to conserve and restore forests on downstream water supply quantity values. Identify forests at greatest risk to type conversion and areas with the most forest carbon at the greatest risk to loss as well as the opportunities for proactive conservation of large, ecologically relevant landscapes and where improved management can significantly increase carbon stores.

F-7.4. Research and develop new products and markets for excess biomass material and comprehensively calculate the costs and benefits of forest treatment activities compared with a status quo approach.

F7.5a. Identify soil types that are best suited for biochar integration, and the best application strategies for this material.

F7.5b. Perform full greenhouse gas and carbon lifecycle analyses for wood products and biomass utilization pathways, including those imported from out of state.

F-7.5. Develop and disseminate tools to assist landowners, local and regional land use planners, and forest managers in assessing current forest conditions and desired future conditions for carbon resiliency and forest health.

Ongoing Actions

- CAL FIRE's Demonstration State Forests, the U.S. Forest Service Pacific Southwest Research Station, the University of California, and other landowners have research reserves, studies, and demonstrations across geographic and elevation gradients to inform our understanding of climate change in California's forests.
- The Air Resources Board is developing a Natural and Working Lands Greenhouse Gas Inventory to assess net greenhouse gas emissions from forests.
- CAL FIRE is required by statute to produce periodic assessments of the forests and rangelands of California. Draft indicators are being developed for the next Forests and Rangelands Assessment.

- The Board of Forestry and Fire Protection is implementing a monitoring and reporting process for annual forest carbon stocks using Forest Inventory and Analysis data, as required by Assembly Bill 1504 (Skinner, 2010).
- The Fourth Climate Change Assessment includes research projects on the impact of changing wildfire risk on the California homeowners' insurance market, fuel treatment for forest resilience and climate mitigation, and innovations in measuring and managing forest carbon stocks in California.
- Through research with the Lawrence Berkeley National Laboratory, the Natural Resources Agency is investing in the California Natural and Working Lands Carbon Model, an inventory that will quantify and compare the changes in landscape carbon due to different management options for the entire California landscape.

Ocean and Coast

In 2014, nearly 75 percent of California's population lived in coastal counties and along the State's iconic 1,270 miles of mainland coastline and the San Francisco Bay's additional 500-mile shoreline. In 2013, the ocean and coast contributed $44.2 billion to the state's GDP, provided $19.3 billion in wages and salaries, and 502,073 jobs. These figures demonstrate how much the people and economy of California relies on the coastline and the ocean. The short- and long-term risks from climate change, such as sea level rise and other changes in our coastlines will undoubtedly affect a vast number of people and industries. California is one of the world leaders in both addressing climate change and protecting our coastal and ocean habitats and resources. Because of the ever-growing value of California's coastal areas and our dependence on the coast and ocean for recreation, food, and critical infrastructure, it is important to quantify how climate change will impact our ocean and coasts and how we can best anticipate, and plan and prepare for these changing ocean conditions. Therefore, understanding and addressing climate change is paramount to California's work and milestones on ocean and coastal protection.

Globally, the ocean absorbs about a third of the CO_2 that society releases into the atmosphere every year, significantly reducing the amount of this greenhouse gas in the atmosphere and dampening climate change related stressors and impacts. The CO_2 emissions that the ocean absorbs are fundamentally changing the chemistry of our ocean, making it more acidic (decreasing its pH). An increase in ocean acidity was first felt along our West Coast, characterized by the upwelling of cold, CO_2-rich water into shallower coastal areas where key species develop, grow, and live. Ocean acidification makes it harder for many of these organisms to develop, thrive, and protect themselves; for example, damage to shelled organisms and shellfish industries has already been documented as calcium carbonate which is needed for shelled organisms to build their shells is less available when atmospheric CO_2 is absorbed by and interacts with seawater.

In addition to changes in ocean acidity, increasing sea surface temperature and ocean heat content are melting glaciers and ice sheets. Coupled with the thermal expansion of seawater, these changes are causing sea levels to rise. Warming also contributes to increased storm activity and will eventually trigger profound changes in ocean circulation. Episodic and extreme events such as storm surges and high tides coupled with sea level rise and land subsidence directly affects Californians living in coastal and inland delta counties, causing increased flooding that disrupts services and infrastructure systems in regions across California. It is critically important to understand the range of sea level rise projections on several timescales, while factoring in the uncertainty and feedbacks of our warming atmosphere and oceans, so jurisdictions and decision-makers can perform risk-based analyses and prepare for future uncertainty.

California's state agencies that coastal and inland delta agencies are taking action now to assess the risks and reduce the anticipated impacts of climate change, and are striving to prepare all Californians for the inevitable long-term impacts expected over time. Specifically, state agencies continue to work to understand climate impacts and to enhance the health and resilience of coastal systems. Their collaborative efforts address high priority issues, such as sea-level rise, ocean acidification, and hypoxia, which impact coastal and marine ecosystems, livelihoods and economies, public access to the coast, recreation, and the well-being and safety of coastal communities. Focusing on the cumulative impacts of these various stressors linked to climate change, this sector continues to foster multi-agency collaboration to ensure that effective adaptation strategies are identified and implemented statewide in

California. The sector relies on and supports the development of the best available science to guide these adaptation efforts.

How High Will the Seas Rise?

No matter what, sea levels will rise off California's coast. The question for local governments, of course, is how much.

In April 2017, the Ocean Protection Council released a summary of the latest in sea-level rise science and projects, including the potential impacts on California from rapid ice loss from the Antarctic ice sheet. After public vetting in workshops around the state, the report will be used by state and local agencies to inform planning.

The report includes new information on the expected sea-level changes that will occur based on different greenhouse gas emission scenarios. For example, with very successful mitigation efforts, the report states that there is a 67 percent probability that the Bay Area will experience sea-level rise between 1.0 foot and 2.4 feet by 2100. However, if no significant mitigation efforts are taken, that range increases to 1.6 to 3.4 feet.

The report also emphasizes the importance of preparing for extreme scenarios involving the rapid loss of the Antarctic ice sheet, which would have an enormous impact on global sea level rise and local sea level rise along our coast, bays, and delta. In one such scenario, sea levels along California's coastline could rise up to 10 feet by 2100 – about 30-40 times faster than sea-level rise experienced over the last century.

Recommendation O-1: Leverage regulatory, permitting, and planning authority to preserve coastal communities and resources by adapting infrastructure and other development to be more resilient to sea level rise and extreme events

Climate risks and impacts need to be fully integrated into existing and planned management activities on the coast. This means incorporating climate risks into infrastructure assessment, planning and design along the coast and considering risks that may arise from policies and plans that effect how the coast and ocean is managed and used.

Additionally, to ensure resilient communities, coastal and ocean planning should consider the differential impact of climate risks when evaluating whether disadvantaged communities face unequal burdens from climate risks or insufficient resources to respond to these risks. An explicit effort must be made to build capacity for adaptation in these communities and to ensure that they have the resources to invest in climate adaptation.

Next Steps

- **O-1.1.** Allocate additional local assistance grants for updating and certifying Local Coastal Programs to address climate change and sea level rise in all 76 coastal jurisdictions.
- **O-1.2.** Provide technical assistance and guidelines to plan for sea level rise within local jurisdictions and other agencies.
- **O-1.3.** Integrate climate adaptation considerations into state agency planning, investment, and funding decisions more fully by increasing coordination with local and regional partners, developing useful guidance, standards, and evaluation criteria for decision-making, and prioritizing the use of total economic valuation that accounts for market and non-market values.
- **O-1.4.** Facilitate planning and implementation of adaptation measures in communities with unequal burdens from climate risks or insufficient resources to respond to these risks.
  - **O1.4a** Incorporate environmental equity into various local adaptation grants by using demographic indicators of disadvantaged communities to help target outreach.
- **O-1.5.** Develop policies to protect public trust, cultural, and archaeological resources along the coast.
  - **O1.5a** Identify existing or potential threats to public trust assets and develop policies that ensure the ongoing availability of trust lands and their values for current and future generations.
  - **O1.5b** Assess and plan for the protection of beaches and public access to the shoreline so that the loss of beaches does not disproportionately burden underserved or other underrepresented populations.
  - **O1.5c** Safeguard cultural and archeological resources threatened by sea level rise and ensure California Native American tribes and other affected groups are involved and supported in planning efforts to address these impacts.
- **O-1.6.** Promote hazard avoidance for new development.
- **O-1.7.** Use regulatory authority to reduce risk to existing property impacted by sea level rise.
  - **O1.7a** Begin planning to adapt state-owned existing critical infrastructure at risk from sea level rise such as highways, wastewater treatment plants, airports, ports, pipelines, and transmission lines. Provide guidance and technical assistance to assist non-state entities to begin planning to address critical infrastructure at risk from sea level rise.
  - **O1.7b** When feasible, use phased retreat, or buyout of vulnerable property.

O1.7c Prioritize the remediation of hazardous material cleanup sites on the coast and in high flood risk areas so that they do not spread contamination later due to flooding.

Ongoing Actions

- The Ocean Protection Council is updating the State of California Sea-level Rise Guidance Document to ensure the best available science is incorporated into specific policy guidance for state and local decision-makers.
- Local Coastal Program Grant Programs, which provide support for updating Local Coastal Programs consistent with the California Coastal Act requirements to address sea level rise and climate change impacts, implement coastal resilience.
- Coastal Development Permits address the impacts of sea level rise on new development and integrate adaptation triggers for at-risk development through the permit process.
- BCDC is expanding and completing the "Adapting to Rising Tides" community-based planning program along the entire San Francisco Bay shoreline.
- Assembly Bill 2516 (Gordon) requires the Ocean Protection Council to update the Sea-level Rise Planning Database and support a related project to improve the State's sea-level rise planning resources.
- Coastal regulatory agencies develop lease terms that address hazard liability and protect resources from climate impacts and work with lessees to adapt existing and future facilities to climate change impacts.
- Assembly Bill 691 (Muratsuchi) ensures compliance with sea-level rise assessments for granted public trust lands.
- Policy guidance and model ordinance language for resilient residential shoreline developments was created through the Coastal Commission's "Managing the Coastal Squeeze" Project.
- The State is updating guidelines for incorporating sea level rise into updated General Plans.
- Senate Bill 379 (Jackson), which requires local jurisdictions to provide climate change vulnerability assessments within local hazard mitigation plans to fulfill statutory requirements of the General Plan Safety Element, and requires planning for climate change impacts starting in 2017 integrates several aspects of coastal resilience into local planning activities.
- The Delta Stewardship Council's Delta Levees Investment Strategy takes sea-level rise into account.
- The San Pedro Bay Ports Clean Air Action Plan is being implemented with the State Lands Commission as a partner.

Recommendation O-2: Support natural infrastructure, living shorelines, and other adaptations that protect and rehabilitate coastal and marine ecosystems and beaches.

Decades of coastal development and efforts to stabilize beaches have transformed California's iconic coastline. Eighty percent of the California coastline is actively eroding, and the risk of beach loss is increasing. Projected impacts of climate change will accelerate sea level rise and coastal erosion, and likely make storms more frequent and powerful. Historically, California has responded to coastal erosion and storms by building seawalls, bulkheads, revetments, and other armoring structures along the coast. While these structures intend to safeguard coastal communities, they offer only temporary protection, eventually accelerating long-term erosion and leaving homes and property at risk. When put on an eroding or retreating beach, these structures prevent coastal ecosystems from migrating inward, prevent the shoreline from carrying out natural processes, provide little habitat for estuarine species, and will eventually cause the beach to narrow and disappear.

Additionally, with rising sea levels, wetlands, marshes, and other critical habitats will face inundation and erode. Wetland habitats would need an estimated 150 square miles of open space for inland migration to be maintained for 5 feet of sea level rise. Further, sea level rise will result in the change of some freshwater marshes into salty tidal marshes due to seawater intrusion. Already, an estimated 85 to 90 percent of the wetland acreage in California has been drained, filled, and converted to other uses. Wetlands not only provide habitat for fish, birds, and other species, but also help improve water quality, water supply, and flood control. Thus, protecting wetlands and the benefits they offer will help reduce climate risks. The natural functions of wetlands and other coastal ecosystems support and add value to state, regional, and local economies, public health, and culture. These functions and consequent benefits are increasingly threatened by climate change and coastal squeeze, and their protection is imperative.

California must look to natural infrastructure adaptation measures to ameliorate the climate risks related to coastal erosion, sea level rise, and ecosystem degradation. Living shorelines can stabilize the shore using a variety of structural and organic materials such as wetland plants, submerged aquatic vegetation, oyster reefs, sand fill, fiber, and stone. While stabilizing the shoreline and protecting public access to coastal resources, living shorelines offer benefits including the protection of surrounding riparian and intertidal environment, filtration of runoff and improvement of water quality, the creation of habitat for coastal species, and long-term cost effectiveness due to their adaptive capacity and low maintenance needs.

In addition to living shorelines, natural ecology and coastal processes can be restored through revegetation, ecosystem protection, and management of wetlands, coastal dunes, and marshes. Restored wetlands can offer significant flood protection by reducing destructive wave energy during storms.

Next Steps

O-2.1. Support and encourage the implementation of management strategies aimed at beach preservation, including beach nourishment projects and managed retreat efforts that maximize the beach's ecological and recreational values.

O-2.2. Advance programs for natural infrastructure, including living shorelines, planned retreat, and other nature-based adaptations.

O-2.2a. Develop adequate funding for implementation of these programs, development of goals and success criteria, and commitment to project monitoring.

O-2.2b. Study the outcomes of pilot projects to learn from each project; disseminate findings to improve understanding of the benefits of natural infrastructure.

O-2.2c. Analyze the economic costs and co-benefits such as reduced flood risk and stormwater runoff of current and future nature-based infrastructure projects in comparison to grey alternatives; include market and non-market values.

O-2.3. Promote natural infrastructure solutions within the planning and regulatory process outlined in Recommendation O-1, and provide local governments with guidelines and scientific information about natural infrastructure for coastal land-use planning and decision-making.

O-2.4. Support regional and ecosystem-level projects to restore coastal habitats and natural processes.

O-2.5. Research and explore the extent to which Marine Protected Areas (MPAs) buffer marine resources against the negative impacts of climate change and consider climate impacts in MPA management; continue to ensure adequate enforcement of MPA regulations

O-2.6. Work with regulating entities to support and enhance natural systems in reducing flood risk and treating stormwater runoff.

Ongoing Actions

- Across several agencies like State Coastal Conservancy and Department of Parks and Recreation, coastal restoration and rehabilitation projects are underway to restore and rehabilitate important coastal habitats (i.e., dune restoration and coastal bluff rehabilitation).
- When complete, the South Bay Salt Pond Restoration Project – led by the State Coastal Conservancy – will restore 15,100 acres of industrial salt ponds to a rich mosaic of tidal wetlands and other habitats.
- Estuarine habitat restoration projects are in progress through the California Coastal Estuarine Land Conservation Program.
- Across government decision-making and decisions around public funding, agencies are addressing existing and proposed coastal armoring activities and evaluating innovative solutions, such as natural infrastructure projects that reduce vulnerability to sea level rise and coastal flooding.
- Sediment-related projects at Department of Parks and Recreation will help support coastal restoration and protection and engage on coastal sediment management.
- Living Shorelines Projects are being planned and implemented in Arcata, San Francisco, Newport, and San Diego.
- Development of the State's Sediment Master Plan through the Coastal Sediment Management Workgroup features twelve Coastal Regional Sediment Management Plans to mitigate the adverse impacts of coastal erosion and excess sedimentation on coastal habitats.
- An update to the Southern California Wetlands Recovery Project Regional Strategy is in progress.
- Implementation of Senate Bill 1363 (Monning) is restoring and protecting eelgrass habitat for its multiple benefits including potentially mitigating local ocean acidification and hypoxia and sequestering carbon dioxide.

- The Green Shoreline Infrastructure help desk at BCDC is connect projects with technical experts and develop a comprehensive multi-agency permit application and approval process for projects that place fill in the Bay to accelerate the region's resilience.

Recommendation O-3: Develop actionable science that reflects the latest and evolving trends over a range of spatial and temporal scales

California has a long history of drawing on the scientific community to inform coastal and ocean policy, planning, and management. Monitoring, data gathering, and research can enhance scientific understanding of the impacts of climate change in coastal and ocean areas and the ability of the Sector to anticipate emerging issues. In order to incorporate climate-relevant decision making into management practices, the latest climate science needs to be reflected, used, and continually advanced.

Climate science is a field that is rapidly informed by new data and peer reviewed studies as we learn and better understand how changes in one part of the planet or global carbon cycle reverberate and cascade to other regions. In order to comprehensively reflect the latest trends, we will need integrated models and measurements to develop information and tools for appropriate scales and to bound change over different timescales depending on the decision and choice that is being made. *Safeguarding California* prioritizes continued modeling and continued support and investment in monitoring regarding climate impacts on the ocean and coast. This 2017 update will add to and enhance these priorities.

Next Steps

O-3.1. Identify and research evolving trends to anticipate climate impacts and proactively prepare for a range of potential scenarios.

O-3.2. Secure funding for research and monitoring related to climate impacts on the ocean and coast.

Ongoing Actions

- California participates in the Pacific Coast Collaborative Subcommittee on Ocean Acidification & the Federal Interagency Working Group on Ocean Acidification (IWG-OA) Monitoring Task Force which is collecting and compiling ocean acidification and hypoxia monitoring data across the West Coast to assess information gaps, track changes in ocean chemistry, and make smart future investments.
- FEMA and local partners are collecting beach profile data and high-water mark data
- The Ocean Protection Council is supporting the Coastal Storm Modeling System, which makes detailed predictions of coastal inundation, storm-induced coastal flooding, erosion, and cliff failures over large geographic scales and can be used for to analyze future climate scenarios (sea-level rise and storms).
- The Ocean Protection Council is supporting is supporting a West Coast wide ocean acidification model developed by a team of scientists from NOAA, University of Washington, and the Southern California Coastal Water Research Project and led by UCLA to predict ocean chemistry changes throughout the California Current.
- The State is incorporating sea level rise and climate change modeling for the Sacramento-San Joaquin River Delta through the Department of Water Resources' 2017 Central Valley Flood Protection Plan Update and the Delta Stewardship Council's Delta Levee Investment Strategy; stage-frequency curves were developed for the Delta providing a link between tides and Delta inflow as well as the impacts of climate change.
- FEMA is incorporating sea level rise into their coastal storm surge mapping efforts.
- Coastal site surveys for cultural resources are being conducted by the Society for California Archaeology in partnership with the Department of Parks and Recreation.

- The California Department of Fish and Wildlife and partners are working with Tribes and constituents to update the Marine Life Management Act Master Plan for fisheries, through considering tools and recommendations developed through information gathering projects.
- The Ocean Protection Council is supporting the following information gathering projects: Climate Change and Fisheries working group, peer review for Fishery Management Plans, Productivity and Susceptibility Analysis (PSA) and Ecological Risk Assessment (ERA), as well as supporting the development of socioeconomic guidance for fisheries management. The Southern California Coastal Ocean Observing System and Central and Northern California Ocean Observing System provide and disseminate scientific data and knowledge needed to inform decision-making and better understand the changing conditions of California's coastal ocean.
- California is completing historical hourly tide data to develop hourly sea level rise and storm surge datasets.
- UC San Diego's Coastal Data Information Program provides ongoing beach change measurements, wave research, and long-term manual temperature and salinity measurements.
- State and federal government agencies fund research on atmospheric rivers and coastal landslides.
- The State Coastal Conservancy leads research on saltwater intrusion into groundwater.
- The Southern California Coastal Water Research Project (SCCWRP) plays a crucial role in research and tool development on topics like ocean acidification.
- The State is very involved in efforts to assist Bay Area efforts to define, identify, and fund one or more regional data repositories to collect and share data in ways that best inform rising sea levels strategies and actions.
- The State is also developing indicators for tracking climate change in the Marine Protected Area statewide monitoring program.

Recommendation O-4: Assess community and ecosystem vulnerability through the use of decision-support tools and analyses

Effective adaptation requires understanding climate change vulnerabilities and impacts at appropriate scales. Because there is no one-size-fits-all solution to reduce threats, it is important to assess vulnerabilities and risks through a suite of tools and strategies. In doing so, we will be more equipped to investigate options and prioritize actions that are most suitable to a given community or environment. Through visualization and mapping tools, facilitation and trainings, and robust analyses, we can continue to build more resilient communities and ecosystems; and the state is committed to enhancing training and educational opportunities so we are equipped to assess vulnerability and prioritize appropriate action and response at a range of scales.

Next Steps

O-4.1. Provide continual grants and funding for community-based vulnerability assessments.

- **O-4.1a.** Seek input from residents, beach users, local businesses, and other stakeholders affected by climate impacts in the community through workshops and community events, and ensure that these workshops are accessible to the most vulnerable stakeholders.
- **O-4.1b.** Continue to identify and map coastal infrastructure and vulnerable assets, such as water, energy infrastructure, ports, tourism, and fishing sites.

O-4.2. Assess the vulnerability of archaeological sites and natural and cultural resources to sea level rise.

- **O-4.2a.** Work with tribes on participatory mapping of coastal tribal resources and development of vulnerability assessments.
- **O-4.2b.** Initiate vulnerability study of the Department of Parks and Recreation's natural and cultural resources' exposure to sea-level rise.

O-4.3. Study the vulnerability of ecosystems to impacts of climate change such as northward species shifts, lower productivity and food, exotic species, reduced coastal water quality, toxic algae blooms, health hazards, inundation of beaches and wetlands.

- **O-4.3a.** Identify critical areas of habitat at risk along the coast and areas needed to allow them to migrate as seas rise; prioritize funding to acquire and preserve them.
- **O-4.3b.** Identify vulnerability of coastal beaches and wetlands and priority upland transition sites.

Ongoing Actions

- The State provides support for vulnerability assessments through resources like:
  - Decision support tools for coastal storm surge in a changing climate.
  - Cal-Adapt sea level rise maps.
  - FEMA Flood Risk Reduction Project identification.
  - the Adapting to Rising Tides Program.
- The Department of Parks and Recreation is conducting an assessment of its infrastructure and natural and cultural resources' exposure to sea-level rise.
- The State is conducting a statewide coastal habitat vulnerability assessment.
- The State Coastal Conservancy provides Climate Ready program vulnerability assessment grants. The Ocean Protection Council's Local Coastal Program Grant Program also supports the development detailed local sea level rise vulnerability assessments and adaptation plans

- The State Lands Commission maps existing and proposed coastal infrastructure leases and legacy coastal hazards, and it identifies sites that are vulnerable to climate change impacts.
- California coastal zone management agencies are undertaking many related assessments like:
    - a Coastal Commission synthesis of sea level rise vulnerability assessments and information by county and statewide summary report.
    - a complete multi-sector, county scale rising sea level vulnerability assessments for all nine counties that touch San Francisco Bay.
    - an assessment of sand resources on the California outer continental shelf
    - finalized vulnerability assessments, including sea level rise, of all Department of Water Resources facilities.

Recommendation O-5: Widely communicate guidance, data, and resources for ocean and coastal adaptation strategies, further outreach and education efforts, and provide pathways for meaningful community engagement

Ongoing outreach is needed to raise awareness and improve understanding of the impacts of climate stressors on valuable coastal and ocean communities and resources. There are a variety of tools to facilitate implementing successful implementation strategies, such as policy guidance documents, models and viewers that demonstrate where areas may be impacted by climate stressors such as sea-level rise or ocean acidification. Once these tools are finalized, agencies work to communicate how to use these tools and why and how they are applicable to local or regional jurisdictions, such as cities, counties or regions. Agencies should also advance and expand outreach and education efforts and climate related training activities to ensure that vulnerable communities are prepared for and can effectively plan for the impacts of climate change.

Next Steps

O-5.1. Conduct outreach and communication on impacts to beaches, dunes, and wetlands from "coastal squeeze," when shoreline protection and other development prevent the inland migration of shoreline habitats, leading to inundation of that land area and loss of habitat/beach area. Communicate best practices for managing coastal squeeze, such as natural infrastructure.

O-5.2. Develop best practices for seeking inclusive participation in planning decisions related to sea level rise and climate change along the coast. Use targeted, culturally-sensitive communication to engage underserved, low income, and linguistically isolated communities and communities of color, and strategies such as providing interpreters, offering a variety of venues for public comment, and locating community meetings so that they are accessible to public transportation and closest to communities most affected by climate impacts.

O-5.3. Continue outreach/training of local officials regarding implementing adaptation options through updates to Local Coastal Programs, Hazard Mitigation Plans, General Plans, and/or other relevant planning documents.

O-5.4. Conduct relevant outreach directly to specific marine resource users and sector communities, like fishers, who may be impacted by climate change.

O-5.5. Engage community and increase education opportunities through citizen science projects that further our understanding of climate impacts.

O-5.6. Employ community-based habitat restoration, involving individuals, organizations, and academic institutions, in helping to improve and restore coastal habitat in their communities.

O-5.7. Expand existing public awareness programs like the California King Tides website and the Whale Tail Program.

Ongoing Actions

- The Integrated Climate Adaptation and Resilience Program at the Governor's Office of Planning and Research coordinates regional and local efforts with state actions to adapt to the impacts of climate change, emphasizing climate equity considerations across sectors and regions and strategies that benefit both greenhouse gas emissions reductions and adaptation efforts, in order to facilitate the development of holistic, complementary strategies for adapting to climate change impacts.

- A California Department of Fish and Wildlife Climate College climate education course focused on climate science and adaptation issues in the marine environment for California Department of Fish and Wildlife staff and partners, and lecture materials are archived online
- The Marine Life Management Act (MLMA) Master Plan Amendment Discussions for Interested Stakeholders, webinars and meetings are led by the California Department of Fish & Wildlife Climate Ready Webinars through the State Coastal Conservancy.
- The Whale Tail Grant Program educates children and the public on marine and coastal issues while supporting beach maintenance and habitat restoration projects.
- The California King Tides Project is a great example of citizen science initiatives in partnership with federal, state and local organizations that help validate coastal inundation models.
- The Quick Guide Coastal Appendix provided through the Department of Water Resources gives guidance for communities to consider when integrating climate change adaptation into their coastal planning for the Federal Emergency Management Agency's National Flood Insurance Program. This supports National Flood Insurance Program Community Assistance Visit Workshops across the state to aid communities in maintaining their National Flood Insurance Program eligibility.
- Other education, and outreach efforts that the State supports include:
    - the Adapting to Rising Tides Program.
    - the Policies for a Rising Bay Project.
    - Bay Plan Climate Policies.
    - training and presentations on the California Coastal Commission's Sea Level Rise Policy Guidance.
    - Coastal Commission reports and website updates, including creation of a web tool, to communicate coastal county and statewide vulnerabilities as well as case studies on Local Coastal Program update efforts.
    - the engagement strategy around the update to the State of California Sea-level Rise Guidance Document.
    - the International Alliance to Combat Ocean Acidification (OA Alliance) and creation of an action plan to address ocean acidification in California.
    - a climate change and sea-level rise training program for State Lands Commission staff, which includes training on how to incorporate sea-level rise analyses into lease conditions.

Recommendation O-6: Coordinate across agencies and with external partners to ensure efficient problem solving to address climate change impacts.

State agencies that work with ocean issues are continuously collaborating and exchanging information to address changing ocean and coastal conditions due to climate change. Because ocean currents and resources are not bounded by traditional jurisdictional lines, it is critical that agencies collaborate across their jurisdictions in order to safeguard the health of our ocean and coastal ecosystems and resources, with a particular focus on safeguarding vulnerable populations. Impacts such as sea-level rise, ocean acidification and hypoxia, and storm surge and severe storm events vary in severity along the California coastline, and require effective coordination and planning to ensure successful adaptation of our coastal communities, ecosystems and economies. Many state agency working groups and task forces are targeting specific climate change issues on the ocean and coast to address climate change impacts on our ecosystems, resources, and communities, and to ensure successful adaptation within the state to the impacts of climate change.

Next Steps

O-6.1. Continue collaborating across agencies to ensure a nimble and efficient response to emerging climate change impacts on the ocean and coastal regions

O-6.2. Work with external partners to ensure that robust science, policy and outreach is conducted, and that state resources and guidance are widely communicated across California

Ongoing Actions

- California extensive coastline and will be affected in many ways by sea-level rise and other climate change impacts, so state government is undertaking extensive efforts to coordinate and collaborate on adaptation actions. Coordinating bodies for these efforts include:
    - the Safeguarding and Adaption Working Group of the Climate Action Team (SafeCAT)
    - the Research Working Group of the Climate Action Team (Research-CAT)
    - the Coastal and Ocean Working Group of the Climate Action Team (CO-CAT)
    - the State Coastal Leadership Group on Sea-level Rise
    - the Coastal Sediment Management Working Group
    - the Sea-level Rise and Floodplain Management Focus Group
    - the Bureau of Ocean Energy Management (BOEM) Intergovernmental Renewable Energy Task Force
    - the Pacific Coast Collaborative Subcommittee on Ocean Acidification
    - the International Alliance to Combat Ocean Acidification (OA Alliance)
    - the Interagency Harmful Algal Bloom (HAB) Task Force
    - the San Francisco Bay Regional CHARG (Coastal Hazards Adaptation Resiliency Group)
    - a sea-level rise mapping coordination group
    - the Technical Advisory Council of the Integrated Climate Adaptation and Resilience Program
    - West Coast Ocean Partnership and West Coast Regional Planning Body
    - the Pacific Marine and Estuarine Fish Habitat Partnership and its studies of key species use of estuarine habitats as nursery areas
- Critically, state government takes care to align sea-level rise adaptation planning with state and local Hazard Mitigation Planning to achieve coastal community resilience.

Water

The data are irrefutable: California's hydrology is already changing due to global climate shifts. The vulnerability of the water sector to climate change stems from a modified hydrology that affects the frequency, magnitude, and duration of extreme events, which, in turn, affect water quantity, quality, and infrastructure. Changes in hydrology include declining snowpack, earlier snow melt, more precipitation as rain than snow, more frequent and longer droughts, more frequent and more severe flooding, changes in the timing and volume of peak runoff, and consequent impacts on water quality and water availability. Vulnerabilities of water resources include changes to water supplies, land subsidence, increased water pollution, erosion, flooding, and related risks to water infrastructure and operations, degradation of watersheds, alteration of ecosystems and loss of habitat, multiple impacts in coastal areas, and ocean acidification. Additionally, rising sea level will produce higher storm surges during coastal storms, and climate impacts are reducing the percentage of annual precipitation that falls as snow.

California is preparing for and addressing impacts of climate change comprehensively across all components of the water cycle. Continued progress will require maintaining efforts to coordinate among federal, state, and local resource managers and to present key actions and tangible next steps in the State's adaptation strategy. This update builds consistency and alignment with the most up-to-date information, and past adaptation work and roadmaps within the water sector, such as the California Water Action Plan.

The Department of Water Resources (DWR) and the State Water Resources Control Board (Water Board), along with other agencies, have updated their recommendations on how to make water systems more integrated, more resilient, and able to adapt to impacts of climate change. There is a great deal of work to be done, but California has a solid foundation to continue to safeguard its people, environment, and economy into the future.

Safeguarding California's Water Supply from Climate Change

Two of every three Californians gets some or all of their drinking water from the Sacramento-San Joaquin Delta, where nearly half of the state's land mass drains in a web of channels to San Francisco Bay. The Delta is home to the central pumping plants of the state's two biggest water projects. Climate change threatens the delivery of water from these two projects in several ways. As sea levels rise, saltwater from the Bay will push deeper into the Delta, closer to the pumping plants, and repelling it will require the release of greater volumes of water from upstream reservoirs. Drawing down reservoirs to repel salt will make it harder to keep rivers cool for young salmon and meet water supply needs. As average temperatures warm, Californians can expect heavier rain and less snow, which will increase peak flood runoff – and pressure against the Delta's aging, earthen Delta levees. A failure of levees could cause saltwater to rush deep into the Delta toward the water project pumps. To avoid interruptions of water supply deliveries and restore more natural flow patterns in the Delta, the state proposes to build new water project intakes along the Sacramento River and 35-mile-long tunnels to convey water under the Delta to the existing pumping plants. At an estimated cost of $17.1 billion, California WaterFix is the state's single most expensive and far-reaching climate change adaptation project.

Recommendation W-1: Vigorously prepare California for flooding.

More than seven million Californians and $580 billion in assets are exposed to the hazards of flooding. Flooding occurs in nearly every part of California, and has cost hundreds of lives and billions of dollars in damage. Climate change heightens the threat of high stream flow levels due to increases in frequency and magnitude of extreme precipitation in a warmer climate. More must be done to reduce flood risk.

Next Steps

W-1.1. DWR will work with the U.S. Army Corps of Engineers to determine the potential for updating specific reservoir Flood Control Rule Curves – the manuals that guide reservoir operations to ensure flood safety -- to reflect current science and engineering methodologies and climate-induced changing hydrology.

W-1.2. DWR will propose legislation requiring once-a-decade updates to non-federal dam Emergency Action Plans and related dam failure inundation maps.

W-1.3. DWR will work so that dam owners are required to examine a wider range of scenarios beyond the complete fair weather failure of the dam in their Emergency Action Plans.

W-1.4. DWR will ensure collaboration with federal agencies including the National Oceanic and Atmospheric Administration and the National Aeronautics and Space Administration, as well as the research community, on improving both monitoring and scientific understanding of the role of the climate system in extreme precipitation events in order to better inform water management during extreme events and changing snowpack. The following areas of collaboration for research should continue to be prioritized:

- **W-1.4a.** Atmospheric rivers
- **W-1.4b.** Rain and snow trends
- **W-1.4c.** Upland watershed monitoring
- **W-1.4d.** Seasonal winter outlooks
- **W-1.4e.** Sea-level rise
- **W-1.4f.** Paleohydrology

W-1.5. DWR and the Water Board will collaborate with federal, State and local agencies as well as the research and academic community to assess the adverse impacts to human health and safety, industries, water and other physical infrastructures, communities and ecosystems of floods and related extreme events.

W-1.6. DWR will support collaboration and communication of flood models that incorporate climate impacts in the Regional Flood Management Plans.

W-1.7. DWR will update grant guidelines and proposal solicitations for its Small Community Flood Risk Reduction and Urban Flood Risk Reduction programs to include consideration of future projections of flood flows and to support climate change adaptation in future rounds of funding.

W-1.8. DWR will work to develop flood inundation maps for major stream systems that consider future projections of hydrology in cooperation with the Federal Emergency Management Agency and the U.S. Army Corps of Engineers.

W-1.9. DWR will incorporate future climate extremes and variability in its Flood Investment Strategy included in the Statewide Flood Management Planning Program, which works with organizations across the state to develop flood management policies and guide financial investments to protect people and property.

Ongoing Actions

- The Central Valley Flood Protection Board's 2017 Central Valley Flood Protection Plan Update incorporates climate change in order to assess the true costs of managing flood waters to protect the State Plan of Flood Control facilities for the design life of structural and non-structural investments.
- The Central Valley Flood Protection Board is undertaking ongoing efforts to incorporate and prepare for future climate extremes and variability in its Flood Investment Strategy, included in the Central Valley Flood Protection Plan.
- DWR will continue its close collaboration with the Governor's Office of Emergency Services (Cal OES) in the preparation of the State's 2018 Hazard Mitigation Plan.
- DWR collaborates closely with Cal OES during regional and statewide flood emergencies, and disaster emergency response plans include emergency support function decision support matrices that require coordination among the department, Cal OES and the Federal Emergency Management Agency. Strengthening these activities helps support climate change adaptation because increased flood risk is projected to occur in the future.
- The Water Board, DWR, and other state and local land use agencies continue collaboration to prioritize storm water capture and infiltration.
- The Water Board is funding up to $186 million in storm water capture and infiltration projects through Proposition 1 that provide multiple benefits including attenuation of flood flows and increased groundwater recharge.
- The Water Board is implementing the 2016 Strategy to Optimize Resource Management of Storm Water (Storm Water Strategy), a high-level planning effort that will, in addition to capturing and treating storm water, result in local and regional storm water management that produces multiple benefits, including reduced or attenuated flooding of downstream utilities, facilities, and water bodies, and increased coordination and cooperation among wastewater, storm water, flood management, transportation, and drinking water agencies.
- Municipal Separate Storm Sewer System National Pollutant Discharge Elimination System permits include provisions that result in multiple benefits, including reductions in flooding.
- The Water Board will continue to promote low-impact development strategies to manage storm water and attenuate localized flooding.

Recommendation W-2: Support regional groundwater management for drought resiliency.

During a typical year, approximately 40 percent of the state's total water supply comes from groundwater. During dry years, groundwater provides 60 percent (or more) of the state's total supply, and serves as a critical buffer against the impacts of drought and climate change. With the 2014 enactment of the Sustainable Groundwater Management Act (SGMA), which provides new authorities for local agencies to directly manage groundwater resources, the State is making progress on the recommendation to support regional groundwater management for sustainability and drought resiliency. Moving forward, state government needs to further its work to support the formation of groundwater sustainability agencies and implementation of groundwater sustainability plans in coordination with other flood and water management plans.

Next Steps

W-2.1. DWR will provide water budget and climate change datasets, tools and guidance to support groundwater sustainability agencies in their evaluation of potential climate change impacts in groundwater sustainability plans by the January 2020 or 2022 deadlines.

W-2.2. DWR will update its groundwater basin prioritization to include assessment of adverse impact on local habitat and local streamflow and also use the best available statewide data sets for analysis.

W-2.3. DWR will provide technical and financial assistance from Proposition 1 to local agencies to support groundwater sustainability plan development.

W-2.4. The Water Board will prepare for the possibility of state intervention to ensure groundwater resources can be protected in the event that local groundwater management efforts are not successful. Preparation includes development of a fee schedule and the capacity to collect groundwater extraction data.

W-2.5. DWR will evaluate the groundwater sustainability plans and alternative plans according to adopted regulations, and will coordinate with the Water Board to ensure state intervention is effective and appropriate.

W-2.6. DWR will estimate water available for replenishment need to be refined to provide ongoing support and technical assistance to groundwater sustainability agencies, and to assist in the review of the department's Water Available for Replenishment analysis included in groundwater sustainability plans. The timing and magnitude of a wide range of potential climate change effects may lead water managers to different conclusions and decisions, highlighting the need to consider the effect of climate change on both water budgets and water availability estimates.

W-2.7. DWR will work with federal, state and regional partners and land use agencies to explore and implement easements and projects for temporary storage of flood waters on agricultural lands to increase groundwater replenishment during periods of high water.

Ongoing Actions

- DWR provides facilitation services to support the local agencies in forming groundwater sustainability agencies to meet the SGMA formation deadline and to support development of groundwater sustainability plans.

- DWR published its initial Draft Report of Water Available for Replenishment in January 2017 and will periodically update the analysis and report to provide planning guidance to groundwater sustainability agencies, and provide information on interregional groundwater interaction, groundwater dependent ecosystems, and stream-aquifer connections.
- DWR developed and adopted regulations for Basin Boundary Modification that were implemented in 2016 and will be the basis for future periodic basin boundary updates.
- DWR published best management practices and selected guidance documents in December 2016 to help groundwater sustainability agencies and other stakeholders develop groundwater sustainability plans. These documents will be updated periodically as better information becomes available.
- DWR will continue to improve and build new tools to support groundwater sustainability agencies and local agencies to report information and data and to support their water management efforts.
- DWR will include progress on achieving sustainable groundwater management by local agencies through periodic updates of Bulletin 118, California's official compendium on the occurrence and nature of groundwater statewide.
- The Water Board's permits for Aquifer Storage and Recovery projects support groundwater replenishment with treated drinking water during times when water is available. The Water Board will continue its efforts to ensure an effective permitting process.
- The Water Board continues to evaluate the issuance of temporary water right permits that allow for underground storage of flood flows and continue to evaluate how processes for capturing flood flows can be efficiently permitted.
- With $744 million in Proposition 1 grants, the Water Board is funding projects that clean up and prevent contamination of groundwater that serves as a source of drinking water.

Recommendation W-3: Diversify local supplies and increase water use efficiency.

California faces the threat of greater scarcity of water supplies, increased water demand, and limited water supply reliability. State government needs to promote and incentivize regional self-reliance, diversified local water supply portfolios and maximized water conservation, water use efficiency, as well as improved storm water management for groundwater recharge.

Next Steps

W-3.1. DWR will publish "Managing for Regional Sustainability: DWR's Strategic Path Forward."

W-3.2. DWR, the State Water Board, and other agencies will work together to develop methodology and standards for urban water suppliers to set targets for indoor use, outdoor irrigation, commercial, industrial, and institutional water use.

W-3.3. DWR and the Water Board develop and implement actions to minimize water system leaks and set performance standards for water loss.

W-3.4. The Water Board will develop conservation regulations and rules that permanently prohibit water waste.

W-3.5. The Public Utilities Commission and the California Energy Commission will certify innovative technologies for water conservation and efficiency.

W-3.6. The Water Board will initiate Phase II projects of its Storm Water Strategy supporting the objective to increase storm water capture and use through regulatory and non-regulatory approaches.

W-3.7. The Water Board will work to address knowledge gaps and conduct additional research related to the protection of public health and direct potable reuse of recycled water, and to draft regulations for direct potable reuse of recycled water.

W-3.8. DWR and the California Department of Food and Agriculture will strengthen and expand the requirements for Agricultural Water Management Plans to include water budgets, measures to increase water use efficiency, and drought contingency plans, and to require such plans by a greater number of water suppliers.

Ongoing Actions

- DWR and the Water Board manage many grants and programs to increase regional planning and coordination which improve self-reliance, diversification of local water supplies, and increase water use efficiency, with some promoting multiple benefit approaches.
- The Water Board's Storm Water Strategy to incentivize statewide use and redefine storm water as a resource results in local storm water management that produces multiple benefits that will contribute to diversification of local supplies through, but not limited to, replenishment of depleted groundwater aquifers, increased storm water use for local irrigation and non-potable water demands, increased flows in local streams and rivers, incentives for regionalization of local utilities, increased regional and local community partnering, and joint-involvement in regional and local water resource management. In addition to increased water supply, the resulting multiple benefits for California communities include improved water quality, increased space for public recreation, increased tree canopy, restoration of natural hydrograph, and enhanced stream and riparian habitat area.
- Statewide water conservation requirements, and prohibition of wasteful water use practices will continue to be implemented under the Water Board's forthcoming long-term water conservation regulation.

- The Water Board adopted a General Order for recycled water use to streamline permitting of non-potable recycled water projects statewide, and encourage recycled water projects by acknowledging recycled water as a resource, and allowing recycled water programs that are implemented in multiple Regional Water Board boundaries to be permitted by the Water Board. These actions support the state goal of increasing the use of recycled water in California by 200,000 acre-feet per year by 2020 and by an additional 300,000 acre-feet per year by 2030.
- The Water Board is developing the Surface Water Augmentation regulation which will provide guidance on how to safely use recycled water to augment a drinking water surface reservoir.
- DWR's Integrated Regional Water Management grant program contributes to the state's climate change efforts through the establishment of plan standards that address climate change and must be used to evaluate projects included in the plan development or update. The implementation grant program funds projects that include greenhouse gas reduction or climate change adaptability as a primary or secondary benefit.

Recommendation W-4: Reduce Sacramento-San Joaquin Delta climate change vulnerability.

Nearly half of the land mass of California drains to San Francisco Bay through the Sacramento-San Joaquin Delta (Delta). The largest estuary on the West Coast, the Delta is a source of drinking water for two-thirds of the state's population and millions of acres of productive farmland. The Delta also serves as an important corridor for Chinook salmon and provides habitat for abundant wildlife, including threatened and endangered species. Once a mosaic of habitats that included vast wetlands, the Delta has been drained and diked into dozens of farmed islands ringed by levees. As the Delta's dried, tilled peat soil oxidizes, many of the islands are sinking – some are already 15 to 20 feet below sea level. The Delta's more than 1,000 miles of levees are vulnerable to collapse from earthquakes and the climate change effects of sea-level rise and more severe storms. The failure of multiple levees could cause saltwater to rush inland and contaminate the drinking water source for 25 million people. The State needs to further its work in reducing vulnerability of Delta levees, restoring lost habitat, and reducing reliance by water districts around the state on the Delta for water supply.

Next Steps

W-4.1. The Water Board is in the process of a phased process to update and implement the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan (Bay-Delta Plan), which sets water quality and flow standards designed to protect the many beneficial uses of Delta water. Phase 1 involves updates of lower San Joaquin River flow requirements, and southern Delta salinity requirements. Phase 2 involves updates to Delta outflow, Sacramento River tributary and Delta eastside tributary inflow, coldwater habitat and interior Delta flow requirements. The updates to the Bay-Delta Plan and its implementation will include adaptive management provisions to address and respond to scientific advances, changing environmental conditions including climate change, and habitat restoration actions, and changes in water supply infrastructure.

W-4.2. The Natural Resources Agency will coordinate and advance at least 30,000 acres of critical habitat restoration in the Delta during the next four years through California EcoRestore program.

W-4.3. The Department of Fish and Wildlife's will develop the Delta Conservation Framework to guide Delta conservation planning and investment until 2050.

W-4.4. The State will permit and build California WaterFix, the State-federal project to install new intakes in the northern Delta and carry water underground to the existing federal and state water project pumping plants in the southern Delta. WaterFix would safeguard water supplies from levee collapse and salinity intrusion and allow for more natural flow patterns in the Delta.

Ongoing Actions

- DWR and the U.S. Bureau of Reclamation continue work to finalize the environmental analysis for WaterFix and pursue permits from the Water Board, National Marine Fisheries Service, U.S. Fish and Wildlife Service and other agencies.
- DWR continues its work to convert marginal farmland on Sherman and Twitchell islands in the western Delta into wetlands and demonstration plots for alternative farming practices. The pilot study and proof of concept will support larger-scale projects that reduce and reverse subsidence, sequester greenhouse gases, and improve water and air quality on Delta peatlands.
- The Delta Conservancy is working with local private land owners to

- The Delta Conservancy is working with a large partnership of agencies, landowners, and academics to promote carbon management practices in the Delta by getting landowners to "grow" carbon through wetlands for profit by utilizing a newly approved California Wetland Carbon voluntary protocol that allows those carbon savings to be sold in international markets.
- California EcoRestore continues to pursue habitat restoration projects to address aquatic and terrestrial ecosystem needs in order to improve the overall health of the Delta.

Recommendation W-5: Prepare California for hotter and drier conditions and improve water storage capacity.

California faces the threat of a hotter and drier climate. In addition to increased groundwater, surface storage and conjunctive use water management, strategies to increase resilience under such conditions include flood and storm water management for augmenting water supply, water recycling, conservation and efficiency, and groundwater replenishment and sustainable management. The State is poised to make its biggest new water storage investment in a generation as the California Water Commission administers $2.7 billion from Proposition 1 to pay for the public benefits of new groundwater or surface storage projects. Through a competitive process, the Water Commission expects to award funds as soon as 2018.

Next Steps

W-5.1. The Water Commission, working with other state water and wildlife agencies, will complete review of applications submitted to its $2.7 billion Water Storage Investment Program, ensuring that all projects are evaluated for performance under changing future conditions.

W-5.2. DWR will develop and maintain research partnerships relevant to the observation, prediction, and management of atmospheric rivers including changes in atmospheric river characteristics associated with climate change.

W-5.3. DWR will help produce scientific research to explore and develop probabilistic estimates of drought vulnerability in California under future climate conditions.

W-5.4. DWR and the Water Board will continue to develop partnerships that foster scientific research to provide additional relevant information to support policy and operations.

W-5.5. Under its Drought Contingency Plan, DWR will coordinate climate change adaptation activities with drought preparedness.

W-5.6. DWR will work with other state, federal and local agencies to evaluate the potential effects of reoperating the state's flood management and water supply systems in the context of climate change as part of its System Reoperation Study.

W-5.7. DWR will support urban water suppliers in the development of more consistent and substantive water shortage contingency plans that include a five-year drought risk assessment and annual water budget forecasts, and work with communities to develop drought response actions.

Ongoing Actions

- Proposition 1, the $7.5 billion water bond passed overwhelmingly by California voters in 2014, includes $2.7 billion for investments in water storage projects. The Water Storage Investment Program will fund the public benefits of project throughout the state that provide measurable benefits to the Delta ecosystem or its tributaries. The California Water Commission adopted regulations in December 2016 to guide the investment of public benefits associated with new storage projects. Projects must evaluate performance under changing future conditions.
- The California Department of Water Resources will participate in and collaborate with science partnerships such as the U.S. Global Change Research Program Water Management Indicators Work Group and NASA's Western Water Applications Office to further develop water management related science objectives that could be used in climate change tracking and the development and refinement of adaptation strategies.

- The State Water Resources Control Board administers drought-related emergency grants and loans for drinking water, and assists in identifying and permitting alternative water supplies for public water systems anticipating severe shortages or water outages, with funding approach prioritizing disadvantaged communities and low-income households.

Recommendation W-6: Address water-related impacts of climate change on vulnerable and disadvantaged populations and cultural resources.

Under California's Human Right to Water Policy, "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption." However, for millions of Californians, the costs of drinking water are unaffordable, and many of the state's residents do not have access to clean and reliable drinking water. Disadvantaged communities that already have problems in securing safe water and sanitation are unlikely to have the capacity to deal with additional challenges to water quality and quantity climate change could cause to drinking water and wastewater infrastructure. The State must support the resilience of communities to withstand, recover, and learn from the impacts of climate change. The State must prioritize aid to disadvantaged communities facing public health risks.

Next Steps

W-6.1. The State will ensure disadvantaged communities receive an equitable distribution of benefits from State processes and technical and financial assistance programs, and assist with climate change information about communities where climate change might pose undue burden.

W-6.2. DWR will award grants to small communities protected by facilities of the State Plan of Flood Control to complete feasibility studies that have the goal of increasing small community flood protection to the 100-year level. Improving the level of flood protection should include climate change projections.

W-6.3. The Water Board will develop funding guidelines for a new $9.5 million grant program that will improve access to clean drinking water in public schools and prioritize funding small disadvantaged communities.

W-6.4. The Water Board and the Office of Environmental Health Hazard Assessment will identify communities most vulnerable to climate change impacts to ensure access to information and technical assistance.

W-6.5. The Water Board will work to provide technical assistance and financial support to protect drinking water systems that are highly vulnerable to climate change impacts, with emphasis on disadvantaged communities and vulnerable populations as directed by the March 2017 resolution.

W-6.6. The Water Board will work to develop and provide information and public outreach on potential climate change impacts to water quality, and options and funding opportunities for adapting to those impacts, including protecting source watersheds, drinking water and wastewater treatment infrastructure.

W-6.7. The Water Board will increase outreach to environmental justice and disadvantaged communities and Native American tribes in collaboration with non-governmental organizations.

Ongoing Actions

- The Water Board has launched the Human Right to Water Portal with information on state efforts to assist local communities in addressing contamination problems and improve access to safe, affordable drinking water.
- The Water Board's Household and Small Water System Drought Assistance Program, administered by three not-for-profit organizations, provides grants and loans to small water

systems and individual households to address drought-related drinking water emergencies, with funding approach prioritizing disadvantaged communities and low-income households.

- Financial and technical assistance for permanent and sustainable solutions for provision of safe, clean, affordable, and reliable drinking water, and for wastewater treatment services, particularly for small systems and disadvantaged communities are provided through the Water Board's Office of Sustainable Water Solutions.
- The Water Board's Cleanup and Abatement Account administers grant funding to address drinking water emergencies and urgent drinking water needs, including improvements to water quality and water supply, with a funding approach that prioritizes disadvantaged communities.
- Proposition 1 allocates $260 million to the Clean Water State Revolving Fund Program's Small Community Wastewater Grant Fund to assist small disadvantaged communities in addressing their wastewater needs.
- The Drinking Water State Revolving Fund Program provides low-interest loan and grant agreements for planning and infrastructure improvements and related actions to meet safe drinking water standards, ensure affordable drinking water, or both. Proposition 1 funding is only available for projects benefiting small, disadvantaged communities.
- The Water Board priority is to facilitate and fund the consolidation of small drinking water systems serving disadvantaged communities through coordination with funding partners, and stakeholders, as identified in the 2015 Safe Drinking Water Plan for California report.
- DWR prioritizes disadvantaged communities in all Water-Energy grant programs, funded through the Greenhouse Gas Reduction Fund.
- California Conservation Corp crews work in vulnerable and disadvantaged communities on climate-related projects such as turf removal, irrigation retrofits, plumbing retrofits, erosion control on riverbanks, flood preparedness, and flood fighting.
- DWR conducts climate change coordination activities with Native American tribes, collaborating with regard to climate change tracking, impacts, and adaptation.

Recommendation W-7: Continue to mainstream climate considerations into water management through improved understanding of climate risks and tool development.

Warmer temperatures, reduced snowpack, extreme precipitation events and more severe droughts all severely impact water management. California has played a leadership role support for and use of downscaled climate change models. State government can build on improved scientific understanding of the causes, impacts and risks of climate change to state water resources by developing tools and outreach for water managers for coordinated adaptation actions.

Next Steps

W-7.1. DWR will complete and disseminate results from the Vulnerability Assessment and Adaptation Plan from its Climate Action Plan. The primary water system analyzed is the State Water Project, but the tools used can be applicable to local water management agencies.

W-7.2. The Public Utilities Commission will develop a new urban water resilience modeling tool to assess water system capability resilience metrics such as the ability to respond to and recover from a disturbance.

W-7.3. DWR will revise its Economic Analysis Guidebook to include economic analyses that consider a broader accounting of costs and benefits, valuation of ecosystem services, and sustainability indicators and metrics

W-7.4. DWR will work with the Energy Commission and the Natural Resources Agency to continually incorporate the best available water-related climate data on Cal-Adapt.org, including updated projections for precipitation and snowpack, for local climate change planning data.

W-7.5. DWR will employ advanced techniques for decision making under deep uncertainty to assess the vulnerability of activities and assets under State control that face the greatest climate change threats and the adaptation strategies that can be employed to minimize or mitigate those threats under a wide range of future risk scenarios.

W-7.6. The Water Board will incorporate climate change considerations consistently across all activities, and one of the first steps is to obtain access to relevant data and model outputs.

Ongoing Actions

- As part of DWR's Climate Action Plan: Phase II, climate change scenario selection is being coordinated and standardized across all of the department's programs and for local water management, including legislatively mandated programs such as SGMA and the Water Storage Investment Program. This activity builds on a three-year collaboration with DWR's Climate Change Technical Advisory Group and activities by other state agencies and the State's Fourth Climate Change Assessment to draw from a consistent set of potential future climate change projections.
- DWR is developing new methodologies to estimate the water content of the Sierra Nevada snowpack using aerial and satellite based technology.
- In partnership with the Federal Emergency Management Agency and the U.S. Army Corps of Engineers, DWR is updating flood inundation maps for the National Flood Insurance Program and for community risk awareness. Utilize new methodologies to conduct flood risk assessment

across the full spectrum of return period flood events and do not limit analysis to the 100-year return period flood.

- Baseline data collection is ongoing through the Water Board's Surface Water Ambient Monitoring Program and the Groundwater Ambient Monitoring and Assessment, which will inform adaptive management in response to climate change stressors.
- DWR and the State Climatologist's Office is now publishing an Annual Hydroclimate Report that includes a broad range of climate-related metrics, a discussion of climate signal detection, and possible approaches to improve knowledge of climate impacts.
- DWR is working in partnership with the National Weather Service to coordinate volunteer participation in citizen science activities such as the Community Collaborative Rain Hail and Snow (CoCoRAHS) Observation Network. This data will support climate change assessments of potential precipitation changes in the state.
- Cross-cutting risks are addressed through DWR's white paper "Connecting the Dots between Water, Energy, Food, and Ecosystems Issues for Integrated Water Management in a Changing Climate."
- DWR collaborates with the University of California on a number of water-related climate science studies and with other federal agencies on studies, tools, and observations that improve our understanding and increase our capacity to respond to water management risks impacted by climate change.
- DWR will continue to engage water agencies and support public understanding of climate change by sharing data and science on observations, impacts and climate change projections for water supply, educational training, and guidance materials.

Recommendation W-8: Utilize low-impact development and other methods in state and regional storm water permits to restore the natural hydrograph.

The State is well on its way in making progress on this recommendation with the adoption of the statewide Strategy to Optimize Resource Management of Storm Water (Storm Water Strategy), which provides a vision, mission, goals, objectives, and specific projects to establish the value of storm water as a resource in California. Storm Water Strategy projects will evaluate existing programs, incentivize integrated water management and storm water capture and use, and emphasize low impact development. The resulting multiple benefits for California communities include improved water quality, increased water supply, and increased space for public recreation, increased tree canopy, and enhanced stream and riparian habitat area. This action area supports actions for greening and reduction of urban heat island effects and water resources for important ecosystems.

Next Steps

W-8.1. The Water Board will initiate Phase II projects of the Storm Water Strategy supporting the objective to increase storm water capture and use through regulatory and non-regulatory approaches.

W-8.2. The Water Board will develop technical guidance and permitting tools to promote statewide implementation of post-construction requirements based on watershed processes.

W-8.3. The Water Board will incorporate Storm Water Strategy elements/products in regulatory permits.

Ongoing Actions

- Green infrastructure and low-impact development designs are being facilitated through permits.
- Implementation of the Water Board's Storm Water Strategy offers multiple benefits, including improved water quality, more diversified water supply, increased space for public recreation, increased tree canopy, restoration of natural hydrograph, and enhanced stream and riparian habitat area.
- The Water Board will continue to collaborate with the Natural Resources Agency on the Urban Greening Grant Program to support the combined benefits of storm water capture and groundwater recharge with greenhouse gas reduction.
- The Water Board Storm Water Grant Program promotes the beneficial use of storm water and dry weather runoff by providing financial assistance for projects that provide multiple benefits while improving water quality.

Recommendation W-9: Require closer collaboration and coordination of land use and water planning activities to ensure that each reinforces sustainable development that is resilient to climate changes.

California faces the threat of increasing scarcity of water resources and must foster sustainable development that minimizes water use and is resilient to climate change. The state should also strengthen alignment of land use planning and integrated water management, as described in the California Water Plan Update 2013, to facilitate stronger collaboration between land use and water planners.

Next Steps

W-9.1. OPR will support the integration of water resource and land use planning in the update of OPR's General Plan Guidelines.

W-9.2. DWR will implement SGMA's requirement for water and land use agencies to share information and develop consistent water and land use plans. When fully implemented, SGMA is expected to drive substantial improvements in collaboration and cooperation between land use and water agencies as groundwater sustainability agencies work to align their long-term water supplies and water demands and propose management actions to achieve sustainable groundwater management.

W-9.3. DWR will support the integration of water resource and land use planning considerations as part of climate resilience strategies in partnership with the U.S. Bureau of Reclamation on various watershed basin studies.

W-9.4. State agencies will use a common approach to incorporate agricultural land stewardship strategies in their programs and projects that consider multiple uses of the land, including production, flood management, groundwater recharge, habitat conservation and water supply benefits.

Ongoing Actions

- California Landscape Conservation Cooperative efforts to incorporate climate change planning in land use and water resources planning (such as the Central Valley Landscape Conservation Project resources and recommendations) are supported by State initiatives.
- DWR and Sonoma State University's Center for Sustainable Communities developed an integrated water and land management tool for comparing development outcomes of different residential land cover and infrastructure choices.
- State and Regional Water Boards continue to integrate statewide and regional policies, plans, and permits to incentivize:
    - The unification of planning efforts for drinking water, storm water, and wastewater with local land-use and climate change planning efforts; and
    - The regionalization of local utilities to address regional water and land-use objectives and goals.
- DWR released a Technical Methods Manual on how to amend/modify a Federal Emergency Management Agency Coastal Flood Insurance Rate Map to incorporate sea level rise. In response to an increased flood risk due to climate change, DWR will provide technical assistance to urban and urbanizing communities in the Central Valley to develop 200-year flood inundation maps that will guide sustainable development in accordance with the requirements of Senate Bill 5 (Machado, 2007).

Recommendation W-10: Protect and restore water resources for important ecosystems.

California faces the threat of losing or degrading critical habitats and ecosystem services. State government must advance its protection of aquatic and terrestrial ecosystem resilience in the face of climate change. This recommendation is tightly linked to the actions to protect and enhance the Delta ecosystem.

Next Steps

W-9.1. DWR will complete ecosystem services valuation and economic analysis for the next update of California Water Plan.

W-9.2. The Natural Resources Agency will continue to be a key partner in restoring wetlands habitat, minimize air pollution and protect against environmental degradation around the Salton Sea through its Salton Sea Management Program.

W-9.3. The Water Board and the Department of Fish and Wildlife will implement a suite of actions to enhance flows statewide in at least five stream systems that support critical habitat for anadromous fish, as identified in the California Water Action Plan released in 2014 and updated in 2016.

W-9.4. The Water Board will update plans, permits, and policies; coordinate with other agencies to enhance ecosystem resilience to the impacts of climate change; and work with relevant agencies to restore and maintain healthy watersheds, reduce vulnerability to catastrophic fires, and support resilience in recovery efforts as directed by a March 2017 resolution.

W-9.5. The Water Board will identify actions to minimize impacts associated with ocean acidification, hypoxia, increasing temperature and nutrients, and to support resilient ocean and coastal ecosystems.

Ongoing Actions

- State and Regional Water Boards provide ongoing support for aquatic ecosystem restoration through funding, permits, monitoring, and technical assistance on case-by-case basis.
- The Water Board continues to issue water shortage notices in water bodies where available water supply cannot satisfy the demand of senior water rights, or the flow needed for instream beneficial uses.
- The Water Board is developing models and associated tools to support its instream flow related work. These models will assist the Water Board in determining water availability and water demand in priority watersheds throughout the state and help to evaluate potential water supply effects from alternative management and climate change scenarios.
- The Water Board is integrating adaptive strategies in municipal and industrial permits to protect and restore the chemical, physical, and biological integrity of the state's surface and ground waters to ensure continued efficacy of regulatory programs during times such as drought.

Research to Safeguard Natural and Managed Resource Systems

The thirty-four high-level recommendations in the Natural and Managed Resource Systems constitute a comprehensive and interconnected policy framework to make California's natural resources more resilient to climate change. The State's investments in research through the Fourth Climate Change Assessment are designed to directly inform this comprehensive adaptation approach. This table shows how these ongoing research projects link to the existing adaptation framework while spurring new action to safeguard California.

Project Title	Informing Recommended Actions
The Impact of Changing Wildfire Risk on the California Homeowners' Insurance Market	**F-1, F-6, F-7**
Migration Corridors as Adaptation to Climate Change: Why, How, and What Next	**B-1, B-2, F-5**
Fuel Treatment for Forest Resilience and Climate Mitigation: Critical Review	**B-3, F-1, F-4, F-5, F-6**
Increasing Soil Organic Carbon to Mitigate Greenhouse Gases and Increase Climate Resiliency for California	**A-1**
Soil Water Dynamics, Carbon Sequestration, and Greenhouse Gas Mitigation Potential of Using Composted Manure and Food Waste on California's Rangelands	**A-1, A-3, W-9**
Economic and Environmental Implications of California Crop and Livestock Adaptations to Climate Change and Climate Policy	**A-3, A-4, A-5**
Innovations in Measuring and Managing Forest Carbon Stocks in California	**F-1, F-6, F-7**
Drought Planning and Climate Adaptation of Small Self-Sufficient Water Utilities	**A-2, W-2, W-3, W-5, W-6, W-7, W-9**
Assessing and Communicating the Impacts of Climate Change on the California Coast	**B-1, B-6, O-2, O-4, O-5**, **W-1**
Identification of Natural Infrastructure Options for Adapting to Sea Level Rise	**B-3, B-5, O-1, O-2**, **W-3**
California Mussels as Bio-Indicators of the Ecological Consequences of Global Change: Temperature, Ocean Acidification, and Hypoxia	**B-4, B-5, O-1, O-2, O-3**
Advancing Hydro-Economic Optimization to Identify Vulnerabilities, Tradeoffs, and Adaptation Opportunities in California's Water System	**W-2, W-5, W-7**
Addressing Institutional Vulnerabilities to Climate Change: Drought as Stress Test for Water Allocation and Environmental Protection	**B-5, F-5, O-2, W-2, W-5**
High Resolution Measurement of Levee Subsidence Related to Natural Gas Infrastructure in the Sacramento-San Joaquin Delta	**W-1, W-4**
Improving Hydrological Snowpack Forecasting for Hydropower Generation Using Intelligent Information	**W-7**
Modeling the Impact of Wildfires on California's Transmission and Distribution Grid	**F-6**
Investigations on the Impacts and Adaptation Options for Regional Electricity and Natural Gas Systems from Sea Level Rise	**O-1, O-2, O-5**

Tracking Progress in Safeguarding California

The hundreds of next steps identified across dozens of high-level policy recommendations in 10 different sectors in this plan show California's commitment to preparing for ongoing and inevitable climate impacts. With hundreds of additional ongoing actions, the sheer breadth and complexity of state climate change adaptation activity can make it difficult to develop a clear understanding of the State's achievements and opportunities for action.

While this 2017 update is built on the foundation of the 2009 *California Climate Adaptation Strategy*, 2014 *Safeguarding California: Reducing Climate Risk* plan, and 2016 *Safeguarding California: Implementation Action Plans*, there is a clear need to transparently track the State's progress in implementing adaptation actions. By institutionalizing comprehensive reporting and update processes, the State can better ensure continuity and accountability of existing efforts.

In accordance with state law, the Natural Resources Agency will report annually to the Legislature on actions taken to implement the plan. Each report should include, at minimum:

- A status update on each next step identified in this 2017 update by the appropriate agency or agencies, and
- A description of any next steps or commitments not detailed in this update included with status updates under the most appropriate high-level recommendation.

Before release of the 2018 report on the implementation of the *Safeguarding California Plan: 2017 Update*, the Natural Resources Agency will conduct an analysis of all the actions identified in the 2009, 2014, and 2016 adaptation plans to document all pending and completed actions. While these documents were consulted as references and sources for this update, it will be important to systematically show progress and opportunities.

Successfully adapting to climate change in California will require a steady commitment to actionable research, far-sighted reform, and increasing collaboration and grassroots action. State government is only part of the solution to facing the threats from a changing climate, but accountability and transparency will serve as an important part of the foundation needed to scale up statewide comprehensive responses to mounting climate change impacts.

This edition of the *Safeguarding California Plan* demonstrates the persistent importance of incorporating consideration of climate change impacts in all policy discussions. As scientific understanding, local and regional coordination, and comprehensive strategies continue to develop, the *Safeguarding California Plan* will also evolve and develop new ways to measure adaptation progress. Moving forward, metrics tracking climate impacts and relevant government responses can enhance understanding of vulnerability and how to increase resilience throughout the state.