Natural Resources Agency

Safeguarding California: Reducing Climate Risk

An update to the 2009 California Climate Adaptation Strategy

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PROLOGUE

As climate change shifts from a far-off concern to a present-day crisis, Californians are most vulnerable precisely where we're most fortunate. Rising seas and gathering storms threaten our justly famous coastlands, home to most of our population. Heat waves and droughts pressure farms and ranches that are among the most productive in the world. And our magnificent forests are at greater risk from wildfires that worsen in warmer weather.

Knowing what's at stake, California has become a global leader in responding to the growing climate threat. Our innovative policies are reducing greenhouse gas emissions and accelerating the transition to a clean-energy economy. At the same time, we are planning and preparing for the unavoidable risks of climate change. Our efforts fit within an integrated, three-R's strategy:

- Reducing Emissions – A centerpiece of our efforts is the Global Warming Solutions Act of 2006, which set the goal of reducing heat-trapping emissions to 1990 levels by 2020, a target we are pursuing by various means. The AB 32 Scoping Plan, updated every five years, outlines our strategies and defines our priorities for reducing emissions and driving the transition to a clean-energy economy.
- Readiness – While these efforts are essential for reducing the magnitude of climate change, they will not prevent it from occurring. Given the risks, investments are needed to protect our people, environment and economy from these inevitable impacts. The Safeguarding California Plan provides guidance for state and local decision makers in their efforts to prepare for climate-related risks and minimize economic losses.
- Research – Our approach is built on science. Research helps us to identify climate change impacts and risks, informs the development of our policies, and helps us measure progress toward our goals. Among our most recent scientific assessments are Indicators of Climate Change in California (2013) and the Third Climate Change Assessment (2012).

Over the coming decades, confronting climate change will require unprecedented collaboration across state government and involve nearly every aspect of the state's planning and investments. In recognition of this, the Governor's Environmental Goals and Policy Report serves as a broad overview for how state efforts work together on a variety of fronts to achieve long-term sustainability.

Climate change represents one of the greatest challenges of our time, but it is a challenge well-suited to California's strengths of leadership and innovation. Our policies are becoming a catalyst for further actions around the world. By embracing this role, we can avoid the worst

impacts of climate change and forge a cleaner, healthier and more sustainable future for all Californians.

EXECUTIVE SUMMARY – SAFEGUARDING CALIFORNIA

California and the world's climate are changing, posing an escalated threat to health, well-being, nature, and property. Extreme weather, rising sea levels, shifting snowpack, among other impacts will touch every part of peoples' lives in the next century. Planning key actions now will help us lessen impacts and cope with changes. Many aspects of the environment face historic displacement. In government at every level, we must work together to safeguard our state. And ultimately, each and every one of us needs to take steps to reduce our own impacts and increase our resilience in the future.

The Safeguarding California Plan provides policy guidance for state decision makers, and is part of continuing efforts to reduce impacts and prepare for climate risks. This plan, which updates the 2009 California Climate Adaptation Strategy, highlights climate risks in nine sectors in California, discusses progress to date, and makes realistic sector-specific recommendations.

California is a leader in the global effort to fight climate change. The state is pursuing a broad, integrated strategy to reduce greenhouse gas emissions and build the foundation for a new clean energy economy. While these efforts will reduce the magnitude and impact of climate change, they will not prevent it from occurring. Given the potential impacts and the long-term nature of effective planning, it is only prudent to begin preparing for these impacts. Actions needed to meet these challenges will not be cheap, but will cost far less than taking no action. Every step that we take today helps save valuable resources in the future. To that end, the plan details 11 current efforts already underway.

Right now, more extreme fires, storms, and heat waves are costing lives and property damage. State of the art modeling shows that a single extreme winter storm in California could cost on the order of $725 billion – with total direct property losses of nearly $400 billion and devastating impacts to California's people, economy and natural resources. The health and fiscal consequences are dire. Climate change poses a threat not just to lives and health, but the financial resources of governments and the insurance industry.

More broadly – and likely more costly – are rising seas that threaten our coast, while disappearing snowpack in the Sierra Nevada presents new challenges for our state's water management. In the near term, we must take practical, affordable steps to maintain our water, power, and transportation infrastructure, and plan for longer term actions as well.

Below are the nine broad areas impacted by climate change, with real-world, realistic recommendations for actions that we can take today to ensure a better future. In addition, we

have included seven strategies that cut across each one of these nine broad areas that can be realistically implemented to help safeguard California.

Safeguarding our Everyday Lives from Climate Change:

- A Changing Water Future: Develop an urban water use plan that reduces reliance on distant, unpredictable sources.
- Keeping the Lights On: Promote development of smart grids that are connected, but localized.
- Cooling California: Promote strategies to keep Californians cool and guard against longer, more frequent heat weaves, which are already responsible for a growing number of hospitalizations and deaths.
- Do Better Today, Live Better Tomorrow: By reducing our carbon output today, we can lessen the extent of impacts in the future.

Safeguarding our Natural World:

- Nature Moves with the Climate: As climate patterns shift, so will nature. Providing habitat connectivity and chances for adaptation will help allow species and habitats to survive.
- Help Nature Protect Herself: Improve forest and other habitat resilience.

Safeguarding California – What Science and Lawmakers Can Do:

- Knowing the Real Impacts: Sound science will highlight risks, and help provide a path to solutions.
- Help is on the Way: Assess adequacy of emergency responders.
- Better Together: Collaborate with federal and local government.

Seven Strategies to Safeguard California: Cross Sector Themes

These nine areas touch every part of modern life for people and nature: 1) Agriculture, 2) Biodiversity and Habitat, 3) Emergency Management, 4) Energy, 5) Forestry, 6) Ocean and Coastal Ecosystems and Resources, 7) Public Health, 8) Transportation, and 9) Water. For these nine areas, common themes were identified during the development of the plan. This important identification resulted in identifying seven strategies that cut across all areas that can be acted upon.

- All core functions of government must make the risks Californians face from a changing climate an integral part of their activities.
- Provide risk reduction measures for California's most vulnerable populations.

- Identify significant and sustainable funding sources for investments that reduce climate risks, human loss, and disaster spending.
- Support continued climate research and data tools to inform policy and risk reduction activities.
- Maximize returns on investments by prioritizing projects that produce multiple benefits and promote sustainable stewardship of California's resources.
- Prioritize climate risk communication, education, and outreach efforts to build understanding among all Californians.
- Promote collaborative and iterative processes for crafting and refining climate risk management strategies.

Current Efforts to Prepare California for Climate Risk

Climate change impacts communities and crosses political and jurisdictional boundaries. Cooperation and coordination is essential across a wide variety of factors including: government at all levels (state, federal, tribal, local and regional), businesses, insurers, investors, non-profit organizations, foundations, community groups, and individuals. Fortunately, we already have many examples of progress, including:

- Creation of the Cal-Adapt tool allows visualization of local climate impacts in California
- 2012 California Climate Adaptation Planning Guide is designed for local and regional governments
- 2013 Climate Change Consortium for Specialty Crops sets out impacts and strategies for resilience
- Desert Renewable Energy Conservation Plan (DRECP) is an effort underway to support programmatic development of large-scale renewable energy and the co-equal objective of conservation of the California desert; approximately 22.5 million acres of federal and non-federal California desert land are in the DRECP plan area.
- The State Hazard Mitigation Plan has integrated climate risks since 2007
- Energy efficiency standards have saved Californians more than $74 billion in reduced electricity bills since 1975, and have helped to foster greater energy reliability
- Urban forestry investments reduce heat island effects and provide air and water benefits
- 2013 State of California Sea-Level Rise Guidance Document is part of California's response
- 2013 Preparing California for Extreme Heat is another part of the response
- 2013 Addressing Climate Change Adaptation in Regional Transportation Plans provides guidance for California's Municipal Planning Organizations and Regional Transportation Planning Agencies

- Construction of four coastal observatories in Eureka, Bodega Bay, Big Sur, and Santa Barbara will help improve flood watch and flood warning information for local emergency responders

Reducing climate risks protect California's people, economy, and natural resources. Investing in action now saves lives and provides long term cost savings; one study found that every dollar spent on a FEMA hazard mitigation grant produced, on average, four dollars of benefits. Implementation of this Safeguarding California Plan will help foster a vibrant and sustainable future for California.

INTRODUCTION

California is taking important steps to reduce emissions, but no matter how quickly we reduce emissions, some amount of climate change will occur due to prior and on-going emissions. Many climate impacts are already unfolding in California. This means that we must take action now to safeguard California's people, economy, infrastructure, and natural environment from climate risks. This report is an update to the state's *2009 Climate Adaptation Strategy*. Based on a series of sector-specific analyses, it identifies key actions that the state needs to undertake to advance efforts to address climate risks and to move from planning to implementation. The *Safeguarding California Plan* is the guiding document for reducing climate risk, which is one of the three pillars of the state's comprehensive climate change policy.

California's Comprehensive Approach to Climate Change

Climate change is the defining issue for the state's future. The Governor's draft Environmental Goals and Policy Report lays the groundwork for the state's continued long-term, deep greenhouse gas (GHG) emission reductions and provides strong direction on the need to prepare for climate impacts and risks already beginning to threaten California. The state's efforts on climate risk reduction are complemented by the other two pillars of the state's climate change strategy – reducing GHG emissions and supporting research on climate change vulnerabilities and strategies to reduce these risks.

California has made significant investments in responding to climate change, including one of the world's most comprehensive programs to reduce greenhouse gas (GHG) emissions. Based on the direction provided by the Global Warming Solutions Act of 2006 (Assembly Bill 32 or AB 32), the state is well on its way to reducing GHG emissions to 1990 levels by 2020. These efforts are documented in the *AB 32 First Update to the Climate Change Scoping Plan* (AB32 Scoping Plan). The state is already looking at GHG emissions reduction goals past 2020.

California has also invested significant resources and leveraged the intellectual capital of the state to maintain a robust research program on the impacts of climate change; technologies to reduce emissions; and approaches to preparing for climate risks. The state's research agenda is directly informed by the state's policy needs as articulated in the *AB 32 Scoping Plan*, *Safeguarding California Plan*, and other climate-related documents and processes; for instance, many of the research needs outlined in this document have been incorporated into the State's Climate Change Research Plan, which outlines the state's near-term climate research needs across sectors and mitigation and adaptation efforts.[1] Through an iterative process, the results of the state's research efforts are directly incorporated into policy guidance and analysis. The state's Third Climate Assessment was released in July 2012 and provides much of the basis for the sector-specific analyses featured in the *Safeguarding California Plan*. A Fourth California Climate Assessment will provide critical additional information to support decisions that will safeguard the people, economy and resources of California. Among other informational gaps about climate vulnerabilities, California still lacks critical information regarding expected climate impacts from extreme weather events. California also needs to better understand the

scope, timing, cost and feasibility of various management options to address climate risks. Accurately understanding climate risks and management options will allow the state to prioritize actions and investments to safeguard the people, economy and natural resources of California. In August 2014, three public workshops will be held to solicit public comment and input on a proposed scope of work for the Fourth California Climate Assessment

Planning for Climate Risks in California

California's *2009 Climate Adaptation Strategy* (2009 CAS) was one of the nation's first multi-sectoral plans for preparing for the impacts of climate change. The *Safeguarding California Plan* is an update to the 2009 CAS, incorporating new information on climate vulnerabilities and management approaches. The *Safeguarding California Plan* is built on the most up-to-date science and sector-specific analyses of California climate risks and management strategies.

The *Safeguarding California Plan* is not meant to replace the 2009 CAS, but to add new recommendations and replace portions of the prior document where new information allows for updating and revision. Except where revisions and new recommendations supersede, the strategies in the 2009 CAS continue to be relevant and are carried forward.

The 2009 CAS was built on several guiding principles. Many of these principles are still relevant and are carried forward as updated here:

- Use the best available science to identify risks and adaptation strategies;
- Understand that an effective strategy for preparing for climate risks should evolve as new information is available;
- Involve all relevant stakeholders;
- Establish and maintain strong partnerships across all levels of government, tribes, businesses, landowners, and non-governmental organizations;
- Give priority to strategies that also achieve benefits other than climate risk reduction benefits, including additional benefits to public health, the economy, environmental justice, and conservation of natural resources; and
- Ensure that strategies to reduce climate risk are coordinated, to the extent possible, with the state's efforts to reduce GHG emissions and other local, national and international efforts.

The *Safeguarding California Plan* is designed as policy guidance for state decision makers. Climate risks often present cross-sectoral challenges, and may require cross-sectoral solutions. As a result, the Safeguarding California Plan identifies cross-sectoral linkages throughout. Each sector chapter features its own recommendations; cross-sectoral strategies are presented in the Introduction.

The *Safeguarding California Plan* is the result of cross-agency collaboration and public input that drew on the experiences and knowledge of leaders from each of the sectors represented. The sector-specific analyses that follow this introduction provide additional detail on progress

to date and challenges and opportunities. The sector-specific analyses, together with the cross-sectoral themes discussed below, provide a robust discussion of necessary next steps to further safeguard California's people, economy, infrastructure and natural resources from climate risks.

Future updates of the state's multisectoral guidance to address climate risks may include expanded discussions of risks to business and labor, as well as additional recommendations with respect to coordination with local and regional governments. For more information on climate risk and business, please see [Inset 2] below.

Key Strategies to Advance Efforts to Reduce Climate Risk in California

The sector-specific analyses featured in the *Safeguarding California Plan* highlight the opportunities and challenges for implementing climate risk reduction actions. Climate impacts occur at different scales (global, national, regional and local) and impacts may vary from place to place. Because of this, many strategies to reduce climate risk must be crafted at a regional or local scale. Climate data development and tools must also be tailored to support regional and local risk reduction efforts.

Several common themes emerged during the development of the sector-specific materials featured in this Safeguarding California Plan. These common themes point to the need for cross-sectoral coordination and collaboration. Leadership and support are needed to help transition from planning for climate risks to taking action to reduce risk. The state has an important role to play in enabling efforts to reduce climate risk, helping climate risks become a mainstream policy consideration, and ensuring that all state agencies are taking climate risks into account. State agencies need to consider climate change in their normal day-to-day business and operations. In particular, the state needs to take the following actions:

1. Establish a mandate and guidelines for all state agencies to consider climate risks in their policies, planning efforts, and investments
2. Provide data, tools, and guidance to support efforts to reduce climate risks; and
3. Build the capacity to plan for and implement actions to reduce climate risk through collaboration, education, outreach and funding.

These three actions will improve clarity and direction on how to move ahead on risk reduction activities and will help support risk reduction activities across sectors at the state, regional and local scales. Further information on implementing these actions is provided below.

ESTABLISH A MANDATE AND GUIDELINES FOR ALL STATE AGENCIES TO CONSIDER CLIMATE RISKS IN THEIR POLICIES, PLANNING EFFORTS, AND INVESTMENTS

California is already experiencing the effects of a changing climate. Over the coming decades, as global average temperatures continue to increase and sea levels rise, these effects will become even more pronounced. As the state is making plans and investments for the future, these risks need to be taken into account.

The 2009 CAS 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." [2] To see this implemented, the state needs to take two critical steps:

1. Require that climate risk considerations be incorporated into state infrastructure planning; and
2. Provide guidelines for state agencies to incorporate climate risk considerations into all policies, plans, and investments.

Incorporate Climate Risks into State Infrastructure Planning

State agencies should identify climate risks to existing and new infrastructure projects. For new projects, climate risks should be considered in the planning, siting, design, construction, and maintenance of infrastructure projects. Similar risk considerations should be included in the maintenance and rehabilitation of existing infrastructure. All new investments should be made to minimize climate risks to the project and long-term risks associated with development generated by the infrastructure investment. In cases where the benefits of the project are deemed to outweigh climate risks, adequate risks management provisions must be made.

Full-life cycle cost accounting should be used in all infrastructure planning projects. This will help ensure that the costs of protecting an infrastructure investment from climate risks over the lifetime of the investment will be fully accounted for upfront and accounted for in the comparison of project alternatives. However, it is important to note, that such full-life cycle accounting for infrastructure projects may not fully capture broader societal costs associated with climate risks to development that occurs in response to the infrastructure project.

Develop Guidelines for State Agencies to Incorporate Climate Risks Into Policies, Planning and Investments

A cross-agency working group including representation from the Governor's Office of Planning and Research, the California Natural Resources Agency, the California Transportation Agency, the California Environmental Protection Agency, the California Department of Public Health, the Office of Emergency Services, the Department of Finance, and the California Department of Food and Agriculture should develop guidelines for state agencies to follow as they incorporate climate considerations into all policies, planning, and investments. This group should work in coordination with the Climate Action Team. At a minimum, these guidelines should address the following critical issues to ensure successful efforts to reduce climate risks.

Encourage Iterative Approaches

Global greenhouse gas emissions will continue to determine the pace and scale of climate impacts. Direct observation of climate impacts will help to refine and improve our modeled projections of climate risks. State programs need to be able to adjust their strategies for

reducing climate risks as new information emerges. Therefore, long-term planning processes need to adopt iterative approaches to incorporate the best available climate science. State programs should be required to establish processes for incorporating new climate information and updating management practices and goals.

Protect California's Most Vulnerable Populations

Climate change will have disproportionate impacts on the state's most vulnerable populations. Threats to food security, public health, and water supplies will disproportionately affect the poor, elderly and other communities without adequate resources to respond. Steps need to be taken to identify these vulnerable populations and to ensure that California's most vulnerable people have access to information, services and resources to prepare and respond to climate risks.

Achieve Multiple Benefits from Efforts to Reduce Climate Risks and Prioritize Green Infrastructure Solutions

Steps to increase resilience can provide other types of significant benefits. Efforts to reduce climate risk should also achieve other types of benefits to the extent possible. Other benefits to consider include public health benefits besides those directly associated with climate risk reduction, economic benefits, and other environmental benefits besides those directly associated with climate risk reduction. Furthermore, actions that reduce climate risks across multiple sectors and actions that address multiple climate risks should be prioritized. Significant cross-agency coordination and collaboration will be needed to identify and implement risk reduction opportunities with multiple benefits.

One opportunity to achieve broad environmental benefits is through the use of natural infrastructure solutions to mitigate climate risk. Restoration and conservation of natural systems such as forests, grasslands and shrublands, agricultural lands, and wetlands can provide more resilient natural systems that also offer protection from climate impacts. For example, wetlands can provide protection from flooding, while also providing valuable habitat and other hydrological benefits. Prioritizing these solutions can maximize the benefits of investments to reduce climate risks by providing a broad portfolio of benefits across several sectors.

Integrate Efforts to Reduce Climate Risk with Efforts to Reduce the Emissions that Cause Climate Change to the Fullest Extent Possible

The state's climate program needs to maximize opportunities to reduce GHG emissions while also building resilience. Examples include energy efficiency measures, which can reduce energy demand and greenhouse emissions while at the same time reducing load on the state's energy system. These types of integration efforts can provide opportunities to leverage funding, such as revenues from the AB32 cap-and-trade program, to advance efforts to reduce climate risk.

Develop Metrics and Indicators to Track Progress on Efforts to Reduce Climate Risk

As the state undertakes more comprehensive efforts to reduce climate risk, it is important that metrics and indicators are developed as proxies by which the effectiveness of risk reduction activities may be measured. Such metrics may include tracking of processes undertaken to advance risk reduction and measures of the impacts of these policies and programs on changing vulnerability. Data collection on risk reduction actions and outcomes will be needed to support such evaluation, and careful consideration must be given to relevant timeframes over which progress is monitored. Disconnects may exist between the timeframes for achieving risk reduction and timeframes relevant for evaluation of policies. The capacity of natural and human systems to respond to climate risks and efforts to reduce climate risk may vary, and it is important to identify trends and gaps in adaptive response in order to refine strategies for addressing climate risk.

The Office of Environmental Health Hazard Assessment's (OEHHA) *Climate Change Indicators for California* provides valuable information about the changes in the state's physical and natural systems that are already underway. The Governor's Office of Planning and Research is also leading an effort develop an integrated set of indicators to help track progress on the state's efforts to reduce GHG emissions and build climate resilience.

PROVIDE DATA, TOOLS AND GUIDANCE TO SUPPORT EFFORTS TO REDUCE CLIMATE RISK

Climate science lies at the heart of much of the state's climate policy. The state's investment in research has played a large role in its leadership on climate change policy. As the state looks to move ahead on efforts to reduce climate risk, there are three critical areas that it must invest in:

1. Additional research to fill informational gaps about California's climate vulnerabilities and additional research on the scope, timing, cost and feasibility of management options to address climate change;
2. Tools and guidance to support efforts to plan for climate risks at the state, local, and regional level; and
3. Supporting monitoring to gather direct observations of the changing climate.

Climate Vulnerability Assessments and Research on Management Options

California's comprehensive climate policy is grounded in the most up-to-date climate science. California has completed three California Climate Change Assessments.[3] These assessments have provided initial information on climate risks, economic impacts, and barriers to efforts to prepare for climate risks across different sectors and different regions in California. The information developed through these assessments has served as a strong foundation for the state's policies to reduce the emissions that cause climate change, as well as efforts to reduce climate risk.

The state has leveraged its research investments through coordination with other partners. The state has drawn upon the strong intellectual capacity of California's universities and laboratories. The state has also worked closely with federal agencies and laboratories, local and regional governments and other partners and stakeholders.

Additional research is needed to fill continuing knowledge gaps regarding California's climate vulnerabilities and the scope, timing, cost and feasibility of regionally relevant management options to address climate change. Additional vulnerability assessments for the state's population, natural systems, and infrastructure will be important for allocating limited resources to build resilience. More detailed research needs are discussed in the sector-specific discussions contained in this *Safeguarding California Plan*. As noted above, scoping for a Fourth California Climate Assessment has been initiated in 2014, and will focus on helping to produce this needed research.

Tools and Guidance

Investment in tools to make climate data easily accessible and usable by decisionmakers is a critical role for the state. Cal-Adapt [see Inset 1] is an online, interactive, visualization tool that enables researchers, decisionmakers, 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.

As further described in the Public Health section of this document, the California Department of Public Health (CDPH) has developed a Climate Change Population Vulnerability Screening Tool which supplemented an existing environmental justice screening method with metrics associated with climate change impacts and adaptive capacity, such as population sensitivities, air conditioning ownership, green space, and ecological risks. An interagency working group lead by CDPH is currently exploring further social vulnerability mapping for climate change and best practices for social vulnerability assessments.

In addition to providing tools like those described above, the state plays an important role in providing guidance on how to use climate data and providing guidance regarding processes for planning and implementing actions to reduce climate risk. The state has already issued a number of important guidance documents which are further discussed in this document, including the 2011 Climate Change Handbook for Regional Water Planning, the 2012 Adaptation Planning Guide, the 2013 Ocean Protection Council's State of California Sea-Level Rise Guidance, and the 2013 Preparing for Extreme Heat in California: Guidance and Recommendations. The state should continue to provide guidance on best practices for utilizing climate data and preparing for climate risks.

Supporting Monitoring to Gather Direct Observations of the Changing Climate

The state has already invested in some monitoring networks that help provide information about the environment in order to support our understanding of changing climate conditions

and how to respond to climate risks. These monitoring networks include equipment that provides some measurements for air quality, sea level rise, atmospheric rivers, and other environmental conditions. Current monitoring equipment must be maintained and upgraded over time, and the *Safeguarding California Plan* also identifies a number of different areas in which additional monitoring efforts are needed. Monitoring information can help refine climate change projections, inform early warning systems, and aid California's efforts to respond and prepare for climate impacts.

BUILD CAPACITY TO PLAN FOR AND IMPLEMENT ACTIONS TO REDUCE CLIMATE RISK THROUGH COLLABORATION, EDUCATION, OUTREACH, AND FUNDING

In addition to incorporating climate risk considerations into state policy, planning, and investment decisions and further developing climate data, tools and guidance, it is necessary that the state build capacity to advance efforts to plan for and implement actions to reduce climate risk. Capacity building may be achieved in the ways described below.

Foster Collaboration and Innovation Across State Agencies and Across Levels of Government

Climate impacts will span sectoral and jurisdictional boundaries and efforts to respond to climate risks will necessarily require coordination between state agencies and across political boundaries (international, national, regional, state and local). For example, the Biodiversity chapter of this document identifies more than 14 state entities, as well as federal and local agencies, that work on biodiversity issues. Collaboration across entities is necessary for information sharing, can help generate innovative new approaches to addressing climate risk, and can help optimize the utilization of the scarce resources available to address climate threats. Collaboration is an integral part of preparing for a changing climate.

Collaborative work on climate challenges is already occurring in California. This *Safeguarding California Plan* was developed by a large working group of state entities, with important input gleaned from tribal leaders, stakeholders, and other partners. More information about the entities and individuals who contributed to the development of the Safeguarding California Plan may be found in the acknowledgements in Appendix B of this document.

California is also an active member of the President's State, Local and Tribal Leaders Task Force on Climate Preparedness and Resilience (Task Force).[4] The Task Force was established in November 2013 to advise the Administration on how the Federal Government can respond to the needs of communities nationwide that are dealing with the impacts of climate change.

California has more than 100 federally recognized tribes and the largest Native American population of any U.S. State. The Brown administration renewed its commitment to coordination with Native American tribes when Governor Brown signed Executive Order B-10-11, with the intent of strengthening communications and collaboration between California state government and Native American tribes. The state will continue implementation of this direction as it works to foster strong working partnerships with tribal nations and lead efforts to

better coordinate with tribes on preparing for climate risks. Tribes are already experiencing climate impacts and working to address climate change.[5]

Local and regional entities in California are also working on collaborative efforts to address climate. For more information on such efforts, please see [Inset 3] below.

Develop a Comprehensive Climate Education and Outreach Strategy

It is necessary to invest in human capital to build the required expertise to address the new challenges presented by climate change. Providing state employees with access to climate training activities can also help build needed human capital. Some state entities have already started to develop these types of programs.[6] State agencies and departments should be provided with the resources to enable and encourage climate training for staff. Climate literacy programs should provide both general climate information and content specifically related to the activities and mission of the hosting agency or department. Training should disseminate climate science and climate risk information and empower staff to integrate climate change into their professional responsibilities. The state should develop a standardized curriculum for the general climate information portion of its internal climate literacy program. This standardized curriculum should also be made available as a public resource. The state should also work with education providers to integrate climate literacy into school curricula.

A high degree of engagement by governments at all levels, the private sector, communities, and individuals is needed in order to effectively prepare for climate risks. This level of engagement is predicated on effective communication of climate risks. The state should develop and maintain a standard set of communication materials regarding climate risks in California, and should provide translated materials for non-English speaking communities. Those materials should be made available online and through outreach efforts. Outreach efforts should be focused on increasing public awareness and increasing community engagement in preparing for climate risks. Funding will be needed to support adequate outreach efforts.

Provide Significant and Sustainable Funding for Investments that Reduce Climate Risks, Human Loss 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. Although needed investments are very substantial, these investments will save lives and provide very significant long-term savings. Significant, sustainable funding sources are needed. In order to achieve the needed level of investment, the state will need to work closely with governments at multiple scales (federal, tribal, regional and local) as well as a variety of non-governmental partners including members of the business community. Indeed, some important efforts are underway in the private sector to better quantify the economic risks of unmitigated climate change in order to better understand the nation's exposure to climate risk and inform decisions about the future.[7] Innovative risk sharing mechanisms will need to be considered and utilized.[8] Investments must

account for time frames needed to realize benefits, changing climate risks over time, and the life expectancy of any capital investments.

4. Next Steps

The *Safeguarding California Plan* presents a call to action to address climate risks that threaten the state's people, economy, infrastructure and natural resources. Climate impacts are already manifesting in California, and strong state leadership is critical in order to safeguard our communities. While some of the recommendations in this *Safeguarding California Plan* may be carried out through existing programs and staff, the document more broadly describes needed actions to reduce climate risks in California even where current policies, staffing and funding capacity do not yet exist.

Inset 1

Cal-Adapt—California's Easy Access Tool for Visualizing Local Climate Impacts.

With a proliferation of climate research tools and resources over the past five years, it has become increasingly difficult to identify definitive sources of aggregated climate data for planning purposes. The state of California plays an important role in helping to develop regionally relevant climate research to support policy and planning efforts. Implementation of many actions to enhance community resilience will happen at the local and regional levels, and the state is committed to working cooperatively with local and regional governments to support their efforts to prepare for climate risks. Recognizing that climate data must be translated into a usable format and that having numerous sources of climate data can be difficult to navigate, the state created a tool called Cal-Adapt (http://cal-adapt.org); a web-based climate planning tool where you can quickly find information to help visualize impacts associated with climate change at the local level.

Cal-Adapt addresses one of the major challenges facing planners who are working to enhance community resilience in the face of climate risks: a scarcity of tools and definitive sources located in one easy access location that can provide regionally relevant information. Designed in response to a recommendation in the 2009 California Climate Adaptation Strategy, Cal-Adapt was specifically designed to support planning activities and provide public information on climate impacts and risks in the state. Cal-Adapt provides visualization tools and easy access to important data sets specific to California. The user-friendly platform provides a convenient and effective way to explore climate impacts and vulnerabilities. Since its release, the website is being used by local and regional entities to find out how the climate may change in their jurisdictions, and these partners have been providing the state with useful feedback about the functionality of the tool.

Cal-Adapt was originally developed with funding from the California Energy Commission's Public Interest Energy Research program. Limited funding has been identified to support a tool update in 2014. The goal of the 2014 update will be to refresh the data sets incorporated in the

Cal-Adapt tool and make the tool more responsive to the needs of local decision makers. However, as climate change projections and observations continue to evolve, planning efforts become increasingly sophisticated, and implementation of local climate plans moves forward, it will become increasingly important to continually maintain and enhance this tool to ensure it reflects best available knowledge.

Inset 2

Climate Risk and California Business

Climate change poses significant risks to businesses including supply chain disruptions, destruction of business assets, and interruption of distribution networks. By taking action to reduce climate risks, California can support a resilient and prosperous business community.

Businesses are important partners for the state with respect to preparing for climate impacts. For instance, as discussed in the Emergency Management section of this document, the insurance industry provides important risk sharing mechanisms that can work in tandem with government policies to reduce climate risk. Institutional investors can adopt investment practices that encourage positive climate action.[9] Companies help create markets for ecosystem services.[10] Businesses and industry groups can encourage the development of climate policies and raise awareness about climate change issues.[11] And, as discussed elsewhere in this document, innovative technologies, materials, and design can improve energy efficiency, reduce heat island effects, and reduce risks from the changing climate.

Inset 3

The Alliance of Regional Collaboratives for Climate Adaptation

The Alliance of Regional Collaboratives for Climate Adaptation (ARCCA) was formed in early 2012 to address the emerging impacts of climate change, including extreme storm events, heat waves, droughts, and sea level rise. ARCCA 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 mission of ARCCA is two-fold: to enhance cooperation and best practices sharing between regions and work more effectively with the State in its development of climate adaptation plans, policies and programs.

AGRICULTURE

INTRODUCTION

California is the leading agricultural state in the nation in terms of economic value and crop diversity. Farming and ranching are a critical part of our economy and daily lives, providing healthy fruits and vegetables, nuts, grains, lean meats and dairy protein that we eat and drink, cotton and wool for the clothes we wear, and bio-based energy to power our homes and businesses. In 2012, California agriculture generated $44.7 billion in revenue - representing 11.3 percent of total U.S. agricultural revenue.[12] California produces more than 400 different commodities on approximately 80,500 farms employing 800,000 people involved in all stages of farming and ranching.[13] California has a diversity of farm sizes including many small-scale and medium-scale farms. Agriculture depends on weather and a wide range of ecosystem processes that support productivity, so any significant changes in climate present potential vulnerabilities for the sector and may have serious implications for the well-being of California's economy and its people. In fact, California's agricultural bounty is a function of the fact that we are one of only five Mediterranean growing regions in the world; because of our climate California's farmers and ranchers are able to produce a wider diversity of commodities, many of them year round.

While California farmers and ranchers have always been affected by the natural variability of weather from year to year, the rate and scale of climate change is increasing and is outside the realm of experience for the agricultural community.[14] Projected climate changes in California include: changes to water quality and availability; changing precipitations patterns; extreme weather events including drought, severe storms, and floods; heat stress; decreased chill hours; shifts in pollinator lifecycles; increased risks from weeds, pest and disease; and disruptions to the transportation and energy infrastructure supporting agricultural production. The combined effect on agriculture from multiple changing climate variables is complex, difficult to predict, and can be a mix of positive and negative impacts (e.g. longer growing periods, but more pests); but by midcentury and beyond, climate change is projected to have overall detrimental impacts on most current crop and livestock production.[15] However, the vulnerability of agriculture to climatic changes is strongly dependent on the response taken by humans to moderate the effects of climate change, and there are many opportunities to minimize climate risks and safeguard our agricultural resources and food supply.[16]

Climate risks to California's agriculture cannot be fully understood without consideration of its national and global context. California's agriculture is interconnected to the nation and the world in important ways. The state produces nearly half of U.S.-grown fruits, nuts, and vegetables; and across the nation, U.S. consumers regularly purchase several crops produced solely in California.[17] Additionally, California's agricultural exports have grown at an exceptional pace over the past decade, increasing from $6.51 billion in 2001 to $18.18 billion in 2012.[18] California also imports agricultural products, including commodities not grown in the United States such as bananas and coffee, and feed grain to support California livestock.[19] Given these important interconnections, any climate-related vulnerabilities to agriculture within the state or

within trading partner states can have implications for Californians and non-Californians alike.

The risk of significant climate changes is present against a backdrop of other stressors to California's food and agriculture. Farm and grazing lands in California decreased by more than 1.3 million acres between 1984 and 2008. This loss averages about one square mile every four days. Urbanization accounts for the vast majority of this loss, more than 1.04 million acres over the 1984-2008 timeframe.[20] According to the California Department of Finance, California's population will continue to grow and will cross the 50 million mark in 2049[21], so there will be continued pressures for farmland conversion at the same time that food demands are increasing and climate impacts are unfolding. Furthermore, a recent study by the University of California Los Angeles (UCLA) also notes that food insecurity has increased significantly over the last decade among low-income Californians; with 3.8 million adults struggling to afford food in 2009, including households with children.[22]

California's farmers and ranchers have a demonstrated history of innovation in enhancing agricultural resource use efficiency and environmental stewardship while at the same time growing more food with limited water and land. However, climate risks will bring unprecedented, new challenges and opportunities. There is an urgent need to invest in science and research efforts to ensure California farmers and ranchers can adapt to climate change while increasing their productivity to help feed a global population that is projected to climb to more than nine billion people within the next few decades.[23] Developing and supporting California-specific agricultural research, management options, and appropriate technical and financial assistance will help to ensure the resilience of California's agricultural sector and the health of California's economy and its people.

Several state entities play an important role with respect to food and agriculture in California. The state also has important federal, local and private sector partners with respect to food and agriculture. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks. For more information, see Box 6 *California Food and Agriculture below.*

Climate Risks to California's Agricultural Resources

California's unique Mediterranean climate, and its many microclimates, supports a diversity of crops. California is the nation's leading agriculture state in gross cash receipts; $44.7 billion in 2012. A large portion of the crops grown in the state are "specialty crops", which are defined as fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops including floriculture. California is the United States' sole producer of several crops such as Clingstone peaches, olives, pistachios, walnuts, almonds and artichokes.[24] Agriculture relies directly on climate and natural resources, and is inherently vulnerable to changes in temperature, water resources, storm events, shifts in pollinator lifecycles, and other risks associated with climate change.[25] Risks to agriculture threaten the economic livelihood of California and the food security and the well-being of all those who depend on California agriculture. (For more information on food security, please see Box 4 Food Security and Climate Impacts to California Agriculture.)

Due to the many human and environmental factors influencing agriculture, the complex interaction of multiple projected climate changes (e.g. changing water availability coupled with changing temperatures and changing insect populations), and increased variability in weather over time and across space, climate change impacts are difficult to predict for a specific agricultural operation. Nevertheless, rigorous analysis of California weather data shows that climate change is already occurring in the state. For example, California has already observed a reduction in winter chill hours, due to an increase in average winter temperatures. Winter chill hours are the number of hours below 45°F, and are necessary for the flowers of fruits and nuts to bloom, and for certain crops to achieve homogeneous and viable yields. Several studies indicate that climate change will negatively impact many specialty crop yields and profits by the year 2050 and certainly by the year 2100.[26] (For a first person perspective on California's changing climate and its impact on agriculture, please see Box 1 below.)

Box 1

FIRST PERSON NARRATIVE: John Diener, Red Rock Ranch Inc., Five Points, California (Narrative used with permission)

I've been farming in Five Points for more than 30 years, and our family farming history dates back to the Great Depression. At Red Rock Ranch Inc., we have about 5,000 acres and grow many fruit and vegetable crops including almonds, grapes, wheat, alfalfa, sugar beets, tomatoes, and spinach.

Our farm is located in Fresno County, in the West Side region where water availability has been a challenge for many years. Over the past 10 years, I have noticed three trends that are making this challenge even greater. First, we are getting less rain, and this causes us to have to use more imported water and groundwater to supplement our crops. This puts a stress on the whole system. The inconsistent rains make it hard to plan when to prepare the fields, plant and manage crops.

Second, the snowpack is not lasting as long into the summer as it used to. Our efficient use of the developed water within California's water reservoir system is dependent upon a gradual melting of the snowpack in the Sierra and Cascade mountain ranges. As weather patterns have changed, the snowpack has melted earlier and faster in the spring, and farmers are not able to be as efficient with their water use. This is happening during the same time that the state's population is growing, creating more demand for urban and industrial uses which has grown four-fold since the 1970's, and as more pressure has been building for keeping water in ecosystems for environmental purposes.

Third, as the weather gets warmer with climate change, agricultural demand for water is intensifying. For example, in 2012 we had the hottest September on record. We used approximately 30 percent more water than we normally would during that month because the water was evaporating faster and the plants needed more water moving through their circulatory systems to stay cool.

Over the past decade, we have had an approximately 50 percent decrease in surface water supply availability, and I can directly attribute declines in our crop yields over that time to water shortages. This was most obvious in 2009 when we got only 10 percent of our historical water allotment, rather than the 25 percent we had expected — and we saw a 50 percent decrease in crop yields that year.

All of this not only makes it challenging for farmers to stay in business, but it has impacts on employment (the Central Valley has some of the state's highest unemployment rates) and the economy. Agriculture is a $44.7 billion industry, counting only the actual farm product sales; there are also many other related businesses and jobs that depend on it, not to mention the tax base it contributes to the state economy. Obviously, there is a food security issue at stake too — California produces more than half of the country's fruits, nuts and vegetables and more dairy products than any other state. More than half of that food is grown in the Central Valley.

Though agriculture gets blamed for using more than its share of water, the fact is that we have made huge strides in recent years on irrigation efficiency. But clearly, in the face of intensifying climate change impacts on water scarcity, we are going to have to find a way to do even more if we want to stay in business and keep feeding so many people.

The solutions to greenhouse gas reductions will have other benefits for the Valley too. Our air quality issues are caused in part by fossil fuel combustion that produces carbon dioxide and also particulate matter. While improvements have been made in farming practices, all Valley residents and businesses have to do even more to address the serious health impacts on our communities and families. We should also remember that plants like clean air too. It is in the interests of agriculture, other businesses, and the whole Valley community to keep looking for win-win solutions that address both climate change and air quality.

We all want to have a better life, to be healthy, and to make the world a better place where our kids can thrive. We have to figure out solutions that are real, that work, that can be widely adopted, and that keep farmers in business.

John Diener's Red Rock Ranch consists of approximately 5,000 acres in Fresno County. He farms an array of high value row crops, using innovative approaches to land, water, and wildlife management. Mr. Diener was a member of the California Ag Leadership Class XX and received the prestigious Profile in Leadership Award in the Environmental and Natural Resources Stewardship category. He is the 2009 recipient of Leopold Conservation Award.

California agriculture faces a myriad of climate risks. Different crops can vary widely in their sensitivity to climate.[27] Risks exist for both crops and livestock. Box 2 provides a summary of some of the major climate risks to agriculture. Some of these risks are discussed in more detail below. Box 2 also provides a summary of ways to prepare for and to manage those risks. Risk management strategies are discussed further below.

Box 2

Climate Risks to Agriculture Include: ***(multiple risks may occur together)***	**Risk Management Strategies Include:** ***(multiple strategies may be used together)***
• Changing air temperatures including loss of chill hours (record warm temperatures are becoming more common) impacting both crops and livestock - with increases beyond optimal temperatures causing declining yield and losses • More extreme weather events (more frequent and severe drought, more intense storms, floods, etc.) • Changing water availability and quality from: loss of snowpack and natural water storage, sea level rise and saltwater intrusion, flood events and drought • Altered precipitation patterns and increased soil erosion • Changing pressures from weeds, diseases and insect pests • Changes in timing and coincidence of pollinator lifecycles • Changing ground level ozone and cloud cover • Heat impacts on agricultural workers • Damage or disruption to energy and transportation infrastructure supporting agricultural production • Increases in prices of agricultural inputs (e.g. increased feed prices) • Changes to quality of agricultural inputs (e.g. decline in forage quality)	• Soil conservation practices and building soil health • Adjusting crop/livestock mix • Diversifying crop/livestock mix • Housing/shading for livestock to reduce heat stress • Use of innovative sustainable farm operation systems that integrate energy, water, and natural resource conservation • Avoiding crop and livestock production in high risk locations • Government provision of insurance, loss compensation, incentives and technical assistance to promote more resilient and sustainable farming and ranching systems • Adjusting farm operations and management practices to respond to changes in seasonal temperature and precipitation patterns • Technological and scientific innovation (e.g. new irrigation technologies, decision support tools, enhanced weather forecasting, etc.) • Enhancing water use efficiency • Water recycling • Watershed protection • Developing flood protection (e.g. through restoration or creation of wetlands, etc.) • Developing conjunctive underground water storage • Reduce non-climate stressors such as farmland conversion • Enhance education of employers, workers and labor contractors on the health risks of heat and preventative measures • Implementing management practices to store carbon in soils (e.g., carbon sequestration)

Temperature

Climate change is projected to change both average and extreme temperatures, and to change the timing of temperature fluctuation (e.g. night and day; seasonal changes). Overall, warming is expected on an annual, seasonal, and even daily basis, with impacts differing by region. The significant, overall outcome of warming is the likely reduction in yield of some of California's most valuable specialty crops.[28] For instance, many of California's fruit and nut crops evolved in climates with distinct seasons, and inadequate winter cold can cause late or irregular blooming which affects yields.[29]

Increasing air temperatures can also affect livestock production when temperature exceeds optimal levels. Heat stress in livestock can result in reduced pregnancy rates, longer time needed to reach market weight, and reduced milk production.[30]

Heat stress in workers may reduce productivity, and may lead to illness, disability, or death in extreme exposures.

Water

Crops are sensitive to the availability of water, the quality of water, and the timing of water application. California's different agricultural regions utilize different sources of water; for instance there is the snowpack/runoff dependent Central Valley, the groundwater and reservoir dependent Coastal areas, and the Colorado River dependent Imperial Valley. In general, and regardless of the source, water resources for agricultural irrigation could decrease and become more variable with risks of flooding expected to increase. Impacts will differ greatly by region. Risks include reduced precipitation (drought) or increased precipitation (causing flooding and soil erosion), decreased winter snowpack, altered timing and quantity of snowmelt and runoff, altered reservoir storage regimes, impaired water quality, salt water intrusion, and more variability and uncertainty.[31] For more information about climate impacts to water resources, please see the Water section of this document.

Box 3



California Department of Water Resources
January 1, 2006; Twitchell Island; flood impacts to corn crops

Invasive Plant Species, Insect Pests, and Pathogens

A changing climate creates new conditions that may change weed-infestation intensity, insect population types and levels, the incidence of pathogens, and the distribution of many of these pests. Such effects can impair agricultural production yields and quality, and may necessitate changes to existing management practices.[32] Any increased use of pesticides due to increased pest and disease pressure may have potential impacts on worker health and safety, community exposure, and impacts to ecosystem health.

Infectious Diseases and Food and Animal Safety

Some infectious diseases are transmitted to humans or other animals by insects or other animals (transmitting insects or animals are called "vectors"); and these types of diseases are called "vector-borne" diseases.[33] As noted in the Public Health section of this document, vector-borne diseases are among the most complex of all infectious diseases to prevent and control.[34] This complexity is attributable to the many factors that can contribute to the transmission, rate of transmission and evolution of such vector-borne diseases, including, but not limited to, the vector populations, the disease pathogens carried by the vectors, ecological and climate patterns, and human interaction with the vector population.[35]

Changes in temperature and precipitation associated with climate change may lead to changes in the spread of vector-borne diseases. Climate change may alter the number of disease-carrying vectors. For instance, in places where there is increased rainfall, there may be more

standing water where mosquitoes can lay eggs.[36] A number of vector-borne diseases affect animals in California. For instance, Bluetongue is a vector-borne disease that threatens both domestic and wild ruminants in California (e.g. sheep and cattle); and climate change may have contributed to a dramatic recent expansion in global distribution of the bluetongue virus, most notably in Europe.[37] Horses are also susceptible to West Nile virus which is carried by mosquitoes.[38]

Everyone, from the farmer to the consumer, has a role in keeping food safe. Because of the numerous factors governing food safety, a causal link between climate change and increased risk of food-borne diseases has not yet been well-established. However, as noted in the Public Health section of this document, Salmonella and Camplyobacter display a distinct seasonal pattern that has been associated with climate variability (increased temperatures, heat waves, and flooding) and may thus be exacerbated by climate change.[39]

CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. CDFA's Animal Health and Food Safety Services and Emergency Animal Diseases Management Program[40] may play increasingly important roles in the era of climate change. For more information on climate and emergency management, please see the Emergency Management section of this document.

Compound Impacts and Other Risk Considerations

It is likely that multiple changing climate variables (temperature, precipitation, wind, cloud cover, humidity, etc.) and multiple risks (flooding, extreme heat, pests, weeds, etc.) will occur together or in sequence due to unmitigated greenhouse gas emissions. These compound impacts will be added to existing stressors on agriculture such as farmland conversion. Predicting and assessing the full impact of climate change on agriculture will require integrated studies of multiple factors. More accurate projections and better understanding of how various changes interact will help inform risk management strategies and increase efficient use of available resources.[41]

It should also be noted that catastrophic crop or livestock losses are likely to affect financial viability in a fundamentally different way than moderate losses over longer periods of time.[42]

In addition to extreme heat and storm events, climate change is also expected to increase the frequency and severity of wildfires and such fires may increase soil erosion and otherwise impact water supplies. For more information about wildfire, please see the Forestry section of this document.

Transportation and energy infrastructure supporting agricultural production and food distribution systems are also vulnerable to climate disruptions. For more information about such disruptions, please see the Transportation and Energy sections of this document.

Ground-level ozone is formed primarily from photochemical reactions between two major classes of air pollutants, volatile organic compounds and nitrogen oxides (so called 'ozone precursors'); and climate change is expected to result in more days of weather conducive to

ozone formation in California. (For more information on expected impacts of climate change on ozone formation, please see the Public Health section of this document.) Ozone can have negative impacts on both crops and livestock. For instance, studies indicate that elevated ozone exposure reduces the yield of some crops and reduces the nutritional content of common grassland species used as forage for livestock.[43]

California, U.S. and global agricultural markets are highly interconnected. Therefore, climate changes impacting agricultural yield and production worldwide will have an impact in California. Changes in relative productivity between regions will matter to both California's agricultural producers and consumers. For example, if global yield effects are generally negative, this can drive global food prices up and may benefit California's agricultural producers, but may also negatively impact California consumer welfare.[44]

Risk Management Strategies

The vulnerability of agriculture to climate risks is strongly dependent on human responses to moderate those risks. Adaptive behavior can significantly reduce the potential negative impacts of climate change on food production, farm income, and food security.[45] As shown in Box 2, there are a variety of strategies for managing climate change risks to agriculture.

Adjustments existing management practices such as building soil quality to manage water and nutrient cycles, diversifying crop rotations to manage pest populations, integrating livestock with crop production systems to manage resource cycles, and other practices typically associated with agriculture help increase the resilience of agricultural systems in the face of impacts. While these management practices with multiple benefits help avoid or reduce productivity losses, there may be barriers or challenges with respect to their adoption. For instance, there may be costs associated with transitioning to lower risk areas or installing water use efficiency technologies and the extent of financing and credit availability may limit the adoption of such adaptive management actions. Adaptive responses may also be constrained by "path dependency" such as technological lock-in (arising from prior capital investments) which limits the pace of adoption of innovative technologies. Current policies are not well-designed to integrate climate risks into comprehensive planning efforts or to incentivize adaptive measures.[46]

Adequate preparation for climate risks will require continued development of information about risks to agriculture, the further development of management tools and strategies, and the dissemination of information and technical assistance to both policymakers and farmers and ranchers.[47]

Box 4

Food Security and Climate Impacts to California Agriculture

As California faces the twin challenges of climate change and population growth, our ability to feed our population will be challenged. At the current pace of population increase, every day our planet has approximately 220,000 new mouths to feed.[48] To keep up with the growth in human population, food production must double by 2050. More food will have to be produced

over the next 50 years than has been during the past 10,000 years combined[49]. California, with its unique climate and production of nearly half of U.S.-grown fruits, nuts, and vegetables, is key to helping feed the state, the nation and the world,

California's goal is food security – access by all people at all times to enough safe and nutritious food for an active, healthy life. Conversely, food insecurity describes both reduced food intake as well as reduced quality, variety, or nutritional value of diet.[50] Thus, food insecurity can, paradoxically, be associated with poverty and obesity.[51] Healthy foods like fruits and vegetables are more expensive as compared to many other foods that may be high in calories but low in nutritional value. In addition, access to fresh produce may be unavailable in low-income neighborhoods.[52] An economically stressed family may face limited choices as to their ability to purchase sufficient nutritious food.

In 2009, 3.8 million adults in California, especially those with children and low-incomes, could not put enough food on the table. The highest rates of food insecurity across California were observed in the San Joaquin Valley, some Bay Area communities, as well as in Shasta, Butte, Sutter, Yuba, Ventura, San Bernardino, Orange and Riverside counties.[53]

Negative climate impacts on California agriculture may cause price increases in foods that are important to food security.[54] Price increases for healthy foods may further exacerbate our food insecurity issues.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

The California Department of Food and Agriculture (CDFA), in partnership with the other state agencies, producers, research institutions, local government, non-profit organizations and other entities, are developing strategies and programs to prepare for climate risks to California's agricultural resources.[55] Some of the initial activities are described below.

California Agricultural Vision

In 2008, the State Board of Food and Agriculture inaugurated California Agricultural Vision (CAV) as a process to develop a strategic plan for the future of the state's agriculture and food system. Its motivation was the rapidly growing list of challenges facing agriculture, from regulations and water supplies to urbanization and climate change. After holding public listening sessions, the State Board adopted a Vision to serve as the framework for the plan. The Vision focuses on three basic goals:

- Better Health and Well-being - Meeting the Nutrition Needs of California's Diverse Population;
- A Healthier Planet - Agricultural Stewardship of the Natural Resource Base upon which California and Food Production Depend; and
- Thriving Communities - Food Production as a Driver of Sustainable California Economic Growth.

California Agriculture Vision: Strategies for Sustainability ("Ag Vision") was released in December 2010.[56] Ag Vision identified 12 major challenges for California agriculture along with strategies to address them. One of the challenges is climate change. However many of the other challenges that are identified directly overlap or relate to climate change - including adequate water supply, curtailing invasive species, farmland and water conservation, environmental stewardship, and the promotion of regional markets.

Since the release of Ag Vision, Ag Vision Advisory Committee has continued progress on the strategies and action items within the report to ensure a vibrant future for the state. In April 2012, CDFA released a report detailing progress to date.[57]

Climate Change Consortium for Specialty Crops

As an extension of Ag Vision, in August 2012, CDFA announced the formation of a Climate Change Consortium.[58] The Climate Change Consortium met four times during 2012 and 2013 to hear from researchers on the impacts of climate change such as increasing temperatures, changing precipitation patterns and water availability, increased pest pressures, and pollination concerns. The Consortium made recommendations for climate change adaptation drawing from their varied backgrounds as growers, researchers, and representatives from agricultural associations. The Consortium's recommendations fall into five categories: 1) On-farm strategies to improve resilience, 2) Planning and Resource Optimization, 3) Research Needs, 4) Outreach and Education, and 5) Technology and Innovation. The on-farm strategies are directed toward growers and include practical ideas such as diversifying farming operations, utilizing irrigation and water conservation plans, and considering best management practices that can help attract beneficial predators and pollinators.

The October 2013 final report, *Climate Change Consortium for Specialty Crops - Impacts and Strategies for Resilience*, is directed toward a large audience, including growers, researchers, and agency partners with the purpose of guiding CDFA and its partners in future activities and reducing agriculture's vulnerability to climate change.[59] Implementation of all the recommendations crafted by the Climate Change Consortium will be important; the recommendations below in the "Actions Needed to Safeguard Agriculture" section of this chapter were adopted from the recommendations made by the Climate Change Consortium.

CDFA Environmental Science Farming Panel and Ecosystem Services Database

In August 2011, CDFA convened the Environmental Farming Act Science Advisory Panel. The Panel is charged with reviewing and documenting agriculture's positive impacts to the environment. The Panel recognizes the importance of environmental stewardship practices in agriculture. Its current work focuses on incentives and evaluation of ecosystem services (defined as the multiple benefits gained from farming and ranching including crop and livestock production).[60] As part of the Environmental Farming Act, with consultation from the Science Advisory Panel, an Ecosystem Services Database has been developed.[61] The information contained in this database is collected from farm and ranch websites and on-line case studies. The database can be queried by key word and categories as well as through an interactive map.

The database is designed to communicate, to a wide audience, the many social and environmental benefits offered by farms and ranches in California, including food production.

California-Federal Task Force on Dairy Digesters

Agriculture has the ability to reduce the sector's contribution to greenhouse gas emissions (e.g., approximately 6 to 7 percent of California's total emissions are attributed to the agricultural sector) that cause climate change in a variety of ways. For instance, California is the largest dairy state in the USA, with approximately 1.7 million cows producing more than 3.6 million dry tons of manure per year that must be managed to reduce or mitigate environmental impacts. One way of reducing greenhouse gases is to process manure in anaerobic digesters to produce biogas, a flexible renewable source of energy and fuel.[62]

In 2011, representatives from USDA NRCS, USEPA and CDFA convened the California-Federal Task Force on Dairy Digesters to examine the lack of dairy digesters on California dairies. The three working groups of the task force finalized recommendations to reduce economic, technical and regulatory hurdles currently in place in order to make digester systems more feasible in California. The implementation of those recommendations has included, among other things, increasing the feed in tariff for biogas and consolidating permitting processes and clarifying permitting requirements.[63]

California Bioenergy Action Plan

As noted above, California has enormous potential to create energy from organic by-product materials. The *2012 Bioenergy Action Plan* outlines strategies, goals, objectives, and actions that California state agencies will take to increase bioenergy development in California. Pursuant to the 2012 Bioenergy Action Plan, CDFA is, among other things, leading efforts to develop and implement actions that will enhance the economic, regulatory and technical viability of dairy digesters and co-digestion of other agricultural byproducts.[64]

Agricultural Offsets and Agriculture in Climate Policy

In October 2011, the California Air Resources Board (ARB) adopted the nation's first economy-wide cap-and-trade regulations. As part of the cap-and-trade program, ARB has adopted a Livestock Projects Compliance Offset, recognizing the greenhouse gas benefits of manure management systems.[65]

CDFA, ARB and other governmental partners are continuing ongoing discussions with stakeholders about opportunities for agriculture in climate change policy. The discussion focuses on identifying the role of greenhouse gas emissions from agricultural practices; developing strategies on best practices to mitigate climate change; agricultural offsets; and pursuing incentives and recognition for best practices to support climate change policy. Incentives may include voluntary carbon market compliance, U.S. Farm Bill conservation programs, supply chain initiatives, ecosystem services, and emission reductions to support CEQA mitigation. For more information on federal climate accomplishments related to agriculture, please see Box 5: USDA Action to Prepare for Climate Risks to Agriculture.

Box 5

USDA Action to Prepare for Climate Risks to Agriculture

USDA Climate Adaptation Plan

The U.S. Department of Agriculture (USDA) Climate Change Adaptation Plan presents strategies and actions to address the effects of climate change on USDA's key mission areas including agricultural production, food security, rural development, and forestry and natural resources conservation. The USDA Climate Change Adaptation Plan includes input from eleven USDA agencies and offices. It provides a detailed vulnerability assessment, reviews the elements of USDA's mission that are at risk from climate change, and provides specific actions and steps being taken to build resilience to climate change. The plan advances efforts to integrate climate change adaptation planning into the actions of the federal government. [66]

Report on Climate Effects and Adaptation Strategies

In February 2013, USDA released a report synthesizing the scientific literature on climate change effects and adaptation strategies for U.S. agriculture. The report is entitled Climate Change and Agriculture: Effects and Adaptation.[67]

Research to Prepare for Changing Climate Conditions

USDA is supporting a variety of climate-related research. For instance, researchers at the USDA Agricultural Research Service (ARS) are developing heat-tolerant varieties of spinach and lettuce to ensure California will continue to provide important specialty crops to consumers.[68]

USDA is also working to support efforts to reduce the greenhouse gas emissions that cause climate change. In August 2013, USDA released for public comment a new report that outlines a set of scientific methods for quantifying greenhouse gas emissions and carbon storage at the local farm, ranch or forest scale.[69]

Efforts to Preserve the Genetic Diversity of Crop Species

As further described in the Biodiversity and Habitat section of this document, a number of efforts have begun to systematically collect and preserve genetic material in recognition of the risk of biodiversity loss from threats such as climate change. The mission of the USDA ARS National Center for Genetic Resources Preservation (NCGRP) is to acquire, evaluate, preserve and provide a national collection of genetic resources to secure the biological diversity that underpins a sustainable U.S. agricultural economy through diligent stewardship, research and communication.[70] For instance, noting that 20% of the world's livestock breeds are at risk of extinction, and that such a contraction limits the flexibility of livestock producers to respond to future biological or economic challenges, the USDA Plant and Animal Genetic Resources and Preservation Research Unit is continuing the development of germplasm and tissues collections for all major livestock species in the U.S., so that industry and the research community can access these resources at any time. Genetic preservation efforts will be important for food

security and the economic vitality of the agriculture sector.[71]

Climate Hubs

In February 2014, USDA announced the creation of seven regional climate hubs and two sub-hubs, including a Southwest sub-hub in Davis, California. The Climate Hubs will build on the capacity within USDA to deliver science-based knowledge and practical information to farmers, ranchers and forest landowners to help them adapt to climate change and weather variability. The Hubs will build capacity within USDA to provide information and guidance on technologies and risk management practices at regional and local scales.[72]

Invasive Species Preparation and Response

As noted in the Biodiversity and Habitat section of this document, climate change may result in species migration, range shift, and novel combinations of species, and as discussed above agriculture may face changing pressures from invasive pests, weeds and diseases. These changes will occur against a backdrop where global trade is increasing over time, and more opportunities will arise for the introduction and establishment of invasive species through California, the nation's trading hub. In 2011, the Invasive Species Council of California (ISCC), comprised of six state agencies, approved *Stopping the Spread: A Strategic Framework for Protecting California from Invasive Species*. The Framework recommends a number of actions, including creating and funding a Rapid Response Work Group to guide response to new invasive species. The ISCC created the California Invasive Species Advisory Committee (CISAC), a stakeholder body, to advise the council and develop recommendations, which included developing the Strategic Framework and the 2013 Update and presenting them to the ISCC. The ISCC is planning to update the Framework by the end of 2014.[73]

CDFA is also preparing a Statewide Plant Pest Prevention and Management Program Environmental Impact Report (PEIR). The goal of this statewide program is to create a vehicle that provides a time-sensitive and efficient framework for evaluating potential environmental impacts of invasive pests and the pest management activities implemented by CDFA and its partners.[74]

Agricultural Research

CDFA, through its Specialty Crop Block Grant Program (a USDA program), is funding research to identify risks, develop adaptation measures and provide information to producers in adapting to climate change. California's leading research institutes, enabled in part by CDFA funding, are studying crop chilling, heat requirements, crop phenology, and furthering our understanding of the effect of agricultural management practices on greenhouse gas emissions.[75] CDFA's Fertilizer Research and Education Program is also funding and facilitating research into how to reduce nitrous oxide greenhouse gas emissions from nitrogen application fertilizers.[76] CalRecycle and CARB are collaborating on research that includes investigating GHG emissions or emissions reductions from the application of finished compost to agricultural soils.

The state's Climate Change Assessment program has also enabled research specifically focused

on climate impacts to California agriculture. The Second Climate Change Assessment included six agriculturally-focused studies, and the Third Climate Change Assessment included three studies, including initial efforts to examine climate impacts and strategies for specific regions in California such as Yolo and Fresno County.[77]

Protecting Agricultural Land

As noted above, the risk of significant climate changes is present against a backdrop of other stressors to California's food and agriculture, including significant loss and conversion of agricultural land. Farm and grazing lands in California decreased by more than 1.3 million acres between 1984 and 2008. This loss averages about one square mile every four days.[78] Farmland protection is an important strategy for reducing stressors on agricultural production as climate risks escalate. Furthermore, protecting farmland from conversion can otherwise reduce California climate risks by helping to ensure food security, providing habitat and corridors for wildlife, and helping with flood mitigation and groundwater recharge. Protecting farmland can also have significant greenhouse gas benefits; one study has indicated that urban land produces seventy times more greenhouse gas emissions per acre than cropland.[79]

Land use planning in California occurs mostly at the local or regional level, and local and regional governments are key partners for the state with respect to farmland protection. The California Land Conservation Act of 1965--commonly referred to as the Williamson Act--enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments which are much lower than normal because they are based upon farming and open space uses as opposed to full market value. The Open Space Subvention Act of 1971 provided local governments an annual subvention of forgone property tax revenues from the state through the year 2009; however, these payments have been suspended in more recent years due to revenue shortfalls.[80]

The California Farmland Conservancy Program (CFCP), a grant-funding program run by the California Department of Conservation, has successfully conserved over 56,000 acres of California farmland since 1996.[81] The CFCP provides grants to local governments and qualified non-profit organizations. These grants support local efforts and planning projects that protect agricultural land resources. The State of California Wildlife Conservation Board also administers the Rangeland, Grazing Land and Grassland Protection Program which has supported conservation easements intended to prevent rangeland conversion, protect livestock grazing, and sustain the related water quality and open-space benefits of grazing practices.[82] Funding for both the CFCP and Rangeland, Grazing Land and Grassland Protection Program has diminished significantly in recent years.

In April 2012, Fresno City Council voted to support a 2035 General Plan Update that supports farmland protection and smart growth principles that contain sprawl. At the City Council meetings on the 2035 General Plan Update, there was a wide and diverse support base for the smart growth approach.[83] This is a significant step for a large city surrounded by some of the state's best agricultural land. Smart growth can also reduce the greenhouse gas emissions that

cause climate change, both by reducing vehicle miles traveled and by preventing conversion of agricultural lands to urban lands which have a significantly higher greenhouse gas footprint.[84]

Other innovative planning projects that will help protect agricultural land and resources are also underway. For example, the Sacramento Area Council of Governments (SACOG) is undertaking the Rural Urban Connection Strategy (RUCS), which is creating an agricultural mapping tool that will be integrated into its model used for urban land use analyses. The project is evaluating the greater Sacramento area's growth and sustainability from a rural perspective – and will ultimately be the region's economic and sustainability strategy.[85] The San Joaquin Valley Greenprint will compile information describing the lands, waters and living resources of the San Joaquin Valley region and the trends affecting them, in order to reinforce local efforts and serve as a guide to local, state, federal and private sector decision-makers as they make choices about the future of the Valley's agricultural resources.[86]

Heat and Agricultural Worker Safety

As noted throughout this document, climate change is expected to bring more frequent and more severe weather events, including more extreme heat events. Since 2005, California employers have been required to provide services that protect outdoor workers— adequate water, shade, rest breaks, training and emergency procedures. In 2010, the standard was strengthened to include a high heat provision that must be implemented by five industries (agriculture, construction, landscaping, oil and gas extraction and transportation or delivery of agricultural products, construction material or other heavy materials) when temperatures reach 95° F and above. These enhancements included mandates to remind employees to drink water more frequently, to observe employees for signs and symptoms of heat illness, to ensure effective communications to summon help if needed, and to provide close supervision of new employees.[87] For more information on heat and health, please see the Public Health section of this document.

Improving Water Management in California

As further discussed in the Water chapter of this document, pursuant to SB 7x7, or the Water Conservation Act of 2009[88], DWR, in consultation with the California Agricultural Water Management Council, academic experts, and other stakeholders, developed a proposed methodology for agricultural irrigators, farmers and ranchers to use in quantifying the efficiency of agricultural water use and a plan of implementation that includes estimated implementation costs, roles and responsibilities, and types of data that would be needed to support the methodology. "A Proposed Method for Quantifying the Efficiency of Agricultural Water Use: A Report to the Legislature" was released in May 2012.[89]

In 2009, the Governor and Legislature also enacted SB 7x6, which requires the reporting of groundwater levels to DWR.[90] Specific recommendations for improving water use efficiency, preparing for hotter and drier conditions, supporting regional groundwater management for drought resilience, and other water-related recommendations to respond to climate risks are discussed in the Water chapter of this document.

Resource Conservation Districts – Mobile Irrigation Labs and Mobile Water Labs

Resource Conservation Districts (RCDs) are "special districts" set up under California state law for the control of runoff, the prevention or control of soil erosion, the development and distribution of water, and the improvement of land capabilities.91 The lands included in a district shall be those generally of value for agricultural purposes, including farm and range land useful for the production of agricultural crops or for the pasturing of livestock, but other lands may be included in a district if necessary for the control of runoff, the prevention or control of soil erosion, the development and distribution of water, or land improvement, and for fully accomplishing the purposes for which the district is formed. Many RCDs offer Mobile Irrigation Labs or Mobile Water Labs that perform on-farm water use evaluations to improve irrigation efficiency and awareness of water conservation tools.92

ACTIONS NEEDED TO SAFEGUARD AGRICULTURE

As described above, important first steps have been taken to help protect California agriculture from climate risks. Ensuring the sustainability of food production in the face of climate risks will require a concerted collaborative effort by farmers and ranchers, government agencies, agricultural service organizations, research institutions, and other partners. Such efforts will be important to safeguard California's agricultural production and economy, and will be important to food security in California, the nation, and the world. Recommended actions are described in more detail below.

Developing and promoting adoption of management strategies and systems that reduce climate risks to agriculture

Actions to develop and promote adoption of management strategies with multiple benefits that reduce climate risks to agriculture will be important, these may include:

- Developing new and adapting existing best management practices that reduce climate risks, including, for example, soil conservation practices and practices that support pollinator health;
- Developing incentive programs for sustainable, science-based practices that create resilience to climate impacts, including pilot-projects to demonstrate proof-of-concept;
- As further discussed in the Water section of this document, management strategies that reduce climate risks to water are needed including, but not limited to, enhanced flood management, water use efficiency, and regional groundwater management for drought resiliency;
- Reducing the rate of farmland conversion to buffer against climate risks to food production by supporting smart growth and reducing urban sprawl, and supporting farmland conservation;
- While continuing breeding research as discussed above, also supporting efforts to systematically collect and preserve agricultural genetic material in recognition of the risk of agricultural biodiversity loss from climate change;

- Investing in and improving agricultural equipment to be adaptable between crops to facilitate shifting crop patterns and to optimize capital investments in the face of changing climate conditions; and
- Working with industry to develop new technologies for field-level monitoring of climate impacts, including, for example pests.
- Provide technical assistance and financial incentives to farmers and ranchers implementing climate resilience strategies and systems.

Understanding and responding to evolving trends that relate to agriculture

Changing climate risks and emergency management

CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. As noted in the Emergency Management section of this document, climate change is likely to require improvements emergency preparedness and response capacity. As discussed above, climate change has implications for infectious diseases and food and animal safety. It will be important to ensure that CDFA has adequate support and capacity to respond quickly to emergencies related to food and feed safety and agricultural diseases and pests.

Supporting new revenue streams for agriculture that support positive climate action

Climate change threatens the California agricultural sector with economic losses, and the ability to develop new revenue streams may help provide added fiscal resilience for California farmers and ranchers. Activities that generate new revenue streams may themselves help foster positive action on reducing the emissions that cause climate change, and help to build resilience against climate risks. For instance, as discussed above, the development of anaerobic digesters and co-digestion of agricultural by-products can provide flexible, renewable energy and help with waste diversion goals. Developing incentives for agricultural ecosystem services, such as beneficial soil practices (for example, cover crops, tillage practices, and the use of compost), can provide greenhouse gas and water quality benefits, and such practices can also foster greater resilience in the face of climate impacts (for instance by improving soil moisture during hotter, drier conditions).

Cross-sectoral climate impacts

Climate risks to other sectors are important to agriculture. Climate risks to water and management strategies to address those risks are obviously important to agriculture. Impacts in other sectors are also important, for instance, impacts to the energy system can disrupt agricultural production, impacts in the transportation sector can have critical implications for agricultural goods movement, and climate impacts to biodiversity and habitat may have impacts on species that are beneficial to agricultural production.

Furthermore, impacts to the agricultural sector can have important implications for other sectors. For instance, increasing temperatures, may require increased energy or water consumption for agriculture (for instance, to enhance or provide livestock cooling systems). As discussed in this chapter, declining agriculture productivity or price increases related to climate

impacts may also have impacts on public health. Cross-sectoral collaboration and engagement will be increasingly important in the era of climate change.

Support risk sharing mechanisms that protect food security and California's agricultural sector

As discussed in the Emergency Management section of this document, insurance and disaster relief are important risk sharing mechanisms that can help foster resilience, especially when combined with other efforts to reduce climate risks. However, federal program spending on the types of crops grown in California remains a small fraction of that spent on crops, like corn, wheat, soy, and cotton, which are predominantly grown in other parts of the nation. Climate risks to California's crops and livestock not only threaten California's agricultural sector and economy, climate impacts may cause price increases in healthy foods, like fruits, nuts, and vegetables, that are important for food security in California, the nation, and the world.

California should continue to support national policy reforms that would provide crop insurance and disaster assistance safety net programs to all commodities, and ensure that California farmers and ranchers have access to these types of important risk sharing mechanisms.

Improving Understanding of Climate Impacts on Agriculture

<u>Research, Modeling and Monitoring</u>
Some important work has been completed with respect to research and modeling projected climate impacts to agriculture, but more remains to be done. Needed actions include, but are not limited to:

- Studies of infrastructure and capital associated with relocating crops or shifting between crops; and economic studies of crop relocation or crop shifting, including comparative cost studies of moving or losing certain crops;
- Studies that evaluate the climate benefits of organic materials as soil amendments, such as compost, biochar, and digestate;
- Research supporting the beneficial use of agricultural by-products for renewable energy and organic fertilizers;
- Studies to quantify carbon sequestration and water saving potential of compost use in agricultural setting such as irrigated croplands and rangelands;
- Cumulative impact studies: As discussed in this chapter, agriculture faces multiple changing climate variables and multiple climate risks, and these threats occur against the backdrop of other stressors such as farmland conversion. More research is needed to understand the compound and cumulative impacts of these risks, to develop more accurate projections to inform risk management strategies. Research is needed on the cumulative impact of farmland conversion on adaptive capacity and food security;
- More crop-specific and location-specific studies of climate risks, and modeling projections of productivity effects and impacts to help facilitate the development of

specific, actionable management activities to reduce climate risks (e.g. strategies for salt water intrusion for agriculture located in areas susceptible to such risks);

- Plant and animal breeding research, including research on pest and disease resistance, drought resistance, heat and chill resilience, and stress tolerance;
- Research on changing water needs for agriculture in times of more sustained higher temperatures and extreme heat events;
- Research on climate impacts on vector-borne diseases in animals, along with action to preserve and enhance monitoring, testing and reporting capacity for such diseases, especially in light of reductions in federal funding from the Centers for Disease Control and Prevention for such activities;
- Research on climate change risks to food safety;
- Research on temperature changes and other climate stresses on livestock;
- Further research on temperature changes and other climate stresses on crops;
- Further studies on barriers to efforts to prepare for climate risks and ensure the long-term sustainability of California agriculture, including possible strategies for overcoming such barriers;
- Creating an online "research needs" forum where agricultural stakeholders, including farmers, ranchers and industry groups, can share their needs, observations, and ideas directly with scientific researchers; and promoting cooperative research that involves farmers and ranchers in the research process, including "on-farm" research projects;
- Studies of the economic and social risks of negative climate impacts on California agriculture;
- Further research on climate impacts on weeds and invasive plant species, insect pests, and pathogens affecting crops;
- Further research on climate impacts on pollinators, including native pollinator species;
- Studies of the ability of California's beneficial species to control new or worsening invasive species problems; and
- Studies of the effectiveness of different cropping practices, e.g. organic, crop rotation, fertilization, for addressing climate risks to agriculture.

<u>Visualization Tools</u>

Climate research and data will need to be translated into tools that can be used by agricultural producers involved with on-the-ground management of agricultural resources. Tools may include:

- An early effort at mapping California agricultural vulnerability was developed as part of the Third Climate Change Assessment[93,] but the mapping effort needs to be refined to consider additional variables and more fully assess the vulnerabilities to California's water resources and livestock systems in a spatially explicit manner, and to modify the mapping to accommodate future projections of climate, land use, and socio-economic variables;

- Vulnerability maps showing projected climate risks to California agriculture, should be integrated in state visualization tools such as Cal-Adapt and the California Geoportal;
- Climate risk visualization tools tailored more specifically to agricultural producers should be developed, supported, maintained, and publicized.

Outreach and Education

It will be important to disseminate information regarding the results of continuing research on climate risks to agriculture, the development of best management practices for dealing with such risks, and any expanded business, funding, or risk sharing opportunities that can enhance resilience. This information must be shared with farmers and ranchers, decision makers, and other partners in a format that is easily accessible and readily usable in order to promote timely action to protect agricultural resources from climate risks.

Efforts to foster this type of outreach and educational might include:

- Working collaboratively with partners (such as USDA Climate Hubs, USDA Natural Resources Conservation Service, University of California Cooperative Extension, Resource Conservation Districts, and the California Agricultural Commissioners and Sealers Association) to provide information on climate risks as well as financial and technical assistance to farmers and ranchers interested in adopting practices that create resilience against climate risk;
- Establishing an international exchange program to facilitate the learning and adoption of new tools and techniques to create resilience in farming and ranching in the face of climate risks;
- Developing a comprehensive list of adaptation strategies that have worked throughout the world to reduce climate risks to agriculture, and promote such strategies in California if relevant and useful;
- Hosting a recurring conference focused on preparing for climate risks to agriculture for farmers, ranchers, researchers, government agencies, and other partners;
- Continuing integration of agricultural climate risk considerations into broader state efforts to prepare for climate risks;
- Recognizing and publicizing the efforts of innovative farmers and ranchers who are proactive in preparing for climate risks and adopting practices that foster resilience; and
- Providing online materials, in addition to the visualization tools discussed above, regarding climate risks to agriculture (such as changing water availability, extreme weather events, loss of winter chill and other temperature changes, possible shifts in pests and disease, possible shifts in pollinator lifecycles, etc.).

Box 6

California Food and Agriculture

Several state entities play an important role with respect to food and agricultural in California. The state also has important federal, local and private sector partners. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks.

California Department of Food and Agriculture (CDFA) serves the people of California by promoting and protecting a safe, healthy food supply, and enhancing local and global agricultural trade, through efficient management, innovation and sound science, with a commitment to environmental stewardship.

California Department of Conservation (DOC) among other things, DOC works to safeguard farmland and open space resources.

California Department of Forestry and Fire Protection (CAL FIRE) is dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. The health of forested watersheds is important to California's water supply and water quality.

California Department of Public Health (CDPH) works with partners to implement outreach for CalFresh: California's Supplemental Nutrition Assistance Program which is funded by the U.S. Department of Agriculture. CDPH also has a number of other nutrition and food safety programs.

California Department of Water Resources (DWR) is responsible for managing and protecting California's water resources and supplies.

California Department of Resources Recycling and Recovery (CalRecycle) - part of CalRecycle's mission is to increase the diversion of organic materials from landfill disposal for beneficial uses such as compost and energy production.

Invasive Species Council of California (ISCC) is an inter-agency council that helps to coordinate and ensure complementary, cost-efficient, environmentally sound and effective state activities regarding invasive species. The ISCC is chaired by the Secretary of the California Department of Food and Agriculture and Vice-Chaired by the Secretary of the Natural Resources Agency; its members include the Secretaries from the California Environmental Protection Agency, California Business, Transportation and Housing Agency, California Health and Human Services Agency, and California Office of Emergency Services.

State Water Resource Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting statewide policy and supporting the pollution control programs administered by the Water Boards.

Wildlife Conservation Board (WCB) administers the Rangeland, Grazing Land and Grassland Protection Program.

California has important federal partners with respect to food and agriculture including: the **U.S. Department of Agriculture (USDA)** which provides leadership on food, agriculture, natural resources, rural development, nutrition, forest management, and related issues based on sound public policy, the best available science, and efficient management, and the **Bureau of Land Management (BLM)** which manages livestock grazing on 155 million acres of public lands as guided by Federal law. California also has many important local government partners, including the **County Agricultural Commissioners and Sealers (CACASA)**, as well as private partners on food and agriculture.

BIODIVERSITY AND HABITAT

INTRODUCTION

Climate-related changes are adding pressure to ecosystems already stressed by habitat loss and fragmentation, pollution, disease, population growth, and other human-related impacts. This added pressure is significantly increasing the risk of biodiversity loss and species extinction. Healthy ecosystems and ecological processes provide a variety of benefits including, but not limited to, clean air, clean water, carbon storage, crop pollination, and recreational opportunities such as hunting, fishing, and wildlife viewing. Biodiversity resources are also an important part of the cultural heritage of communities. These are but a few of the many benefits, sometimes referred to as 'ecosystem goods and services' that are enjoyed by California residents and at risk of being negatively impacted by climate change.

The specific implications of climate change for biodiversity and ecosystem goods and services may vary by region, and research is improving our understanding of the potential impacts and projected risks in California. Some of the major challenges facing the biodiversity sector that are being exacerbated by climate change include the accelerated spread of invasive species that negatively impact native species and ecosystem processes, barriers to species migration or movement in response to changing climatic conditions, direct impacts to species health, and mismatches in timing between seasonal life-cycle events such as species migration and food availability. These potential impacts could have serious implications for the ecosystem services described above. Timely action is needed to address these risks.

California state agencies and partners have made important progress with respect to preparing for risks to biodiversity, including groundbreaking collaborative efforts. California agencies and partners have worked together to build a collective vision for how to address climate-related risks to biodiversity through national and regional planning efforts. Since 2009, an abundance of climate research projects and tools have been developed by numerous organizations to help visualize and improve our understanding of climate impacts and the vulnerabilities of fish, wildlife, and habitats. Perhaps most importantly, climate change is becoming an integral part of on-the-ground restoration and conservation activities. Since California habitats are owned and managed by a variety of different entities including federal, state, and private landowners, continued collaboration is particularly important to effective efforts to protect California habitat and biodiversity in the face of escalating climate-related risks. More remains to be done.

Some on-going resource management efforts, such as conservation and restoration efforts, help reduce stressors on ecosystems. However, as temperatures and water availability are changing in California, new efforts are needed to adequately safeguard California's natural resources. For instance, one of the primary means by which species are expected to respond to climate change is to adjust their geographic ranges to track shifting areas of climatic suitability. Therefore, there will be an increasing need to ensure that there are linkages, or 'connectivity', between habitat areas to facilitate the movement of species. Additional research is needed to support these efforts and to continually improve our understanding of climate impacts and risks

to biodiversity. Monitoring of baseline species and habitat conditions and changes on the landscape will be necessary to support adaptive management, and education and outreach efforts will be key to communicating risks and gaining public support for action. To face these risks in a cohesive and effective way, environmental stewardship must be practiced across state agencies.

Several state entities play an important role with respect to biodiversity and habitat in California. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. For more information, see Box 15: *Entities Responsible for California's Biodiversity and Habitat at the end of the chapter.*

Box 7

Declining snowpack and the loss of a fly fishing dream
By William Geer [Used with permission]

The course of my career was pretty well set in July 1958 when I caught my first limit of rainbow trout from Pinecrest Lake up on Sonora Pass in the Sierras. My love for fishing culminated in a career as a professional fisheries biologist in which I have been able to devote field work and research into what makes or breaks good trout waters. I was raised in Salinas far from the Sierra trout waters, but dreamed of one day living along a good trout stream in the mountains.

Now about to retire, I am living my boyhood dream next to a wonderful little trout stream in western Montana – Lolo Creek – where I have enjoyed catching rainbow, brown, brook and cutthroat trout on flies all summer and fall. I figured I finally arrived at where I wanted to be, at least until a few years ago when I walked down to the stream one day in August and found no water – and no trout – in the channel.

The stream had not been drained dry by manmade diversion; it simply ran out of snowmelt. The late summer flows in Lolo Creek that had always been sustained by prolonged snowmelt from the Bitterroot Mountains were gone, victim to snowpack that has declined 17% over the past 50 years due to a changing climate. Even with an increase in spring rains, which do not sustain late summer streamflows, I see the damage that a 17% decline in snowpack has done for fish and fishing in Lolo Creek. I wonder about the consequences of a predicted 25% reduction in snowpack in California. Less snow and more rain have become a west-wide pattern in recent years.

Over the last several years as a fish and wildlife professional, I have focused almost entirely on the impacts of climate change on fish and wildlife, its implications for sustainable hunting and fishing, and on-the-ground adaptation projects that will help fish and wildlife survive in viable populations in the changing environment. I have examined the state-specific impacts of climate change in Montana, Washington, Oregon, Colorado and New Mexico.

In my little neighborhood stream, the reduced snowpack has become evident in both declining June runoff and loss of August streamflows. August is often the worst month in western trout

streams due to low flows that confine trout populations in reduced habitat areas and higher water temperatures that exceed the upper limits of tolerance for cold-adapted native species like cutthroat and rainbow trout. A new research study in Wyoming, Montana and Idaho shows that the problem of declining August streamflows in trout-supporting streams is widespread.

I also fish for native Yellowstone cutthroat trout in the fabled Yellowstone River. The larger Yellowstone River also suffers from climate-driven lower runoff and August streamflows. The warmer water in August has allowed an upstream invasion of nearly 40 miles by warmwater smallmouth bass that have displaced native cutthroats that cannot tolerate the warmer water. The displacement of coldwater trout by invasive warmwater species like bass has become common in rivers and streams throughout the West the last 20 years.

Observations on climate impacts on western streams and trout populations have been made in all western states, and the outlook is not good. New research by fishery scientists in Trout Unlimited and state fish and wildlife agencies forecasts the effects of climate-altered streamflows and higher water temperatures on four species of trout on nearly 250 million acres across the Intermountain West based on fish surveys at 9,890 sites. Projections show a 47% decline in total suitable habitat for all trout by the 2080s. Habitat for brook trout and brown trout is predicted to decline by 77% and 48%, respectively. Cutthroat trout are predicted to lose a further 58% of habitat due to higher temperatures and negative biotic interactions with other fish species more tolerant of warming water.

It is expected that climate impacts on inland California trout streams such as those in the Sierra Nevada Range – the waters most immediately affected by less snow, more rain and warmer water – will mirror the impacts already observed in Montana, Colorado, New Mexico and eastern Washington and Oregon.

I won't be the only fly fisher losing a dream because of climate change in California and throughout the West.

Bill Geer worked for the Theodore Roosevelt Conservation Partnership from 2005 until his retirement in 2013. Bill served as the Director of Western Lands and Climate Change Initiative Manager for the Theodore Roosevelt Conservation Partnership. After earning a B.S. from the University of Montana School of Forestry and a M.S. degree in limnology from Montana State University, Bill spent 40 years as a professional fish and wildlife conservationist. He served as Chief of Fisheries and Director of the Utah Division of Wildlife Resources, Coordinator for the North American Waterfowl Management Plan for the National Fish and Wildlife Foundation, Vice President for both Field Operations and Conservation Programs for the Rocky Mountain Elk Foundation, Inland Northwest Conservation Manager for the Nature Conservancy in Idaho, Executive Director of the Outdoor Writers Association of America, and Special wildlife adviser to both Senator Jon Tester and to the Wildlife Conservation Society. Bill is from Salinas, California and is a well-respected leader in the hunting and fishing community.

Risks, Challenges and Opportunities with Respect to Safeguarding Biodiversity and Habitat

Impacts and Risks

Climatic changes are resulting in changes in biological systems. Changes to air and water temperatures, changes to water quality and availability, sea level rise, ocean acidification, aquatic hypoxia, and altered wildfire regimes are some of the changes that are affecting biological systems.[94] (For more information on ocean acidification and sea level rise, see the Ocean and Coastal Ecosystems and Resources section of this document. For more information on the impact of temperature, precipitation and other climate changes on tree species, please see the Forestry section of this document.) Recent research since 2009 has revealed that climate change related increases in extreme events such as fire, drought, flood, extreme temperatures, and storm events could have significant impacts on habitat, species, and human communities. [95]

Box 8

Ocean Acidification: Implications for Biodiversity

Ocean acidification is impacting the biological diversity of our oceans. As the oceans become more acidic, organisms that use calcium carbonate to construct skeletons and protective structures are especially at risk since acidic conditions can inhibit shell formation.[96] (*See also Ocean and Coastal Ecosystems and Resources Chapter narrative "Seeing is believing: shellfish growers confront ocean acidification").* Ocean acidification can also negatively affect fish larvae.[97] Ocean acidification threatens to disrupt marine food webs, and may lead to changes in fish stocks that threaten food security.[98]

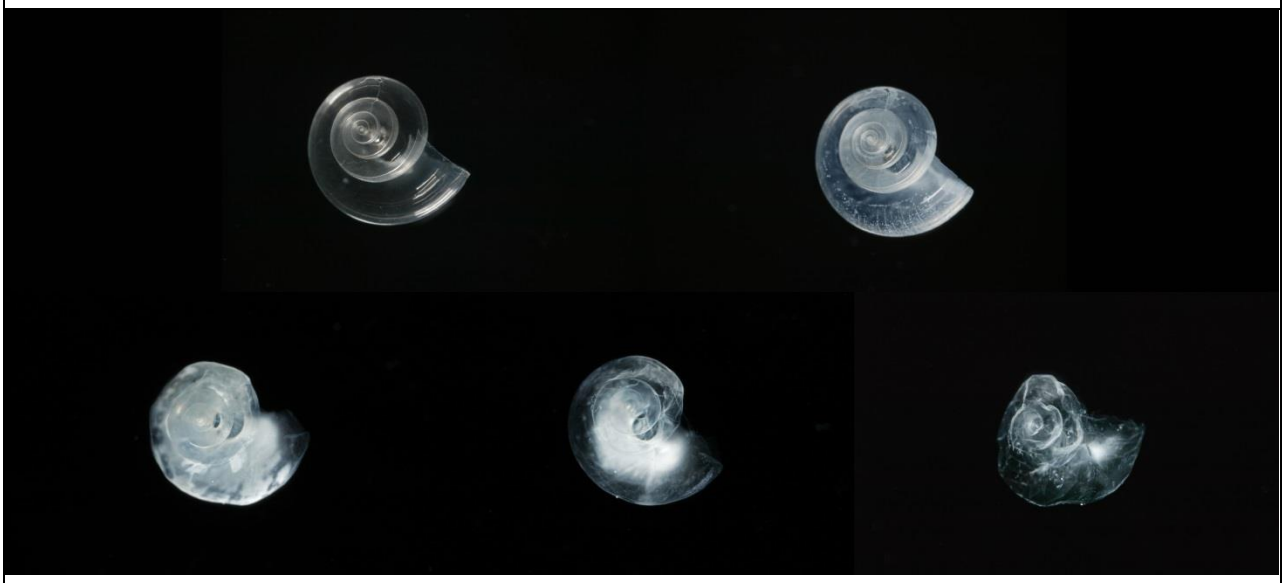


Photo credit: David Liittschwager/National Geographic Stock. Used with permission.

The photos above show what happens to a pteropod's shell when placed in sea water with pH

and carbonate levels projected for the year 2100. The shell slowly dissolves after 45 days. It should be noted that this photograph is provided for illustrative purposes; ocean acidification is occurring over time and the capacity of species to adapt to the pace and scale of acidification is the subject of ongoing research.

Climate changes impact ecosystems and species in a number of ways, and add to pressures on ecosystems already stressed by habitat loss, pollution, and other human-related impacts. The 2009 California Climate Adaptation Strategy[99] provides detailed information on projected impacts and risks to biodiversity. Notable impacts and risks include[100]:

1) Species migration in response to climatic changes, range shift, and novel combinations of species; the population distributions of some North American species are expected to move northward in latitude and upward in elevation. While this means a range expansion for some species, for others it means a range reduction, movement into less hospitable habitat, or increased competition. For instance, a USGS study indicates that temperature increases resulting from climate change in the Southwest will likely eliminate Joshua trees from 90 percent of their current range in 60 to 90 years.[101] Some species have nowhere to go because they are already at the northern or upper limit of their habitat or because there are impediments to migration. The collection of species making up any community of organisms in a given habitat (the "species assemblage") may change and this may result in changing species interactions and ecological processes. [102]
2) Pathogens, Parasites, and Disease: Climate change and shifts in ecological conditions could support the spread of pathogens, parasites, and diseases, with potentially serious effects on human health, agriculture, and commercial fishing, for example.
3) Invasive Species: Climate change may aid or accelerate the spread of invasive species that pose additional threats and stress to native fish, wildlife, and plants.
4) Extinction Risks: Climate changes may favor some species, while disadvantaging others. Climate change, along with habitat destruction and pollution and other human-related impacts, can act as a stressor that contributes to species loss and extinction. The Intergovernmental Panel on Climate Change (IPCC) estimates that 20-30% of the plant and animal species evaluated so far in climate change studies are at risk of extinction if temperatures reach levels projected to occur by the end of this century. While natural systems have some adaptive capacity to respond to change, many ecosystems may lack the ability to survive the rate and scale of environmental change associated with a changing climate. Efforts to reduce the effects of climate and other stressors on habitat and species can help alleviate the risk of species loss and extinction and build resiliency.
5) Changes in the Timing of Seasonal Life-Cycle Events; changes can lead to mismatches in the timing of migration, breeding, pollination, and food availability.
6) Food Web Disruptions: The impact of climate change on a particular species can ripple through a food web and affect a wide range of other organisms.
7) Threshold Effects: In some cases, ecosystem change occurs rapidly and irreversibly because a threshold, or "tipping point," is passed. Early efforts to prepare for climate

risks to biodiversity may help prevent losses from occurring.

The August 2013 Indicators of Climate Change in California report confirms observation of these types of changes, including for instance: the range of some conifer-dominated forests in the Sierra Nevada are shifting to higher elevations; in Yosemite National Park, distribution shifts of some mammal species populations have also been observed and these populations are being found at different elevations compared to the early 1900s; butterflies in the Central Valley have been appearing earlier than usual compared to the past four decades; and warming temperatures and reduced upwelling in the oceans negatively affecting the marine food web have had impacts on Sacramento fall run Chinook salmon abundance, auklet breeding, and sea lion pup mortality. [103]

Management Challenges and Opportunities

Managing natural resources in the face of the highly dynamic and evolving conditions presented by climate change requires more integrated, ecosystem-based approaches. The way conservation actions have been carried out in the past, which often focused on the designation of important or representative sites supporting key habitats or species, may no longer be adequate. To address climate change, managers will need to act over different spatial and temporal scales. The focus of restoration will need to shift from historic species assemblages to more dynamic management approaches that are capable of managing risk in the face of uncertainties and being modified over time to accommodate evolving climate science.[104] State information needs related to improving understanding of climate risks to biodiversity and improving knowledge with respect to management responses for such risks are further described below.

While it will be important to re-examine existing conservation practices to plan for climate risks to biodiversity, this must be balanced with the continued need to meet regulatory responsibilities and work within the confines of existing laws and regulations related to individual species management. Innovative new management approaches and collaborative efforts across disciplines and jurisdictional boundaries will be needed to adequately safeguard California's biodiversity. Important lessons may be gleaned from the study of a variety of resource management techniques. Land acquisition and conservation, restoration, and invasive species removal will continue to be high priority actions that can be taken quickly to increase ecosystem resiliency, however some innovative new approaches to conservation will likely be important and are already being developed in California. Governance structures that can support collaborative decision making are needed, and in some cases must be created. As science and information about the effectiveness of management responses continues to evolve, efforts to plan for climate risks will need to be refined.[105]

Box 9

Traditional Ecological Knowledge

For over 10,000 years, Native Americans from diverse tribes have been practicing natural

resource management. Traditional Ecological Knowledge (TEK) is "the knowledge base acquired by indigenous and local peoples over hundreds of years through direct experience and contact with the environment."[106] This knowledge is place-specific and includes the relationships between plants, animals, natural phenomena, landscapes, and phenology that are used for regular practices like hunting, fishing, trapping, and forestry.[107] Indigenous groups are projected to be among the communities most heavily affected by climate change. Many American Indian and Alaska Native tribes are identifying and implementing culturally appropriate strategies to assess climate impacts and adapt to projected changes. TEK, as an indigenous knowledge system, has the potential to play a central role in both indigenous and nonindigenous climate change initiatives. The detection of environmental changes, the development of strategies to adapt to these changes, and the implementation of sustainable land-management principles are all important climate action items that can be informed by TEK.[108]

As environmental and biological changes related to climate change emerge, there will be a need to manage for a future that may contain species and habitat configurations unlike any we have seen in the past. As noted above, many North American species may migrate to inhabit new locations. Providing corridors and maintaining "connectivity" to facilitate the movement of species between suitable areas and to newly suitable areas over time as climate changes (e.g. northward or up in elevation) is the most frequently recommended strategy for conserving species. Given projected future climate change, it is likely species will need to move significant distances, and they may encounter substantial barriers to such movement.[109] Addressing these barriers can be an important part of preparing for climate risks to biodiversity.

Certain areas of refuge (refugia) will be particularly important as climate change impacts unfold. Refugia can be defined as areas that conserve natural elements that may be eliminated or significantly degraded elsewhere.[110] Refugia can help support the persistence of species and habitats, even in new assemblages. For instance, the Southern Sierras may provide areas of refugia for climate-stressed species because of its unique elevational and latitudinal gradients; a number of efforts are underway to study and protect the Southern Sierra.[111] The Southern Sierras are further described in the Forestry section of this document.

Technology is enabling new forms of scientific collaboration which may support efforts to protect biodiversity resources. For instance, citizen science can help provide information regarding historical conditions and can help monitor changes that may be attributed to climate change. For more information on citizen science, see Box 10.

Box 10

Citizen Science – Crowdsourcing Climate Monitoring

Citizen science is a form of scientific research collaboration involving members of the public[112], which has been greatly enabled through technological advances such as the internet, global positioning system technology, digital photography, and mobile phone technologies[113]. Citizen

science projects that rely on information technologies are often considered a form of "crowdsourcing", where an open call for contributions is made to a large, undefined network of people.[114] The ways in which citizen scientists can contribute to the scientific endeavors varies, and there are a variety of ways in which scientific efforts may be designed to include input from citizen scientists. For instance, citizen scientists with mobile, networked devices can help collect data and help with monitoring efforts; and standardized field protocols for collecting and visualizing data can improve data quality. Innovations in the design of citizen science projects and continued technological advancements will help contribute to the evolution of citizen science and its ability to generate useful scientific data on a large scale.[115]

Citizen science can help contribute to efforts to identify threats to ecosystems and to observe changes in the range of land and marine based species as the climate changes. Citizen science efforts can also provide unique opportunities for public education and engagement. For instance, the National Park Service and the UCLA Center for Embedded Network Sensing (CENS) partnered to design a smartphone application to identify the locations of invasive weeds in the Santa Monica Mountains National Recreation Area. The technology behind the *What's Invasive!* project was developed by CENS, a National Science Foundation supported research center that develops ways to link human interaction with the natural world and technology. This application allows users to take a photo with a mobile device and map the location of invasive weeds. Invasive weeds are a significant threat to native plant and animal species in the Santa Monica Mountains, and combating invasive weeds requires a significant investment of resources. The Santa Monica Mountains National Recreation Area spent $200,000 over a three year period to map invasive weeds in the mountains. Assistance from citizen scientists helps keep the map up to date and better equip park staff and volunteers to remove invasive weeds.[116] The California Academy of Sciences (the Academy) also has a Citizen Science program which focuses on how California biodiversity has changed based on historic knowledge and the Academy's specimen collections.[117] For an additional example of citizen science, see "*Imagining California's Future Coastline – California King Tides Initiative"* in the Ocean and Coastal section of this document.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

Planning Efforts

Natural Community Conservation Planning (NCCP): The NCCP program is an unprecedented effort by the State of California, and numerous private and public partners that takes a broad-based ecosystem approach to planning for the protection and perpetuation of biological diversity. The primary objective of the NCCP program is to conserve natural communities at the ecosystem level while accommodating compatible land use. The program seeks to anticipate and prevent the controversies and gridlock caused by species' listings by focusing on the long-term stability of wildlife and plant communities and including key interests in the process.[118] For more information on California's innovative land use planning efforts, please see Box 11: Innovative land use planning to balance multiple objectives.

Regional Advance Mitigation Planning ("RAMP"): In 2008, a coalition of infrastructure and natural resource agencies, nongovernmental organizations, and academic researchers launched an effort to develop a more comprehensive approach to mitigating unavoidable biological resource impacts potentially caused by state infrastructure projects, such as roads and levees. This approach, called Regional Advance Mitigation Planning ("RAMP)", allows for natural resources to be protected or restored as compensatory mitigation before infrastructure projects are constructed, often years in advance.[119] RAMP considers a landscape scale or ecosystem approach to mitigation and conservation planning, helps to address climate risks, and can be integrated with federal Habitat Conservation Plan requirements and state NCCP requirements. A draft RAMP Statewide Framework has been developed and additional efforts to develop planning methodology and advancement of mitigation are in progress.

California's Wildlife Action Plan: In 2000, Congress enacted the State Wildlife Grants Program to support state programs that broadly benefit wildlife and habitats but particularly "species of greatest conservation need." As a requirement for receiving funding under this program, state wildlife agencies were required to submit a Wildlife Action Plan (a comprehensive wildlife conservation strategy) to the U.S. Fish and Wildlife Service (Service) no later than October 2005. Wildlife Action Plans must be updated every ten years, and the 2015 update is currently being developed. One of the key objectives of the update is to incorporate climate change impacts and adaptation strategies; climate change is already identified as one of four primary stressors affecting wildlife.[120]

Box 11

Innovative land use planning to balance multiple objectives

Cooperation between state, federal, and local governments is necessary to optimize land use planning to balance multiple state environmental objectives especially in light of projected population growth and climate stresses.

California has already undertaken complex planning processes that may serve as models for innovative land use planning efforts that balance multiple objectives.

- The Bay Delta Conservation Plan

The Bay Delta Conservation Plan (BDCP) is being developed to support the co-equal goals of enhancing state water reliability and the ecological health of the Sacramento-San Joaquin Delta.[121] The Sacramento-San Joaquin Delta is a critical element of the state's water system. The Bay Delta Conservation Plan seeks to improve the health of the ecological system as a whole. The plan also aims to provide for a more reliable water supply for California by modifying conveyance facilities to create a more natural flow pattern. The BDCP attempts to balance these goals in a way that is feasible given the variety of important uses in the Delta including flood protection, agriculture and

recreation.

- The Desert Renewable Energy Conservation Plan

The Desert Renewable Energy Conservation Plan (DRECP) is being developed to support programmatic development of large-scale renewable energy and the co-equal objective of conservation of the California desert.[122] The primary driver for renewable energy development in the DRECP area is the state's long-term greenhouse gas reduction goals. The DRECP will streamline permitting under the California Natural Community Conservation Planning Act, the federal Endangered Species Act, and the Federal Land Policy Management Act for utility-scale renewable energy development for solar, wind, and geothermal generation within development focus areas, while providing for the conservation of species and natural communities in a landscape-scale conservation plan.

National Fish, Wildlife, and Plants Climate Adaptation Strategy: CDFW collaborated with federal, tribal, and state partners and played a lead role in creating the first National Climate Adaptation Strategy for fish, wildlife, and plants. This strategy promotes a nation-wide unified approach to climate driven adaptation strategies, reflecting shared principles and science-based practices to safeguard the nation's biodiversity, ecosystem function and sustainable human uses of fish, wildlife and plants. The Strategy was released in March 2013. [123]

CDFW Vision for Confronting Climate Change in California: The September 2011 report "Unity, Integration, and Action: CDFW's Vision for Confronting Climate Change in California" outlines CDFW objectives for responding to climate change.[124]

Climate Change Adaptation Case Studies: Several organizations have created adaptation case studies to provide examples of successful climate preparedness projects. For example, the State Coastal Conservancy has developed case studies from various wetland restoration projects, sea level rise planning efforts, and vulnerability assessments.[125] The Bay Area Ecosystems Climate Change Consortium (BAECCC) has compiled case studies that demonstrate climate-smart conservation and restoration taking place in the Bay Area.[126] CDFW also created a number of case studies to highlight existing programs and projects that are helping CDFW to plan for or minimize the negative impacts associated with climate change. This series of case studies demonstrates that planning for climate change will not always require entirely new or novel management approaches; there are many existing management tools in the toolbox that can be utilized to address climate risks.[127]

Building Resilience: Resource Management and Conservation in the Era of Climate Change

First-of-its-kind Statewide Network of Marine Protected Areas**:** As further described in the Oceans and Coastal Ecosystems and Resources section of this document, on December 17, 2012, 19 Marine Protected Areas (MPAs) became effective in the Northern California coastal region, completing the nation's first statewide coastal system of marine protected areas.

Regional and Local Wetlands Restoration: Ecoregional planning and on the ground restoration projects are taking place along the California coast. In the San Francisco Bay, restoration projects are being supported by the Baylands Ecosystem Habitat Goals project, which is currently being updated to include climate change considerations. The Baylands Ecosystem Habitat Goals report recommends the types, amounts, and distribution of upland habitats, linkages, compatible uses and the ecological processes needed to sustain diverse and healthy communities of plant, fish and wildlife resources in the Bay Area[128]. In southern California, restoration efforts in the Southern California Bight are supported by the Wetland Recovery Project and its Regional Strategy. The Wetland Recovery Project is an effort chaired by the Resources Agency and supported by the State Coastal Conservancy, which has public agencies, non-profits, scientists, and local communities working cooperatively to acquire and restore rivers, streams, and wetlands in coastal southern California[129].

At the Elkhorn Slough National Estuarine Research Reserve, a CDFW ecological reserve and National Estuarine Research Reserve located at the center of the Monterey Bay coastline, intensive monitoring of marsh and water level elevation changes combined with modeling have revealed that predicted rates of accelerated sea level rise will lead to extensive marsh loss in coming decades. The Reserve's Tidal Wetland Project is currently initiating a major salt marsh restoration project involving beneficial re-use of sediments. Using this sediment, the project will create higher salt marshes to make them resilient in the face of sea level rise. The Elkhorn Slough and San Francisco Bay National Estuarine Research Reserves are also spear-heading an ambitious project to enhance the success of native oyster restoration projects in the face of climate change. In addition to restoration activities, Elkhorn Slough staff is undertaking numerous other activities to monitor the effects of climate change. The Reserve collects long-term monitoring data on over two dozen indicators of estuarine health that will eventually be used to track changes and identify adaptation strategies in response to climate change impacts over the coming decades.

Preparing for Climate Risks in the Tijuana River Valley: The Tijuana River Valley contains one of the largest intact coastal wetland systems in southern California, despite intense pressure associated with being situated on an international border between two major metropolitan areas - San Diego and Tijuana. The Tijuana River National Estuarine Research Reserve (TRNERR) has several collaborative projects underway that will help increase southern California's regional resilience to climate change, including the Climate Understanding & Resilience in the River Valley (CURRV) Project. The overarching goal of CURRV is to build upon a regional commitment to understand and adapt to climate change. In order to achieve this goal, TRNERR is collaborating with a diverse stakeholder group, including various state agencies, to conduct a vulnerability assessment that will inform the development of adaptation strategies addressing the impacts of climate change, specifically sea level rise and riverine flooding, to both built infrastructure and the natural environment. Through the Temporal Investigations of Marsh Ecosystems (TIME) Project, results from CURRV are being coupled with perspectives from the past (historical ecology) and present (research and monitoring) to inform restoration in the River Valley, as a model to steer wetlands recovery in the broader southern California region.

Incorporating Environmental Stewardship into Integrated Water Management Practices:

- Fish Passage Improvement Program: DWR, in partnership with the local water district and land owners, removed two fish passage barriers on the Calaveras River/Mormon Slough flood control channel. Through the Fish Passage Program, they have also designed and constructed two fish ladders on lower Butte Creek (Weir 2 and Willow Slough Weir) and completed design work for fish passage improvement at the Fremont Weir/Yolo Bypass. The DWR Division of Safety of Dams is currently overseeing the removal of San Clemente Dam on the Carmel River. This is the largest dam removal to be done in California and will provide access to historic coastal steelhead habitat.
- Meadow Restoration: DWR and the US Forest Service have completed a three-year investigation of the hydrologic effects of meadow restoration and how restored meadows can contribute to improved water management operation as well as ecosystem functioning. Restored meadows can also provide flood flow attenuation benefits and improve baseflows in creeks and rivers. The final report is expected to be released by Summer 2014.
- Flood Corridor Program: DWR continues to pursue nonstructural flood risk reduction projects that are coupled with habitat conservation and agricultural protection through the Flood Corridor Program. The program includes three flood protection grant programs that have awarded over $91 million in grant funding covering over 19,000 acres statewide since 2000. These projects can help restore floodplain functions and riparian habitats and enhance wetland development and water table recharge while reducing flood risk for people and property.
- Twitchell Island Wetland Research and the Sherman Island Permanent Wetland projects: The Department of Water Resources (DWR) is working collaboratively to implement projects that demonstrate subsidence reversal and carbon sequestration through wetland restoration in the western Delta (Twitchell Island Wetland Research and the Sherman Island Permanent Wetland). Through these demonstration projects, DWR will study the costs and benefits of these land use management practices to help reduce stress on Delta levees and define the potential value in a carbon market.

Research and Tools

February 2010 Essential Habitat Connectivity Project Report and Tool: CDFW and the California Department of Transportation (CalTrans) commissioned a team of consultants to produce a statewide assessment of essential habitat connectivity using the best available science, data sets, spatial analyses and modeling techniques. The goal was to identify large remaining blocks of intact habitat or natural landscape and model essential connectivity areas between them that need to be maintained, particularly as corridors for wildlife.

Over sixty federal, state, local, tribal and non-governmental organizations collaborated in the creation of: 1) a statewide wildlife habitat connectivity map using a Geographic Information System (GIS) based modeling approach; 2) an assessment of the biological value of identified

connectivity areas; and 3) a strategic plan that helps varied end users interpret and use the statewide map and outlines a methodology necessary for completing connectivity analyses at finer spatial scales.[130]

Third California Climate Change Assessment studies on biodiversity and ecosystems: The California Energy Commission's PIER program helped fund the following critical studies as part of the Third California Climate Assessment released in 2012:

- Projecting Growth in California (2000–2050) Under Six Alternative Policy Scenarios and Assessing Impacts to Future Dispersal Corridors, Fire Threats and Climate-Sensitive Agriculture;[131]
- Climate Change Impacts on California Vegetation: Physiology, Life History, and Ecosystem Change;[132]
- Consequences of Climate Change for Native Plants and Conservation;[133]
- Identifying Vulnerable Species and Adaptation Strategies in the Southern Sierra of California Using Historical Resurveys;[134]
- Fire and Climate Change in California: Changes in the Distribution and Frequency of Fire in Climates of the Future and Recent Past (1911–2099);[135]
- Decision-Making Under Uncertainty: An Assessment of Adaptation Strategies and Scenario Development for Resource Managers;[136]
- Projected Effects of Future Climates on Freshwater Fishes of California;[137]
- Scenarios to Evaluate Long-Term Wildfire Risk in California: New Methods for Considering Links Between Changing Demography, Land Use and Climate;[138] and
- Potential Impacts of Climate Change on Biodiversity and Ecosystem Services in The San Francisco Bay Area[139].

Landscape Conservation Cooperative (LCC) Funded Conservation Projects: LCC's are collaborative public-private partnerships that provide shared science to ensure the sustainability of land, water, wildlife and cultural resources. The CA LCC has funded more than 25 collaborative projects in the past three years and has provided close to $4 million in project funding with an additional $4 million from partner contributions. These projects have included studies to support and develop decision-support tools and data, monitoring and modeling methods, population and habitat assessments, vulnerability assessments, and conservation planning and design.[140] The North Pacific LCC has also funded over 25 projects, several of which were carried out in the California north coast region, a small portion of the LCC's distribution. These projects have ranged from modeling sea level rise to exploring the use of traditional ecological knowledge in natural and cultural resource management.[141] The Desert and Great Basin LCCs have also supported research projects that address issues in the Desert and Great Basin regions of the state.

November 2010 "Bridging the Gap: Downscaling Climate Models to Inform Management Actions" Workshop sponsored by the CDFW, the US Geological Survey, the US Fish and Wildlife Service, and the California LCC. The workshop brought together those working on downscaling

climate models with ecologists and land managers to explore the use of climate models to inform ecological resource management. [142]

Box 12

Tools to Support Biodiversity Conservation in the Era of Climate Change

Since 2009, several tools that support climate adaptation planning have been developed. In addition to the Cal-Adapt and California Essential Habitat Connectivity tools discussed elsewhere in this document, the following resources are available:

CDFW's Areas of Conservation Emphasis Mapping and Modeling Tool was a CDFW project that was begun in 2009 to provide a spatial model that can be used to identify areas of biological or conservation interest throughout the state, in order to guide and inform conservation priorities.[143]

Point Blue Conservation Science Sea-Level Rise Tool: This sea level rise tool was developed to improve our understanding of how sea level rise may change the extent of tidal marsh habitat and bird species distribution in the San Francisco Bay Estuary.[144]

BIOS and Marine BIOS enable the management, visualization, and analysis of biogeographic data collected by the California Department of Fish and Wildlife and its partner organizations.[145]

California Climate Commons: The California Climate Commons is a project of the California LCC and offers an online environment where natural resource managers can quickly find climate change and related environmental information they need, communicate with each other and with the researchers producing the information, and then share lessons learned. The goal of the Climate Commons is to support conservation practitioners in their application of climate adaptation science and help guide new research directions by facilitating more effective information exchange between the climate change research and conservation communities. The Commons is a collaboration of the California Landscape Conservation Cooperative, Sonoma Ecology Center, Point Blue Conservation Science, and UC Davis Information Center for the Environment.[146]



CalWeedMapper CalWeedMapper provides a dynamic tool for mapping invasive plant distribution at the landscape level. The tool was developed by the California Invasive Plant Council (Cal-IPC) and helps support the development of regional invasive plant management strategies. [147]

Box 13

Climate Vulnerability Assessments

Three state-wide climate change vulnerability assessments, specifically for rare and priority species populations, were recently conducted in California. These assessments will be used to inform conservation planning in California, including management planning efforts within CDFW.

A Climate Change Vulnerability Assessment of California's At-Risk Birds This study, jointly funded by CDFW and PRBO Conservation Science, developed a framework for assessing climate change vulnerability of California's at-risk birds and integrating it into the existing California Bird Species of Special Concern list. Climate vulnerability was defined as the amount of evidence that climate change will negatively impact a population. The research showed that nearly 130 species of birds are vulnerable to the predicted effects of climate change and that 21 of the state's 29 threatened and endangered bird species (72 percent) will be further impacted by climate change, increasing their risk of extinction. Wetland bird species were particularly vulnerable to climate change due to their specialized habitat and the risks posed to wetlands by sea level rise and other climate-driven factors. The complete list of birds and their climate vulnerability scores are available online through the California Avian Data Center.[148]

Climate Change Vulnerability for Rare Plants CDFW, with support from the California LCC, conducted a vulnerability assessment of 156 rare plant species in California to determine which will be subject to negative impacts from climate change. This study employed the NatureServe Climate Change Vulnerability Index to assess vulnerability. Future habitat suitability was examined for these species to assess potential range shifts under various climate change scenarios. The resulting 156 assessments and a refinement of the methodology will be helpful to those needing to incorporate rare plants into their resource management plans.[149]

Amphibian and Reptile Vulnerability Assessment UC Davis, with support from CDFW, is currently undertaking an assessment of the climate impacts to amphibians and reptiles in California. This study includes 158 species.

The Climate Change Vulnerability Assessment Resource Center was created by CDFW to provide access to resources for those interested in learning more about climate change vulnerability assessment efforts related to wildlife and habitats. The Resource Center contains reports generated up to 2012.[150]

Box 14

New Frontiers in Biodiversity Research and Conservation

Estimating the vulnerability of biodiversity to climate impacts across broad areas
Rapid and cost-effective methods to estimate the vulnerability of biodiversity to climate change impacts across broad areas are being developed and implemented to help inform conservation strategies. These methods do not replace species-specific vulnerability assessments, however, they allow biodiversity managers to identify trends within large geographic areas to support timely conservation actions.[151] For instance, the Bureau of Land Management has initiated fourteen Rapid Ecoregional Assessments ("REA") throughout the western United States and Alaska, and has already completed the Mojave Basin and Range REA and the Central Basin and Range REA. REAs synthesize existing information rather than conduct research or collect new data, and are generally completed within 18 months. REAs look across all lands in an ecoregion to identify regionally important habitats and assess the potential of these habitats to be affected by climate change, wildfires, invasive species, and development. REAs identify and map key opportunities for resource conservation, while also establishing baseline ecological data to gauge the effect and effectiveness of future management actions.[152]

Adaptive management for climate risks and uncertainty
The concept of adaptive management of ecosystems for the conservation of biodiversity was developed in the 1970s. Adaptive management involves the following key elements: 1) defining management goals 2) development of plausible alternative management strategies to achieve the goals, 3) implementation of two or more strategies, 4) monitoring, and 5) iterative modification of strategies to improve outcomes. The capacity of adaptive management to accommodate uncertainties is especially useful in light of rapidly changing climate conditions, the complexity of ecological systems, and the uncertainties associated with how ecosystems react to human interventions. However, examples of actual implementation of adaptive management programs are still scarce; for instance, many conservation programs study only one management option at a time which provides 'trial and error management'. Implementation of alternative conservation strategies can provide comparative insights, reduce risk of failure, and aid understanding of system responses to management (e.g. separating policy effects from other causes of ecological change).[153] There is increasing emphasis on adaptive management as an approach for conserving biodiversity in the era of climate change.[154]

Managed Relocation
Managed relocation is the intentional act of moving species, populations, or genotypes to a location outside a target's known historical distribution for the purpose of maintaining biological diversity or ecosystem functioning as an adaptation strategy for climate change[155]. The conservation community is exploring how to support the natural migration and movement of species as climate changes, while avoiding maladaptive practices and over engineered approaches that can lead to negative ecological, social, regulatory, and economic ramifications. Connecting and conserving natural corridors will assist natural migration and species movement.

Genomics research

Genomics is the study of an organism's genetic makeup (or its 'genome'), and the how the genome interacts with environmental and other non-genetic factors.[156] Scientists are exploring how genomics tools and approaches may help inform conservation efforts, especially in an era where climatic conditions are rapidly changing.[157]

Establishing genetic banks

In recent years, a number of efforts have begun to systematically collect and preserve genetic material. For instance, the National Science Foundation is funding a multi-university "Project Baseline" to create a seed bank. The goal of Project Baseline is to create a resource for researchers interested in characterizing the genetic, taxonomic and functional dimensions of biodiversity over space and time in an era of rapid climate change. Studies of evolutionary responses to accelerated environmental change can shed light on the capacity of organisms to adapt to human disturbances.[158]

The Svalbard Global Seed Vault in Norway is an effort to ensure that the genetic diversity of the world's food crops is preserved for future generations, with the recognition that the loss of biological diversity is currently one of the greatest challenges facing the environment and sustainable development.[159] There are also a number of global efforts to create cryopreserved or live gene banks for fish and other species.[160]

For more information on California seed bank efforts, please the Forestry section of this document.

Education, Outreach, and Collaboration

CDFW Climate College and climate education: In early 2012, CDFW launched a ten-month climate literacy program to build staff capacity for incorporating climate considerations into existing professional responsibilities. Although the CDFW Climate College was designed to provide a basic foundation of climate literacy to CDFW staff, the course was open to the public. The inaugural year of the CDFW Climate College was completed in June 2013. More than 340 participants participated in the first year of the CDFW Climate College. A second iteration of the Climate College is currently under development and will be topically focused on climate change and marine issues in the state with the inclusion of a tribal component.[161] The CDFW Climate Science Program also features a variety of online educational materials related to biodiversity and climate change including resources for teachers, a collection of relevant vulnerability assessment tools and guidance, and information on CDFW projects helping to plan for or minimize impacts associated with climate change.

2010 "Climate Change, Confronting the Challenge" Publication The Fall 2010 issue of CDFW's Outdoor California magazine was dedicated to discussing climate change. The publication articulates how fish, wildlife, and habitat conservation and management play an important role in responding to the impacts of climate change and focuses on the importance of a multi-sector

approach to adaptation planning and action. The publication received a gold award in the State Information Officers Council's 2010 statewide competition for excellence in government communications.[162]

Governor's Conference on Climate Change and Extreme Events: California Governor Edmund G. Brown Jr. and environmental, business and public health and safety leaders came together in December 2011 at "The Governor's Conference on Extreme Climate Risks and California's Future."[163] The conference included a presentation and discussion on the "Impacts of Extreme Weather and Climate on Terrestrial and Aquatic Biota in California".

2013 National Adaptation Forum[164] CDFW worked with partners to create, develop, and implement the "Inaugural National Adaptation Forum: Action today for a better tomorrow". Over 500 adaptation practitioners from around the country came together to discuss moving adaptation planning to adaptation action. Planning is currently underway for the next National Adaptation Forum in 2015, and several regionally focused events are under consideration including one in California in 2014[165].

CDFW Climate Change Stakeholder Group Since 2008, CDFW has been convening a Climate Stakeholder Group to provide input on climate change-related conservation planning and implementation efforts. The group includes a diverse group of partners including federal, state, and local/regional governmental entities, NGOs, and members of the research and academic community.[166]

ACTIONS NEEDED TO SAFEGUARD BIODIVERSITY AND HABITATS

The following recommendations build on those made in the 2009 Adaptation Strategy based on emerging science and practice of climate adaptation. The recommendations below require adequate funding and staffing to be carried out.

Develop management practices to help safeguard species and ecosystems from climate risks

1) Improve habitat connectivity and protect climate refugia

Promoting habitat connectivity and protection of refugia will aid in species migration and movement and propagate ecological processes across the landscape. We must utilize existing programs such as NCCP and planning documents such as the State Wildlife Action Plan to continue improving connectivity between existing terrestrial, aquatic, and marine conservation areas in addition to creating new conservation areas where applicable. Priorities for creating, maintaining or restoring conservation areas should include landscape features that will ease the transition to future climatic conditions for species supported by the habitat (e.g., low fragmentation, climatic and elevational gradients, groundwater resources, etc.). Coordination should be promoted among state, federal, and private landholders to encourage consistency across management approaches to maximize biodiversity and promote large-scale connectivity.

2) Implement adaptive management studies to refine approaches for conserving biodiversity, especially for species and communities vulnerable to climate change

As mentioned in the 2009 CAS, the original CA State Wildlife Action Plan (2005) articulated an approach for designing monitoring programs to support adaptive management, which is still relevant today. Actual case studies that implement adaptive management are needed to further understanding of the relative merits of alternative management strategies for conserving biodiversity in the face of rapidly changing climate conditions. NCCP plans already incorporate adaptive management and may provide opportunities to study and refine approaches for managing biodiversity in the era of climate change. Vulnerability studies should help inform where adaptive management studies should be focused and which species and natural communities should be included in such studies.

Enhance biodiversity monitoring in California to detect climate impacts and inform responses

There continue to be gaps in the monitoring of resource conditions that can support effective management decisions in the era of climate change. A comprehensive, statewide approach to biodiversity monitoring is needed to help develop baseline ecological information and to detect changes in terrestrial and aquatic species and habitat patterns on the landscape. Monitoring and observing changing conditions is critical to refining climate impact and species/habitat response models and to informing the development of forward-looking conservation strategies and management actions that account for changing conditions.

The CDFW Species and Natural Communities Monitoring and Assessment Program, or simply Resource Assessment Program (RAP), was designed to help inventory, monitor, and assess the distribution and abundance of priority species, habitats, and natural communities in California. As such, RAP provides a basic infrastructure for addressing biodiversity inventory and monitoring needs in the state. With additional support, this program could be expanded to meet the need for comprehensive, state-wide biodiversity monitoring to support forward-looking management actions that are responsive to a changing climate. Climate considerations should be integrated into monitoring strategy design and the development of monitoring priorities; and strategic monitoring priorities may be informed by other state efforts including CDFW's State Wildlife Action Plan, DWR's California Water Plan, CalFire's Forest and Rangeland Assessment Program, State Water Resource Control Board's (SWRCB) Basin Plan, and the type of statewide climate vulnerability assessment discussed above.

Support Environmental Stewardship Across Sectors

1) Promote Nature-Based Solutions for Adapting to Climate Risks

Nature-based solutions can be a cost-effective means for addressing climate risks, and also provide additional benefits including benefits for habitat and biodiversity (see Box 47: "Wetlands - Nature's Flood Protection" in the Oceans and Coastal Ecosystems and Resources section of this document and Box 35: "Ecosystem Services – Smart Land Use to Save Money and Create More Sustainable Communities" in the Forestry section of

this document). The State should encourage and support the consideration of nature-based approaches for preparing for climate risks where such approaches are available. In order to support informed decision making, funding is needed for studies that help quantify the benefits of ecosystem services that reduce climate risks.

2) Create, maintain and support tools that help resource managers determine when and where to focus conservation activities that will protect biodiversity in the face of climate risks

Improved modeling of the impacts of climate change on wildlife, fish, and plants will be necessary at a scope and scale appropriate for management application. Associated predictive and planning tools are also necessary to ensure that resource management actions are informed by best available science, and such tools require maintenance over time and support to encourage user adoption. As noted above, CDFW developed the Areas of Conservation Emphasis (ACE) Mapping and Modeling Tool to provide a spatial model that can be used to identify areas of biological or conservation interest to guide conservation priorities. Tools such as ACE should continue to be maintained and updated with new biological data developed over time, in order to support biodiversity conservation planning and management decisions within CDFW and other state agencies. Determining what biodiversity-related information and tools would be useful to other agencies in their climate change planning efforts will also be necessary to manage the needs of wildlife, habitats, and humans in tandem.

Improve Understanding of Climate Risks to Biodiversity and Habitats

As further described below, continued research is essential to improve understanding of climate risks to biodiversity and habitats in order to inform management responses that might reduce risks to biodiversity and promote resilience. One overarching need is to improve baseline information; there are still significant data gaps with respect to California's biological resources. Baseline information provides a reference point against which future changes in biodiversity can be assessed. Continued and enhanced predictive modeling combined with monitoring of certain species will be also be needed to guide resource management decisions. Further information is also needed regarding the interactions between plants, animals and their environment, especially as the timing of life cycle events shift in response to climate change. Finally, there is a need to continue vulnerability studies and the identification of critical connections and corridors.

In addition to informational needs around biological resources, it would be useful to consolidate and analyze non-habitat baseline information such as current land uses and land use policies throughout the state, as well as whether municipalities and permitting agencies have incorporated climate change impacts into their land use planning (i.e. General Plans, Local Coastal Programs). This information will be an important part of determining the best opportunities for habitat restoration and land acquisition as part of a larger effort to create a well-connected system of conservation areas, minimize the impacts of climate change to the greatest extent possible, and plan appropriate strategies for long term conservation and management actions.

It is important for the state to coordinate with other research efforts, including the efforts of federal, academic and regional collaboratives, in order to benefit from collaborative work and optimize resources. As noted in the introduction to this document, there is also a need to ensure consistency in data sets and tools developed and utilized by different state entities.

Research needs related to climate impacts and risks to biodiversity and habitat are described below. Additional information on these types of needs may be found in the August 2011 CDFW Climate Change Research Considerations document[167], the February 2012 CDFW Climate Change Research Needs document[168], the California Climate Research Plan, and the forthcoming 2015 update to the State Wildlife Action Plan.

1) Completing habitat and vegetation mapping

High-resolution, state-wide vegetation mapping following the National Vegetation Standard is needed to identify movement of vegetative communities, detect changes in their composition, and identify any new assemblages created throughout time. This information may provide insight into how species will move in accordance with changes in the location of their required habitat. Vegetation mapping can also be directly tied to the California Wildlife Habitat Relationships system, for example, to identify which species will likely be impacted most by these environmental changes. Additional funding and resources are needed to sustain existing efforts related to vegetation mapping, for example through the CDFW Vegetation Mapping and Classification Program.

2) Refining regional connectivity analyses

The California Essential Habitat Connectivity Project was a state-wide effort to identify large remaining blocks of intact habitat or natural landscape and model essential connectivity areas between them that need to be maintained, particularly as corridors for wildlife. Finer-scale, regional corridor modeling and connectivity analyses are needed to help prioritize land acquisition and protection. Corridor prioritization exercises, for example those currently taking place in the Northern Sierra Nevada Foothills and Desert regions of California, should be replicated in other parts of the state. Work to identify critical habitat linkages has also been undertaken along the north-central coast of California led by the Science and Collaboration for Connected Wildlands in conjunction with many other agencies and organizations[169].

3) Additional climate vulnerability analyses

As described below, more research is needed to understand species and habitat vulnerability to climate change. Vulnerability studies will need to be refined and updated periodically to ensure that best available science informs management decisions. Training and tools may need to be developed to help translate vulnerability findings into management actions. Additional funding and resources may be needed to support vulnerability studies over time.

- A comprehensive, statewide climate change vulnerability analysis at the habitat scale is needed to better understand climate risks to California's biodiversity. Vulnerability information at this scale will support ecosystem-based conservation

planning and management efforts, and can also be used to increase our broader, ecoregional understanding of the vulnerabilities of biodiversity to climate change. Existing and future species and taxa-specific vulnerability assessments can also be compared against habitat assessment results to gain further insight into climate risks and inform development of strategies that can help protect biodiversity resources.

- As mentioned earlier in this chapter, a subset of rare plants in the state have already been analyzed for climate vulnerability, however, follow-up coverage of additional rare plant species is needed. Species most likely to be at risk from climatic changes, such as those found in higher elevations, ephemeral systems, vernal pools, etc., should be high priorities for examination.
- A state-wide vulnerability assessment of mammal species of special concern is also necessary.
- A state-wide vulnerability assessment is needed for invertebrates. Examining certain invertebrates will contribute to our knowledge of how some pollinators will be impacted by climate change, with implications for agriculture and other ecosystem services. These species are already being impacted by changes in phenology that have been linked to climate change, and more information is needed on species future vulnerability.
- Marine and aquatic habitat climate vulnerability assessments are also needed. For more information on climate and marine habitat, please see the Oceans and Coastal Ecosystems and Resources section of this document.

4) Understanding extreme events and disturbance regimes

Research is needed regarding the risks posed by extreme events or disturbances (e.g. fire, flooding, drought, insect outbreaks, invasive species, etc.) to ecosystem function, resilience, and services. This will provide additional insight into how some existing stressors or processes may be exacerbated by climate change.

5) Identifying opportunities to address the emissions that contribute to climate change

As mentioned in the INTRODUCTION section of this chapter, carbon storage can be one of the benefits provided by healthy ecosystems. Additional research is needed to quantify baseline carbon information associated with natural systems, and to identify and prioritize conservation and restoration opportunities with carbon sequestration benefits. Pilot projects can help refine understanding of the greenhouse gas storage capacity associated with natural systems.

Information Sharing and Education

1) Create and maintain partnerships that support biodiversity conservation in a changing climate

Collaborating with other agencies and partners supports not only the transfer of data and information, but ensures that conservation priorities with respect to climate change are clearly communicated within the broader conservation community. Communication

is imperative to identifying and promoting common goals, and to support adaptation planning and implementation to conserve biodiversity. Collaboration will also promote complementary actions across jurisdictions on adjacent landscapes, which is vital to achieving our objectives related to habitat connectivity. State agencies should continue to pursue national, regional, and local coordination and promote initiatives to conserve biodiversity beyond the borders of California such as through the Western Governors' Association, West Coast Governors Alliance on Ocean Health, Association of Fish and Wildlife Agencies, the Trilateral Committee for Wildlife and Ecosystem Conservation and Management, and the National Fish, Wildlife, and Plants Climate Adaptation Strategy. Continued engagement with partners in the CDFW Climate Change Stakeholder Group will also be important and should be supported.

2) Promote public education and outreach on climate change impacts to biodiversity

Increasing communication with the public and partners on climate change impacts to biodiversity will raise awareness of this important issue and help create support for state actions that promote biodiversity conservation. State agencies should develop a collaborative messaging campaign centered on California's climate activities to safeguard natural resources, while highlighting the importance of nature-based action.

Many state agencies have staff that interface regularly with the public through education or outreach programs, which provide opportunities to engage the public on this topic. Agencies should work with partners to develop information to be used for public interpretation and classroom education related to biodiversity conservation in the face of climate change. Opportunities may be available at visitor centers in hatcheries, State Parks, wildlife areas, or other facilities run by the state. Helping to educate the public on climate change issues may have the additional benefit of promoting public involvement in data collection activities across many locations with limited costs through citizen science (see Box 10: *Citizen Science – Crowdsourcing Climate Monitoring* in this chapter).

3) Provide support for the continuation of the CDFW Climate College and educational outreach efforts and link those efforts to broader state climate literacy programs

As noted in the Introduction to this document, it is necessary to build internal capacity for state entities to operationalize climate risk considerations into their activities. The CDFW Climate College provides a useful template for a departmental climate literacy program. The CDFW Climate College and related educational efforts should continue to be supported, and those efforts should be linked to any broader state climate literacy efforts.

Box 15

California Biodiversity and Habitat

Several state entities play an important role with respect to biodiversity and habitat in California. The state also has important federal, local and private sector partners. Understanding the jurisdictional scope of these entities is important for a robust discussion of

continued steps needed to adequately prepare for climate risks.

California Department of Fish and Wildlife (CDFW) has public trustee authority to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend for their ecological values and for their use and enjoyment by the public. This includes habitat protection and maintenance through conservation, restoration, and law enforcement to ensure the survival of all species and natural communities. The department is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific and educational uses. CDFW's regulatory responsibilities include environmental permitting and review.

Wildlife Conservation Board (WCB) selects, authorizes and allocates funds for the purchase of land and waters suitable for recreation purposes and the preservation, protection and restoration of wildlife habitat. WCB approves and funds projects that set aside lands within the State for such purposes, through acquisition or other means, to meet these objectives.

California Fish and Game Commission (FGC), established in 1870, is a Commission comprised of five members, appointed by the Governor and confirmed by the Senate. The Commission formulates general policies for the conduct of CDFW, but also has general regulatory powers, including deciding seasons, limits and methods of take for sport fish. The Commission also has responsibilities for invasive species; establishing/regulating use of Marine Protected Areas (MPAs); listing/delisting threatened and endangered species under the California Endangered Species Act; prescribing terms and conditions for issuance of licenses/permits by CDFW; and revoking or suspending privileges of those that violate California Fish and Game laws and regulations.

Many other state entities also play important roles with respect to biodiversity and habitat in California. These entities include:

California Department of Conservation (DOC) among other things, DOC works to safeguard farmland and open space resources that are important to habitat and connectivity.

California Department of Food and Agriculture (CDFA) is responsible for protecting and promoting California agriculture; CDFA's work on preparing for climate risks is further discussed in the Agriculture section of this document.

California Department of Forestry and Fire Protection (CAL FIRE) is dedicated to fire protection and stewardship of over 31 million acres of California's privately-owned forestlands.

California Department of Parks and Recreation California State Parks (CSP) is a trustee agency responsible for managing 1.5 million acres of land in 280 park system units. CSP's mission is to provide for the health, inspiration, and education of the people of California by helping to preserve the state's extraordinary biological diversity and its most valued natural and cultural resources while also providing opportunities for high-quality outdoor recreation. Park units, which constitute about three quarters of the acreage of the system, are protected to "preserve outstanding natural, scenic, and cultural values, indigenous aquatic and terrestrial fauna and flora, and the most significant examples of ecological regions of California" (Public Resources

Code Sec. 5019.53). CSP lands thus protect important habitats and are integral to biodiversity protection efforts throughout the state.

California Department of Water Resources (DWR) is responsible for managing and protecting California's water resources and supplies. DWR is developing comprehensive conservation plans, new Delta habitat enhancement and carbon sequestration projects, Regional Advance Mitigation Planning (RAMP), fish passage implementation actions, floodplain ecosystem studies, and flood system improvement actions in planning for flood, water supply, and drought management. Programs such as the Central Valley Flood Protection Plan Conservation Strategy, System Reoperations Studies, Bay Delta Conservation Plan, and the Fish Restoration Program Agreement are helping to integrate environmental stewardship into DWR's water management practices.

California Ocean Protection Council (OPC) assists with the coordination of ocean-related activities carried out by state agencies. They also develop ocean and coastal policies for California.

California Ocean Science Trust (OST) is a nonprofit 501(c)(3) public benefit corporation established pursuant to the California Ocean Resources Stewardship Act of 2000 (California Public Resources Code Sections **36970-36973)**. OST's mission is to advance a constructive role for science in decision-making by promoting collaboration and mutual understanding among scientists, citizens, managers, and policymakers working toward sustained, healthy, and productive coastal and ocean ecosystems.

California State Lands Commission (SLC) provides stewardship of the lands, waterways, and resources entrusted to its care through economic development, protection, preservation, and restoration. SLC engages in public land management and resource protection to ensure the future quality of the environment and balanced use of the lands and resources entrusted to its care.

Invasive Species Council of California (ISCC) is an inter-agency council that helps to coordinate and ensure complementary, cost-efficient, environmentally sound and effective state activities regarding invasive species. The ISCC is chaired by the Secretary of the California Department of Food and Agriculture and Vice-Chaired by the Secretary of the Natural Resources Agency; its members include the Secretaries from the California Environmental Protection Agency, California Business, Transportation and Housing Agency, California Health and Human Services Agency, and California Office of Emergency Services.

State Water Resource Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting statewide policy and supporting the pollution control programs administered by the Water Boards.

State Conservancies play a big role in habitat conservation and restoration in California including work to enhance habitat and protect important resource lands, including landscape corridors. For example, the Coastal Conservancy has conserved more than 300,000 acres and restored more than 33,500 acres in some of the most biologically rich ecosystems in the state

and the Santa Monica Mountains Conservancy has been a leader in protecting habitat corridors, including implementing the South Coast Missing Linkages plan.

Other Partners In addition to state entities, many tribal nations, federal agencies, local governments, non-governmental organizations, non-profit land conservation organizations, and private sector partners play a critical role in helping to preserve and protect California's wildlife. For example, the **U.S. Fish and Wildlife Service** is responsible for reviewing and permitting projects that have the potential to affect fish and wildlife protected by federal laws. **The U.S. Geological Survey**, **U.S. Forest Service**, **National Park Service**, and **Bureau of Land Management** also play important roles in providing scientific expertise, research, and management of key lands throughout the state. The **National Oceanic and Atmospheric Administration-National Marine Fisheries Service** is responsible for the stewardship of the nation's living marine resources and works collaboratively with the state on management, conservation and protection of these resources while also providing research important for California's coastal and marine resource managers.

The pace and scale of climate changes and the attendant threat to biodiversity have required a greater degree of collaboration among partners in order to begin crafting relevant management responses. Several important collaborative efforts have emerged in California. **Landscape Conservation Cooperatives[170] (LCCs)** were established by the U.S. Department of the Interior and are a network of public-private partnerships that provide shared science to ensure the sustainability of America's land, water, wildlife and cultural resources. The LCCs support efforts to reduce the negative impacts of many landscape scale stressors, including but not limited to climate change. California has four LCCs within its borders, the California LCC, Desert LCC, North Pacific LCC, and Great Basin LCC. The LCCs recognize that challenges facing natural and cultural resources and landscape transcend political and jurisdictional boundaries and require a more networked approach to conservation. Ecosystem-based regional collaboratives such as the **Bay Area Ecosystems Climate Change Consortium[171] (BAECCC)** have also been established. BAECCC was formed to assess climate change impacts to the Bay Area and to identify management actions that will reduce negative impacts associated with climate change while preserving the many services and benefits that are derived from Bay Area ecosystems. Partners include state and federal agencies, NGOs, academic institutions, and more. Collaborative efforts are further discussed in the HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES section above.

EMERGENCY MANAGEMENT

INTRODUCTION

Emergency management includes actions to prepare for, mitigate against, respond to and recover from emergencies and disasters that impact our communities, critical infrastructure and resources by lessoning the likelihood, severity and duration of the consequences of the incident. Mitigation and preparedness focus on activities we can do every day, not just during a disaster. Hazard mitigation is any action taken to reduce or eliminate the long-term risk to human life and property from natural or man-made hazards. Emergency preparedness refers to activities undertaken prior to an emergency to be ready to respond to and recover from any emergency. Emergency response efforts occur during an emergency and flow into actions to recover from emergencies.

Disaster risks typically associated with California include earthquake, flood and fire. However, California also faces emergency risks associated with landslides, avalanches, levee failures, train derailments, infrastructure failures, toxic releases and other public health threats such as heat waves and infectious disease outbreaks.

Climate impacts, such as more extreme weather events, sea level rise, changing temperature and precipitation patterns, and more severe and frequent wildfires, present new risks and uncertainties that will affect all phases of emergency management. Without actions to incorporate climate considerations into emergency management efforts, climate change will increase risk to public safety, property damage, and emergency response and recovery costs to government and taxpayers. For instance, sea level rise will elevate tsunami risks associated with earthquakes in California, and efforts to plan, prepare, respond and recover to such risks must be adjusted accordingly.[172]

In addition to the more traditional disasters that California has face in the past, there is an ever increasing acknowledgement that climate changes present a growing peril to the state. There is growing global recognition that experts from the fields of emergency management and experts in climate science and policy will benefit from collaborative efforts to share approaches, information, goals, viewpoints, and insights.[173] Risk reduction is a common goal of efforts to prepare for climate change and emergency management activities.

In California, this collaborative work has already begun, and the integration of climate impacts into emergency management efforts builds upon strengths and competencies that already exist in California's disaster management agencies. Further work must be done to incorporate the best available climate risk projections and science into emergency management activities. Managing emergency risks based on historical trends will no longer be sufficient.

Working together, we can promote and implement risk reduction activities and increase our awareness and resilience to threats, hazards, and vulnerabilities, and coordinate the development of strategies, actions, and plans to manage risk and create long-term sustainability. Resilience depends on a whole community approach and is a shared

responsibility for all levels of government (federal, state, local and regional, and tribal), private and nonprofit sectors, and individuals. Short descriptions of state entities that play an important role with respect to emergency management in California are provided in Box 27: California Emergency Management at the end of this chapter.

Integrating Risks of a Changing Climate into Emergency Management Activities

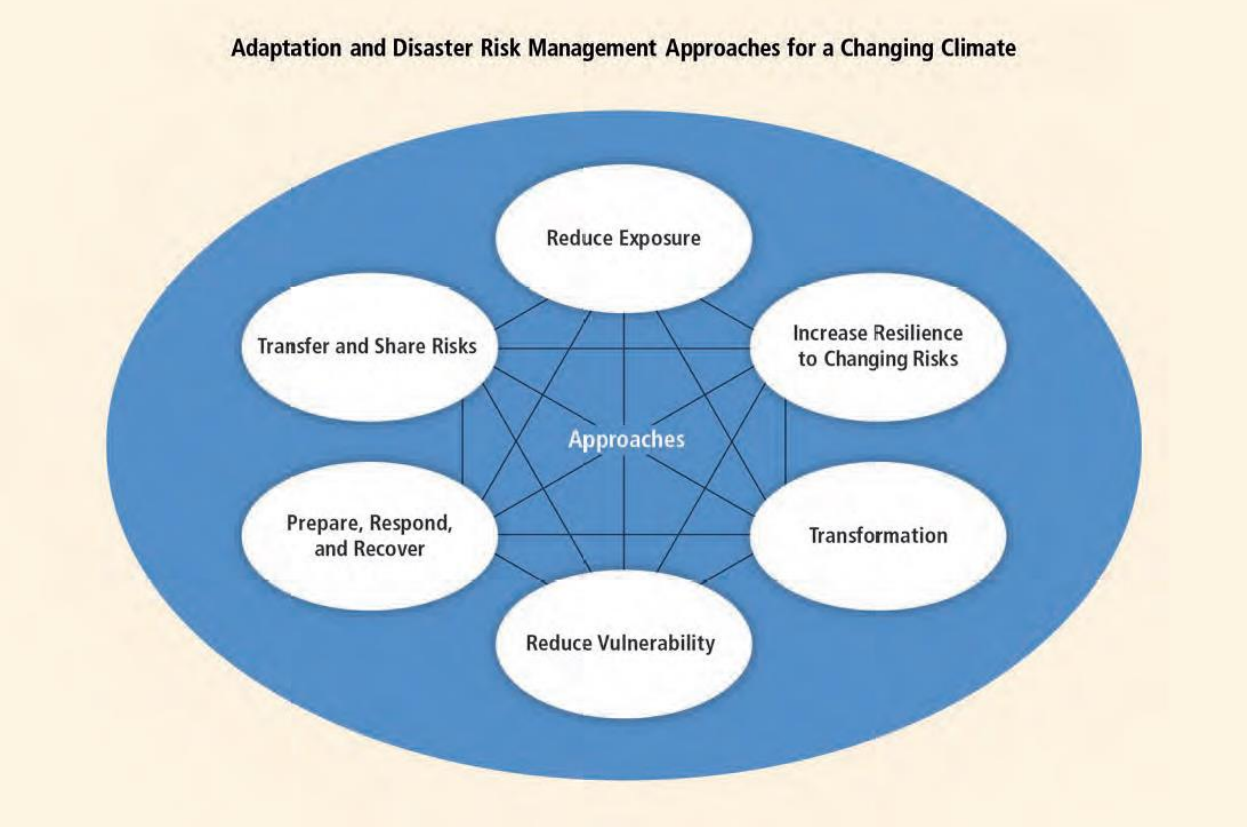
Emergency Management is a comprehensive system of policies, practices, and procedures designed to protect people and property from the effects of emergencies or disasters. It includes programs, resources, and capabilities to mitigate against, prepare for, respond to, and recover from effects of all hazards. While the scope, severity, and pace of future climate change impacts are difficult to predict, it is clear that potential changes could have impacts on emergency management capabilities and increased need for services. The severity of emergencies is determined not only by the occurrence of natural events (that may be increasing in magnitude and frequency due to climate change), but also on the level of exposure and socio-economic vulnerability to those events.[174] For instance, a severe fire in a largely uninhabited area may not cause significant property damage or loss of life. However, a less severe or less extensive fire in an area with many homes and businesses may cause significant property losses and impacts to public health and safety because of the greater degree of exposure. Also not all communities and not all members of a community are equally vulnerable to emergency situations; socio-economic conditions may vary and access to information, services and resources affects how impacts are experienced in emergency situations.[175] For instance, in the Los Angeles-Long Beach Metropolitan Area, a higher proportion of African-Americans do not have access to air conditioning compared to the general population (59 percent versus 40 percent, respectively). Similar trends hold for Latinos (55 percent) and communities living below the poverty line (52 percent).[176]

Incorporating projected climate impacts into emergency management can help reduce exposure and vulnerability and increase the resilience of California communities; working to reduce the causes of climate change by reducing greenhouse gases can also significantly reduce the risks associated with climate change.[177]

Box 16 below illustrates various climate risk adaptation and emergency management approaches for addressing climate risk. Risk sharing and cost transferring systems like insurance and disaster relief are tools for managing climate risk. Working to reduce exposures and vulnerabilities by lessening the likelihood, severity, and duration of adverse impacts from a changing climate is also important. Another approach for dealing with climate risks is to increase the resilience or ability of communities to anticipate, absorb, and recover from hazardous events in a timely and efficient manner that ensures the preservation, restoration or improvement of basic structures and functions. Finally, transformational changes in regulations and laws, technologies, financial institutions, land use management approaches, and other systems will be a necessary part of effective emergency management in the era of climate impacts.[178] These various approaches are overlapping and complementary. These approaches to managing climate risk also build upon traditional emergency management competencies and

are further discussed below in the context of the four traditional phases of emergency management: hazard mitigation, emergency preparedness, response and recovery.

Box 16



From: IPCC, 2012: Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea,K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 1-19.

Hazard mitigation:

Hazard mitigation is any action taken to reduce or eliminate the long-term risk to human life and property from natural or man-made hazards. This can include efforts to reduce exposure and vulnerabilities to climate impacts.

Climate change will result in new "normal" averages with respect to weather (e.g. new average temperatures at given times of year or new average amounts of precipitation in the form of rainfall). Climate change may also result in more 'extreme' events (e.g. Superstorm Sandy or extreme, prolonged heat events). Planning for projected new norms and more extremes must be part of hazard mitigation planning in the era of climate change.[179] Hazard mitigation planning based on historical trends will no longer be sufficient.

Hazard mitigation in the context of a changing climate can take many different forms including, but not limited to:

- Education for first responders and emergency managers on climate risks;[180]
- Minimizing new development in areas most vulnerable to hazards;[181]
- Investing in green infrastructure and other protective structures to address sea level rise;[182]
- Managed shoreline retreat;[183]
- Enhanced flood warning instrumentation;[184]
- Stabilize river banks and restore and create wetlands;
- Relocation or retrofits of structures in hazard areas;
- Climate risk communication and education;[185]
- Forest fire risk reduction through the removal of certain forest vegetation (or "fuels");[186]
- Defensible space clearance around homes and structures to reduce wildfire risk;[187]
- Implementing building codes that require use of fire resistant building materials in areas prone to wildfire risk;[188]
- Promoting sound land use practices;[189]
- Urban forestry and urban greening to address heat island effect;[190]
- Promoting use of cool pavements to deal with urban heat island effect;[191]
- Use of state-of-art materials in new infrastructure to optimize resilience in light of expected climate impacts;[192] and
- Mainstreaming climate risk considerations into government, business, and individual decisions.[193]

Attention to the timing and spatial dimensions of hazard mitigation efforts is critical in the era of climate change. Some efforts to reduce risk in the short term may actually increase exposure and vulnerability over the longer term. For instance, protective structures built to address sea level rise may encourage development patterns that may increase risk in the long term.[194] Therefore, such protective structures should be capable of being augmented over time, and adequate funding for long-term maintenance of such structures is needed.

Funding for hazard mitigation can be very cost effective. One study found that every dollar spent on a FEMA hazard mitigation grant produced, on average, four dollars of benefits.[195]

The California Governor's Office of Emergency Services (CAL OES) leads hazard mitigation activities in California. CAL OES maintains and coordinates the update of the State of California Multi-hazard Mitigation Plan (SHMP). As California's primary hazard mitigation guidance document, the SHMP provides a comprehensive description of the state's historical and current hazard analysis, mitigation strategies, goals and objectives. The integration of climate risks, such as heat emergencies, prolonged drought, wildfires, flooding, sea level rise and severe

storms and erosion, into the SHMP is further described below in the subsection of this chapter titled “Highlights of Steps Taken to Date and Success Stories”.

The State of California is required to review and update its SHMP and resubmit for Federal Emergency Management Agency (FEMA) approval at least once every five years to ensure continued funding eligibility for certain Stafford Act grant programs. This includes FEMA’s hazard mitigation assistance programs: Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Assistance (PDM), Repetitive Flood Claim Program, as well as the Fire Management Assistance Grant Program and Public Assistance grants (Categories C-G). In addition, the state remains eligible for the reduced cost share for grants awarded under the Flood Mitigation Assistance grant programs. States which can demonstrate a more comprehensive “Enhanced Mitigation Plan” are eligible for an increased amount of mitigation funding following a disaster declaration.[196] The 2013 SHMP is an Enhanced Mitigation Plan.

In addition to maintaining and coordinating updates of the SHMP, CAL OES also engages in the following hazard mitigation activities:

- CAL OES supports and assists local governments in the development of Local Hazard Mitigation Plans (LHMPs) required under DMA 2000. CAL OES reviews and provides information on integrating hazard identification, risk assessments, risk management, and loss prevention into a comprehensive approach to hazard mitigation and helps local governments identify cost-effective mitigation measures and projects.

- The DMA 2000 introduced reforms to try and move hazard mitigation planning away from reactive, disaster-driven processes. DMA 2000 instituted a Pre-Disaster Mitigation Grant Program (PDM) which provides funds to states, territories, Indian Tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event; however, funding allocations for the PDM program have declined and there have been proposals to eliminate PDM funding altogether.[197] CAL OES administers the hazard mitigation program for plans and projects through the FEMA Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Grant Program (PDM), and Flood Mitigation Assistance Grant Program (FMA).[198] The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The FMA provides funds to assist States and communities in implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the National Flood Insurance Program.[199] CAL OES maintains a complete listing of mitigation grants.[200] Hazard mitigation that is based on proactively anticipating threats, rather than based on past disasters, will be necessary in the era of climate change since the magnitude, timing, and frequency of natural disaster risk is changing, and historical disaster reference points may no longer be accurate predictors of future threats.

- The CAL OES Dam Safety Program was established by Government Code §8589.5 in 1972 following a near failure of the Lower San Fernando Dam during the Sylmar Earthquake. The Dam Safety Program provides assistance and guidance to local jurisdictions on emergency planning for dam failure events, collects and reviews dam failure inundation maps, and evaluates waivers from the inundation mapping requirement. The Dam Safety program coordinates with the California Division of Safety of Dams and other state and federal agencies in activities to assure effective dam incident emergency response procedures and planning.

  The Cal OES Dam Program is also the designated repository of the official dam failure inundation maps used in California's Natural Hazard Disclosure statement as specified in Civil Code § 1103 for real estate transactions. For information on climate change and dam safety in California, please see Box 17: California Dam Safety & Climate Change.[201]

- CAL OES developed and maintains the MyHazards online tool that allows Californians to identify hazards in their area (earthquake, flood, fire, and tsunami) and learn steps to reduce personal risk.[202] In 2011, CAL OES also launched the MyPlan online tool for hazard mapping to support local planning efforts. CAL OES and the California Natural Resources Agency, partnered with FEMA to develop MyPlan as a risk assessment and communication tool. MyPlan facilitates city, county, special district, and Tribal access to federal- and state-produced hazard data for use in creating maps for preparing, upgrading and reviewing Local Hazard Mitigation Plans (LHMPs), General Plan Safety Elements, Local Coastal Plans (LCPs), and hazard mitigation projects.[203] Currently, the MyHazards and MyPlan tools do not incorporate climate projection data; however, Cal-Adapt, discussed in Inset 1 in the Introduction, does provide climate projections for local areas.

Box 17

Dam Safety in a Changing Climate

Climate change can present new conditions that could potentially even exceed historical dam design standards, and result in dam overtopping or failure.[204] For instance, increases in precipitation, changes in precipitation patterns, changes in run-off timing and quantity, and obstruction of spillways from increased debris and sediment caused by more frequent watershed wildfires can potentially increase the risk of dam overtopping or failure. However, because California dam design standards have been very conservative, climate change is not expected to have a significant effect on the near-term safety of California dams under State jurisdiction for dam safety.[205]

The Division of Safety of Dams (the Division), under the California Department of Water Resources, is charged with protecting people against loss of life and property from dam failure.[206] The Division regulates about 1,250 jurisdictional sized dams in California.[207] There are roughly 180 Federal dams that are exempt from State regulation as well as hundreds of

non-Federal dams that are not subject to Division's regulation due to their smaller size and/or storage.

The Division requires all jurisdictional dams to have sufficient spillway capacity to safely pass the design storm. Dams with even minimal downstream hazard consequences (i.e., the downstream risk associated with a sudden catastrophic failure) are designed for 1,000-year return period storms. As the level of downstream risk increases, the required design storm also increases, up to the Probable Maximum Precipitation (PMP) for the larger dams/reservoirs with extreme downstream hazard consequences. The PMP is determined in accordance with federal hydro-meteorological reports.[208] A "Probable Maximum Precipitation" can be thought of as the ceiling of all possible storms and results from the most severe combination of meteorological and climatological conditions that are considered reasonably possible from the study area.[209]

The Division considers spillway performance to be the greatest threat to dam safety arising from climate changes and is therefore continuing to coordinate with the Department of Water Resources climate staff to incorporate updated climate considerations into its analyses and work.[210] Also, as part of the Division's maintenance and inspection program, dam spillways and their inlets are closely monitored to ensure that they are, or will be, clear of debris prior to the onset of the wet season. Wildfires have historically occurred during the warm season when watersheds and their reservoirs can be managed to ensure spillways remain clear.

Box 18

What is a 100-year storm (precipitation) or a 100-year flood?

A 100-year storm or precipitation refers to a specified depth of rainfall, in inches, for a given duration that has a 1 in 100 or 1% chance probability of occurring at least once at a particular location in any given year. Likewise, a 50-year rainfall event has a 1 in 50 or 2% chance of occurring in any given year. Statewide, 100-year precipitation estimates may vary, depending on the statistical method or distribution that is followed and the rainfall data set(s) used. [211]

Similarly, a 100-year flood refers to a specified rate or magnitude of water flow, usually expressed in cubic feet per second, that has a 1 in 100 or 1% chance probability of occurring in any given year. [212] Its flow value is typically estimated by statistically evaluating recorded stream flow data from a particular watershed.

Not every 100-year precipitation corresponds to a 100-year flood since the recorded data set for the precipitation and the recorded data set for the flood flow values are different from each other and at the time of the storm event, the watershed 's conditions and characteristics are variable. In practice, in the media, both terms are used interchangeably.

As noted elsewhere in this Safeguarding California Plan, climate change is expected to increase the frequency and the magnitude of more severe weather events which will lead to an increase in the magnitude of the 100-year event. For example, a previous 100-year estimated event is now a 70-year event. In addition, the Plan noted that climate change is expected to increase

the frequency of 100-year storms/floods in any year, resulting in multiple 100-year storms or floods that occur in a single year.[213]

Emergency Preparedness:

Emergency preparedness is part of emergency management that encompasses preparations to be ready for disasters that may strike. For CAL OES, this includes activities such as supporting local efforts in emergency planning, integrating the needs of vulnerable populations in emergency planning, and maintaining the State Emergency Plan.[214] Cal OES is delegated by the Governor to support and enhance all phases of emergency management which include Preparedness, Response, Recovery and Mitigation. The Cal OES "Planning and Preparedness Division" web site identifies a number of plans, guidance materials, support information, points of reference, and other materials to assist in development of a successful all-encompassing preparedness program. As further discussed below, many other state entities – including, but not limited to, HHS, CDPH, CDFA, CalTrans, Cal/EPA, the Resources Agency, and the CEC, play key roles in California's emergency preparedness.[215] The need for emergency preparedness is greater than ever given new climate risks, including increasing frequency of disasters, coupled with other trends like a growing California population, which may leave more people vulnerable to the effects of disasters. Climate change will likely require improvements to "surge" or rapidly increase capacity to ensure the ability to meet increased needs during disasters and emergencies – including, for instance, assessing and addressing staffing and equipment needs to create a more flexible workforce by increasing employee readiness, cross-training staff, and increasing the pool of employees who are qualified and trained to respond to disasters and other events.[216]

The State of California Emergency Plan (SEP) addresses the state's responses to extraordinary emergency situations associated with natural disasters or human-caused emergencies. The SEP provides a consistent, statewide framework to enable state, local, tribal governments, federal government and the private sector to work together to mitigate against, prepare for, respond to and recover from the effects of emergencies regardless of cause, size, location, or complexity.

The 2009 SEP recognized growing trends such as greater vulnerability to floods and wildland fires, and the influence of extreme weather events on emergency management activities.
The 2009 SEP also established the California Emergency Functions (EF) which consists of 18 disciplines deemed essential to the emergency management community in California. The California Emergency Functions define state functional capabilities, emergency management activities and resources needed in the following areas:

EF 1 – Transportation
EF 2 - Communications
EF 3 - Construction and Engineering
EF 4 - Fire and Rescue
EF 5 – Management
EF 6 - Care and Shelter

EF 7 – Resources
EF 8 - Public Health and Medical
EF 9 – Search and Rescue (USAR merged with EF 4 Fire and Rescue and Wildland SAR merged with EF 13 August 2013)EF 10 – Hazardous Materials
EF 11 – Food and Agriculture
EF 12 – Utilities
EF 13 – Law Enforcement
EF 14 – Recovery
EF 15 – Public Information
EF 16 – Evacuation (merged with EF 13 Law Enforcement August 2013)
EF 17 – Volunteers and Donations Management
EF 18 – Cyber Security

In 2010, CAL OES released a Contingency Plan for Excessive Heat Emergencies, a contingency plan supporting the SEP. This plan outlines the actions the State of California will take in support of local government when an extreme temperature event is anticipated or has occurred. This plan also provides guidance for local government and non-governmental organizations in the preparation of their heat emergency response plans and other related activities, and is further discussed below under the heading of Highlights of Steps Taken to Date and Success Stories.[217] As noted in the Public Health section of this document, CDPH and Cal/EPA have also released "Preparing California for Extreme Heat: Guidance and Recommendations"[218]. CAL OES also has a Contingency Plan for Extreme Cold/Freeze Emergencies.[219]

The SEP designates lead agencies for each emergency function, and as noted above, many state entities play key roles in California's emergency preparedness. For instance:

- Pursuant to the State Emergency Plan, HHS is the lead agency for Public Health and Medical activities and services statewide in support of local jurisdiction resource needs for preparedness, response, and recovery from emergencies and disasters.[220] As noted in the Public Health section of this document, climate change poses risks to public health, including, but not limited to, severe heat events and smoke exposure from increased wildfires. HHS includes both the California Department of Public Health - Emergency Preparedness Office (CDPH EPO)- the state's lead on health emergencies and the Emergency Medical Services Authority (EMSA). CDPH EPO and EMSA both work closely with CAL OES. Among other things, EMSA coordinates statewide activities for emergency medical services, assists CAL OES with the emergency management component of the State Emergency Plan, and develops the California Disaster Medical Response Plan.[221] CDPH's EPO plans and executes activities to prepare Californians for public health emergencies.[222] CDPH EPO also maintains the "Be Prepared" website to

provide information on preparing for public health emergencies including floods and wildfires.[223]

- CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. As further discussed in the Agriculture section of this document, climate change poses a variety of risks to food and agriculture, including, but not limited to food and feed safety and agricultural diseases and pests; for instance, severe drought is a climate-risk, with significant impacts for agriculture (and other sectors). Drought and drought management is discussed further in the Water section of this document.

- The California Utilities Emergency Association (CUEA) serves as a point-of-contact for critical infrastructure utilities and CAL OES and other governmental agencies before, during and after an event to:

  - Facilitate communications and cooperation between member utilities and public agencies; and with non-member utilities (where resources and priorities allow);
  - Provide emergency response support wherever practical for electric, petroleum pipeline, telecommunications, gas, water and wastewater utilities and;
  - Support utility emergency planning, mitigation, training, exercises and education.

The Energy Commission works with and provides support to CAL OES in the form of information gathering, technical expertise, programs, and contingency planning with respect to energy. The principal contingency planning programs include the Energy Emergency Response Plan, Petroleum Fuels Set-Aside Program, Local Government Program, Economic Assistance Program, and Demand Reduction Program. Climate risks to Energy are further discussed in the Energy section of this document.[224]

Box 19



California Department of Water Resources; 1997

Response:
As noted in this section and in other sections of this document, climate change is likely to lead to more frequent and more severe weather events and climate-related disasters and emergencies, such as heat waves, floods, drought and wildfires. Emergency response capability will likely need to be enhanced in order to address these escalating threats.

Box 20



California Department of Water Resources; 1997

The Standardized Emergency Management System (SEMS) unifies all elements of CA's emergency management community into a single integrated system and standardized key elements. SEMS continues to be used in California for managing emergencies involving multiple jurisdictions and agencies.

SEMS-NIMS Integration- the CAL OES is responsible for coordinating and monitoring the overall statewide integration of the SEMS and the National Incident Management System (NIMS) to meet federal NIMS requirements and timeframes. NIMS was developed by the federal Department of Homeland Security (DHS) pursuant to Homeland Security Presidential Directive/HSPD-5 to ensure that all levels of government across the nation have the capability to work efficiently and effectively together, using a national approach to domestic incident management.

CAL OES Response includes Regional and State Operations California State Warning Center, Public Safety Communications Office, Fire and Rescue, Law Enforcement, Mutual Aid System, Membership in Emergency Management Assistance Compact (EMAC), Catastrophic Response Planning, the Joint State/Federal CONOS, and public/private coordination.

    - When emergencies exceed the capabilities of local resources, CAL OES activates the State Operations Center (SOC) in Sacramento and the Regional Emergency Operations Centers (REOCs) in impacted areas to receive and process local requests for assistance. During major emergencies, CAL OES will call upon its own response resources, state and local government agencies and public/private partners based on their specialized capabilities and expertise to help provide support to local government.

- The California State Warning Center (CSWC) provides emergency communications and is staffed 24 hours a day, seven days a week, 365 days a year. Although the system was established primarily to provide communications and warning in the event of nuclear incident, it serves as a system of communications and notification for all disasters. Upon direction of the CAL OES Executive Duty Officer, the CSWC will begin notification of the on call CAL OES Operational Readiness Team. This team's purpose is to staff the State Operations Center as quickly as possible. The CSWC also begins the notification process of the departmental 24 hour points of contact that are required to staff the State Operations Center.

    - Public Safety Communications Office (PSCO) serves the State of California by providing public safety communications to the State's first responders and oversight of the 9-1-1 system to the People of California. The PSCO is dedicated to the preservation and protection of human life and public safety by delivering reliable and dependable communication services keeping the public connected during times of crisis.

    - CAL OES Fire and Rescue coordinates the systematic mobilization, organization and operation of necessary fire and rescue resources throughout the state and its political subdivisions in an effort to mitigate the effects of disasters, whether natural, technological or human caused. For more information about the impacts of climate change from the perspective of an emergency services first responder, please see Box 22 First Person Narrative - Climate Change and Wildfire in California by Thom Porter - CAL FIRE Unit Chief San Diego.

    - CAL OES Law Enforcement works directly with California's sheriffs and police departments. Law Enforcement deploys assets to disaster scenes, provides law enforcement mutual aid guidance, Search and Rescue resource deployments, and Coroners and Mass Fatality coordination.

    - The Mutual Aid System is an extension of the concept of "neighbor helping neighbor." As a component of the Standardized Emergency

Management System [SEMS], the Mutual Aid System is based on four organizational levels: cities, counties, regions and the State.

- California is a member of the Emergency Management Assistance Compact (EMAC), a congressionally ratified organization among the 50 states and territories. Through EMAC, a disaster impacted state can request and receive assistance from other member states quickly and efficiently.

- Catastrophic planning. Through a collaborative effort by CAL OES and the Federal Emergency Management Agency (FEMA), the Catastrophic Incident Base Plan establishes the Concept of Operations (CONOP) for the joint Federal and State response to, and recovery from, a catastrophic incident in the State of California. The CONOP defines the joint State/Federal organization and operations that support the affected local governments and other entities in the incident area.

- There is a critical need for the organized synchronous exchange of information and resources between public and private sector organizations. To meet that need, CAL OES has agreements with private sector and non-profit organizations which will provide support to the state during times of crisis. Together, these organizations form the Business and Utility Operations Center (BUOC) - comprised of two components: the Business Operations Center (BOC) and Utility Operations Center (UOC) - and they serve as a critical component in emergency response and addressing the needs of impacted communities.

Box 21



Harris Fire - San Diego County - October 2007
Photo: CAL FIRE - Wes Schultz

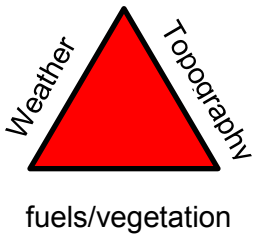
Box 22

FIRST PERSON NARRATIVE: *Climate Change and Wildfire in California*
By Thom Porter CAL FIRE Unit Chief San Diego [used with permission]



As a fourth generation Southern Californian, I have had a lot of opportunity to hear stories of how it used to be. I love the stories and conjecture about the old days. Recently, I have developed an interest in verifying some of the "stories" through research of my family history. I found that I come from a family of outdoorsman/foresters, some of whom helped shape the West. In fact, my great grandfather was one of the first foresters to come to San Diego County and the mountains of Southern California in the U.S. Government's effort to preserve forest lands for the public good. I am honored to follow the family calling and find new challenges with similar scope and importance to those of the past.

In California and much of the West, wildfire is an accepted environmental norm. However, humans cause the vast majority of fires while natural events (lightning, volcanic activity, etc.) cause relatively few. Essentially there are three elements that define wildfire behavior: weather, fuels, and topography. These are the basic components of the wildfire behavior triangle



The wildfire behavior triangle simply displays the elements that effect wildfire spread. It is

important to note that humans can effect change on only one part of this triangle (Fuels/Vegetation). Topography remains more or less constant, changing on the geologic time scale. Weather is the most variable and excessively difficult to predict. Weather is the element that will most quickly alter as the climate changes. Firefighters are keenly aware of what weather pattern changes can do to fire behavior. It is more difficult to determine what the long term effect will be on the health of watersheds and all of the values they support.

For over 100 years, we have geared up to fight wildfires on a seasonal basis. "Fire season" has been a staple in our way of planning for and deploying firefighting resources during the late spring, summer, and early fall. The West has had a predictable cycle of wildfire occurrence (with a few local exceptions). The Southwest gets fires early and then the monsoons dampen the region and fires start to breakout in the Great Basin as summer takes hold. In mid- to late summer, the Pacific Northwest and Northern California dry out, and fires can easily consume the parched vegetation. Southern California closes the "fire season" with the potential for Santa Anna Wind-driven fires. These are some of the most dangerous due to the large population in the region including cities and towns intermixed with wildland vegetation.

The "fire season" cycle identified above seems to be breaking down. There is less predictability. More and more large and damaging wildfires are occurring outside of fire season, deep into the winter or earlier in the spring. Weather is the primary reason for this change. Less precipitation is coming in the form of snow which slowly charges water supply facilities and keeps fire threats in the high country to a minimum until deep into the summer months. We are getting long dry spells sometimes accompanied by winds that drive fires like the Viejas Fire in January 2001 (San Diego County), to over 10,000 acres in one active day of burning. Southern California has its share of large and damaging wildfires. It is part of the Mediterranean climate that indigenous plants, animals and humans have adapted to over millennia. However, the adaptations are based on a cycle that seems to be changing at a rate that can't be matched. Scientists have found that many of the species of animals whose habitat was consumed by the massive wildfires in 2003 and 2007 are starting to return and some are thriving. Others are gone. Those requiring woody debris (stumps, logs, and sticks) and thick leaf litter have not returned and they may not for decades, or ever.

You may wonder why this matters to a forester turned fire chief. As a chief in one of the most progressive wildland fire agencies, I feel it is my duty to know how fire is likely to affect the people and natural resource values of California and beyond. Informed proactive decision making will help me and my colleagues best meet our mission to …serve and safeguard the people and protect the property and resources of California.

Climate change has the potential to shift local and regional weather patterns. Drought may persist in some areas while above average precipitation may occur elsewhere. It is certain however that wildfires will be a permanent issue for Californians. I often say, "Every acre of land can and will burn at some point in time." Where the next large damaging fire will occur is not certain. However, we must expect and prepare for it to come. Likewise, we must plan for a less predictable and longer firefighting season including fires that defy our conventional recollections.

I am proud of California's leadership and governmental effort to address climate change. As a senior manager, I look forward to continuing my personal and family's service to the people and natural resources of California. As the climate changes, there will be tough issues to deal with and I am confident California will lead the way with innovative solutions.

Recovery:

Post-disaster recovery and reconstruction periods provide an opportunity for reducing vulnerability to weather- and climate-related risk. However, an emphasis on rapid rebuilding of infrastructure, homes and businesses often leads to recovering in ways that recreate or even increase existing vulnerabilities, and preclude longer-term planning that could enhance a community's resilience to climate impacts.[225]

Risk and cost sharing mechanisms like disaster relief and insurance can help increase resilience by providing means to finance recovery of livelihoods and reconstruction, and by providing knowledge and incentives for reducing risk.[226] FEMA's National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements.

As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

- Reduce flood damage to insurable property;
- Strengthen and support the insurance aspects of the NFIP, and
- Encourage a comprehensive approach to floodplain management

Please see Box 23**: Climate Change and Insurance** below (please also see Box 48**: Flood Insurance** in the Oceans and Coastal Ecosystems and Resources section of this document). It should be noted, however, that in some circumstances, risk and cost sharing mechanisms can provide disincentives for reducing disaster risk; see, for example, the discussion of repetitive loss and the National Flood Insurance Program in the Oceans and Coastal Ecosystems and Resources section of this document.[227]

CAL OES administers a number of recovery programs including:

- Public Assistance to aid state agencies, local governments, special districts and eligible private non-profit organizations that have been impacted by a disaster. Through Public Assistance, CAL OES facilitates state and federal support to applicants to assist in community recovery from a major disaster or emergency;

- Individual Assistance involves coordination with federal, state, local, and voluntary/non-profit entities to provide recovery assistance following a disaster

where individuals and households, businesses, and/or the agricultural community are impacted; and

- Additional Technical Resources provided through Recovery Programs include post-disaster Safety Assessments, Debris Management and Environmental/Historic assistance to address environmental compliance issues.

- Emergency Function (EF) 14 – Recovery supports and coordinates the state-level activities of its stakeholders in the mission to achieve recovery success within California. The EF 14 stakeholders work together within their statutory and regulatory authorities to effectively and efficiently coordinate recovery operations. EF 14 is currently under development.

- The California Disaster Recovery Framework (CDRF), which is under development, is organized by the six Recovery Support Functions (RSFs) and the recovery core capabilities of public information and organizational coordination (leadership). The RSFs outline roles and responsibilities of stakeholders and anticipate and identify the significant functions or categories of support. CDRF is currently under development.

- National Disaster Recovery Framework, updated in 2013, provides context for how the whole community works together and how response efforts relate to other parts of national preparedness. It is one of the five documents in a suite of National Planning Frameworks. Each Framework covers one preparedness mission area: Prevention, Protection, Mitigation, Response or Recovery.

Box 23

Climate Change and Insurance

The insurance industry is vulnerable to climate change, but can also help society manage climate risks. The insurance industry is the world's largest industry with 4.6 trillion USD of annual revenues.[228] Insurance provides a way of pooling risk and facilitating recovery from losses and disasters. Insurance cannot make whole all losses (such as loss of life and the loss of other irreplaceable items), however insurance can provide important financial relief.

Generally, insurance companies are required to maintain adequate reserves to cover claims.[229] However, when there is the potential for claims to exceed the amount of reserves an insurance company can maintain, insurers look for other instruments to pay claims, including re-insurance[230] and, more recently, catastrophe bonds. However, the cost of reinsurance can decrease the affordability of insurance.[231]

Reinsurance and global risk sharing are ways of making insurance actuarially viable. According to the Reinsurance Association of America:

> "Reinsurance is best thought of as 'insurance for insurance companies,' a way for a primary insurer to protect against unforeseen or extraordinary losses…to share liability when losses overwhelm the primary insurer's resources…reinsurance plays a critically necessary…role in the financial management of natural disaster losses.
>
> In a reinsurance contract one insurance company (the reinsurer…) charges a premium to indemnify another insurance company…against all or part of the loss it may sustain under its policies…Reinsurance is a global business. Its international nature reflects a further spreading of risk and access to broader capital markets to help cover losses. About 46% of all U.S. property/casualty reinsurance premiums, and two-thirds of all U.S. property catastrophe reinsurance premiums, are written by foreign reinsurance companies."[232]

The re-insurance company Swiss Re published a report in 2013, that notes that a loss like the one triggered by Superstorm Sandy should be expected about every five years when looking at the U.S. as a whole.[233] International insurance and reinsurance companies are expected to cover half of total insured losses (in excess of $8 billion USD) from Superstorm Sandy, according to the industry Association of Bermuda Insurers and Reinsurers (ABIR).[234]

The risks can eventually become so extreme, that insurers can decline to underwrite, leaving the public without a means to cover losses[235]. Then, public insurance mechanisms become vital. This has occurred with flood, crop, wind and earthquake insurance.

Public Insurance Mechanisms

The government does offer some insurance products through the National Flood Insurance Program and the Federal Crop Insurance Corporation. Those programs are further discussed in the Oceans and Coastal Ecosystems and Resources section of this document and the Agriculture section of this document. It is important to note, that much of California's agricultural production is not eligible for federal crop insurance. The National Flood Insurance Program's rates have significantly increased due to the Biggert-Waters Flood Insurance Reform Act. As a result, many who are at risk may not be able to afford flood insurance. [236]

States offer insurance through public instrumentalities, such as the California Earthquake Authority and Florida's Citizens Property Insurance Corporation. Because the risk of loss remains high, insurance rates from these providers can be expensive and the take up rate can be low, leaving many who are at risk without coverage.[237]

When losses are not covered by insurance, Federal disaster aid is the last resort for disaster victims. In the event of a major disaster, federal funding for response and recovery comes from the Disaster Relief Fund managed by FEMA and disaster aid programs of other participating federal agencies. These programs are provided with emergency supplemental appropriations to

cover the costs of damages. The federal government does not budget for these costs; without a comprehensive view of overall funding claims and trade-offs, it is difficult for federal decision makers to manage such fiscal exposures. FEMA has obligated over $80 billion in federal assistance for disasters declared during fiscal years 2004 through 2011; with a growing number of disaster declarations—a record 98 in fiscal year 2011 compared with 65 in 2004.[238]

Challenges and Opportunities

When risks are too great or undefined, insurers may withdraw from at-risk market segments, increase prices, or limit coverage, and this creates undesirable societal vulnerabilities.[239] Nontraditional capital in the form of reinsurance backed by hedge funds or insurance-linked securities may help bolster insurance capacity in disaster prone areas[240], but the threat that climate risks pose to insurer solvency is still of concern for insurance regulators.[241]
In 2005, insurance regulators foresaw the impending threat of climate change on the insurance industry and began to address it. Although insurance is regulated on a state-by-state basis – in California, the Department of Insurance, headed by Insurance Commissioner Dave Jones, serves this function, insurance regulators actively participate in the National Association of Insurance Commissioners (NAIC, the U.S. standard-setting and regulatory support organization created and governed by the chief insurance regulators from the 50 states, the District of Columbia and five U.S. territories.)[242]

To address the implications of climate change on insurers and insurance consumers, the NAIC hosted a public hearing in 2005. Subsequently, the NAIC released *The Potential Impact of Climate Change on Insurance Regulation* white paper in 2008.[243] The white paper examined the effects of climate change on insurance industry investment decisions, disclosures and underwriting practices. The white paper also recommended regulators develop a framework for the collection of information related to the impact of climate change on insurers. [244]

In response to the white paper, the NAIC adopted the *Insurer Climate Risk Disclosure* Survey ("survey") in 2010. The eight question survey was designed to be an insurer reporting mechanism that would provide regulators with information on how insurers incorporate climate risks into their mitigation, risk management, and investment plans. Insurers are also asked to identify steps taken to engage key constituencies and policyholders on the topic of climate change. [245]

The survey was modeled after the CDP (formerly named the Carbon Disclosure Project) voluntary questionnaire and, as such, cross references its questions. The CDP questionnaire asks respondents to disclose their greenhouse gas emissions, water management and climate change strategies. Although the CDP holds the largest collection of self-reported climate change data, insurer participation is low. Insurance regulators developed the survey as a way to fill the void of pertinent climate risk information. According to the CDP, insurers typically disclose such things as their carbon footprint reduction efforts, modeling, physical risk assessments, liability concerns, investment strategies, and underwriting policies. Many also report on climate change related innovations and green practices, such as sustainable real estate, catastrophe bonds,

renewable energy practices and green reconstruction. [246]

Unfortunately, California was one of only a handful of states to actually participate in the administration of the survey, and was the only state to do so in 2011, during the second year of the survey[247].

In 2012, the insurance departments of California, Washington, and New York administered the *NAIC Insurer Climate Risk Disclosure* Survey ("survey") for the 2011 reporting year as part of a multi-state initiative. The multi-state initiative was designed to bolster participation in the survey by capturing most of the insurance industry. The survey was required for insurers writing more than $300 million in direct premium in these states, covering 68 percent of the U.S. insurer market. Approximately 470 company responses were collected in 2012 and made publicly available on the California Department of Insurance's website.[248] It should be noted uniform responses were permitted for insurers that are part of a group. [249]

The multi-state initiative was expanded in 2013 to include the insurance departments of Connecticut and Minnesota. Additionally, the required reporting threshold was lowered from $300 million to $100 million in direct written premium and applied mandatorily to all individual companies that write business in one of these states, regardless of where they are domiciled. Assuming full reporting compliance, this change in threshold is expected to double the number of reporting companies and should give insurance regulators, investors and policyholders a better picture of how insurers are responding to climate change. [250]

The California Department of Insurance, which serves as the central filing point and data warehouse, now offers companies the ability to submit their data directly online. The move to online filing will allow submitted data to feed directly into a database sortable by regulators and interested parties, enabling more people to provide analysis. [251]

In recognition of the growing need to ensure that insurers are addressing climate related risks, the NAIC also adopted revisions to the 2013 *Financial Condition Examiners Handbook* at the end of 2012. These revisions incorporated risk-focused examination questions that provide examiners with needed guidance on what questions to ask insurers regarding any potential impact of climate change on solvency. They were specifically designed to help examiners identify unmitigated risks and to provide a framework for them when examining such risks and their impact on how an insurer invests its assets and prices its products. The updates made changes to the Handbooks' Exhibit B – Examination Planning Questionnaire, Glossary, Interview of Investment Management, Interview of Chief Risk Officer, Exhibit V – Prospective Risk Assessment, Investment Repository, and Underwriting Repository sections. [252]

Disclosure of climate risk is important because of the potential impact climate change can have on insurer solvency and the availability and affordability of insurance across all major categories. Munich Re estimates weather related losses increased nearly fourfold in the United States since 1980. According to a study by Munich Re, from the period 1980 to 2011, insurers faced losses of $510 billion from extreme weather events such as prolonged droughts,

hurricanes, floods, and severe storms.[253] Experts predict climate change will continue to intensify the frequency and severity of these types of weather related events. Given these trends, it is important for insurers to identify climate-related factors and evaluate how they will impact their business and the exposures they indemnify. Recognizing the need to ensure insurers account for any potential effect these risks might have on the marketplace and the availability and affordability of insurance, state insurance regulators and other stakeholders have moved forward to administer a climate risk disclosure tool. Disclosures allow regulators a window into how insurers are incorporating these changing dynamics into their risk management schemes, corporate strategy, and investment plans. Disclosures also benefit insurers, providing them with a benchmark from which to assess their own climate change strategies and strengthening their ability to identify how climate change impacts their business. Furthermore, disclosure allows policymakers to gain an insight into needed public policy changes. [254]

Changing Regulation

Effective insurance regulation must strike a balance between allowing insurers to earn a return on their business activities while ensuring their solvency in the event of major losses, and maintaining the affordability and availability of insurance for the public.[255] Continued investments in climate science can help improve data and risk analysis supporting the insurance industry. Reducing the emissions that cause climate impacts can help prevent risks from becoming actuarially uninsurable, and the insurance industry can help disseminate information on emergency management and play an important role in increasing the resiliency of communities.[256]

The difference between the life span of insurance policies and climate risk planning time horizons may present challenges. For instance, when insurance policies are written for one to three years, insurers may have little incentive to reward short-term actions by policyholders that might reduce losses 50 to 100 years in the future.[257]

Government policies to reduce climate risks, such as land use regulation, zoning, and building standards, can work in a complementary fashion with private insurance, by helping to manage risks that are beyond the control of private insurers.[258]

California, as well as other states have enacted laws and regulations that address the impacts of climate change and encourage climate change mitigation.

Florida, for example requires residential property insurance companies to offer premium discounts to policyholders who carry out specified actions to reduce their vulnerability to hurricane- and tropical storm-force winds.[259] This encourages homeowners to mitigate their risks of loss.

In California, the Department of Insurance has facilitated mitigation of carbon emissions by enabling insurers to offer new products.

In 2009, the Department of Insurance enacted new regulations that enabled insurers to offer "pay-as-you drive" automobile insurance, which rewards consumers with reduced rates when they reduce miles driven. Since a reduction in a policyholder's miles driven corresponds to a reduction in an insurers' risk of loss, reduced rates are justifiable under the Insurance Code. Regulations for the product, permits insurers to offer premiums based on distances driven; and reducing vehicle miles traveled which helps reduce the greenhouse gas emissions that cause climate change.

The California Department of Insurance has also approved policy discounts and other financial incentives for green buildings recognizing the reduced risk of loss for buildings with features associated with green buildings. The first commercial green policy was offered by Fireman's Fund Insurance Company in 2006.[260] In 2008, the California Department of Insurance approved the first green homeowners insurance policy, allowing homeowners with conventional homes to rebuild to the latest environmental standards after a loss.[261] (For more on green buildings and energy efficiency, please see the Energy section of this document.)

The Insurance Commissioner also takes an active role in improving California's catastrophe mitigation efforts related to wildfires. Every year more than $100 million is spent on fire suppression and even more in disaster recovery, but California continues to burn and the losses continue to mount. Eleven (11) of the 20 largest fires in California have occurred in the last decade and eight (8) in just the last four and a half (4 ½) years. In an effort to push mitigation, CDI entered into a Memorandum of Understanding with CAL FIRE to mutually promote an increased awareness and collaboration among fire officials, the insurance industry and the public with the following goals:

- Reduce the risk that wildfires will cause in the loss of life or large-scale property damage/loss.
- Increase awareness of fire officials, the insurance industry and the public on methods and ways to prevent and mitigate fire losses.
- Increase incentives for homeowners, businesses, and insurance companies to actively prevent and mitigate fire risks.

New weather-based products (or weather derivatives) are also being developed. Although these would not be considered insurance because they do not provide coverage directly related to losses, they compensate purchasers (often businesses that are weather-dependent) for a shortfall in the realization of a particular weather variable (e.g. rain, snow or temperature) measured over a certain time period. If the weather variable is sufficiently correlated with the policyholder's profit, the payoff of the weather derivative can offset weather-related policyholder losses.[262]

Investing to address climate change

With $25 trillion in assets—equal to global mutual funds or pension funds—insurers are central

players in world financial markets. Recognizing investment opportunities, insurers have invested at least $23 billion in emissions-reduction technologies, securities, and financing, plus $5 billion environmentally focused funds.[263] Using the California Department of Insurance Climate Risk Disclosure Survey results, an organization representing public pension funds has evaluated insurers' preparedness for climate change.[264]

The California Insurance Commissioner has encouraged the insurance industry to make green investments, meaning investments that emphasize renewable energy projects, economic development, and affordable housing focused on infill sites so as to reduce the degree of automobile dependency and promote the use and reuse of existing urbanized lands supplied with infrastructure for the purpose of accommodating new growth and jobs. In fact, insurance companies can receive tax credits offered under the California Organized Investment Network (COIN) program, administered by CDI for making such investments.

Climate Impacts and Different Market Segments of the Insurance Industry

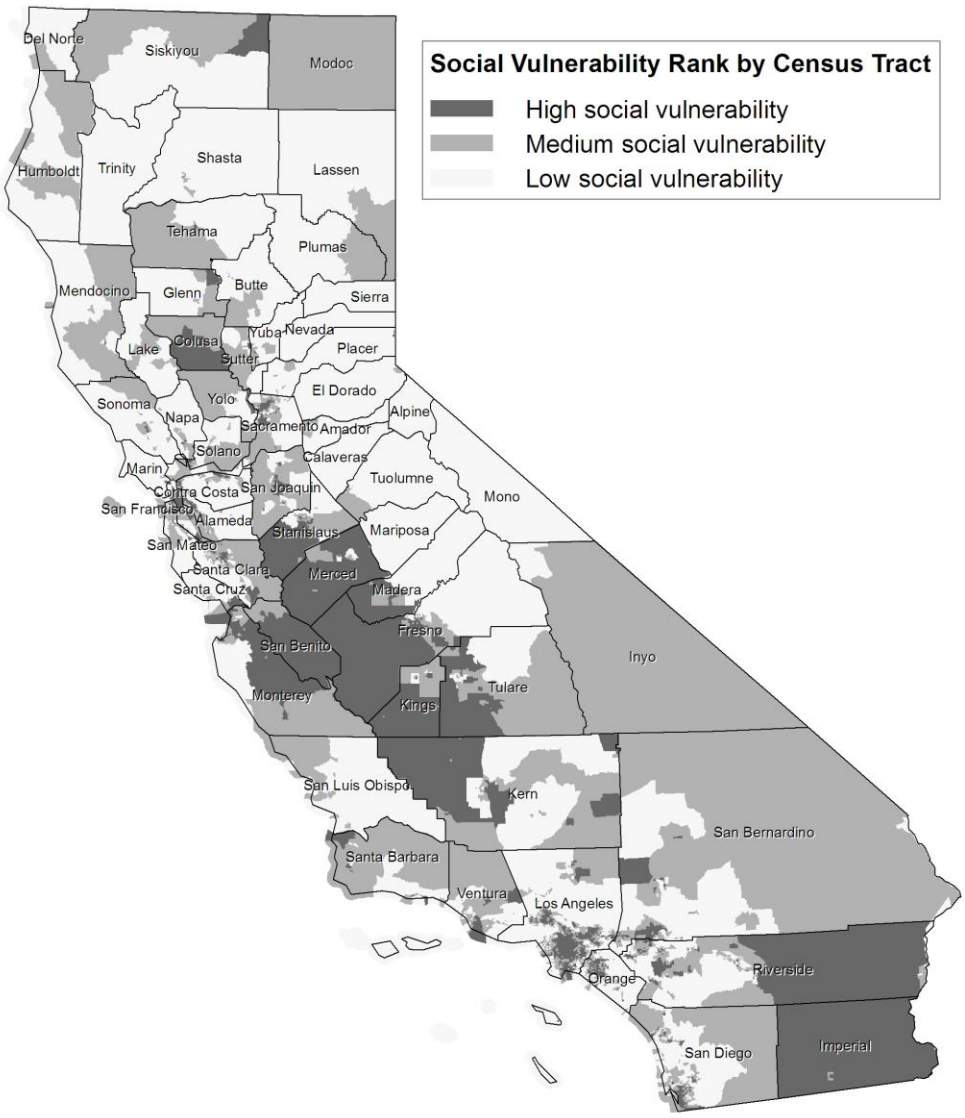
Worldwide, insured claims for weather catastrophes have more than doubled each decade since the 1980s, adjusted for inflation, and average $50 billion USD/year.[265] Insurance by weather event type may vary, as insurance coverage is often limited to specific causes and losses. For instance, property damage coverage may be available for some losses associated with storms, while the same policy may offer no coverage for losses sustained due to heat waves. Increased weather catastrophes are also not the only climate-related risk that may impact the insurance industry.[266] As noted in the Public Health section of this document, climate change may have a number of different health-related impacts. This may have significant implications for the life-health segment of the insurance industry.[267] The life-health segment of the insurance industry represents over half of U.S. insurance premiums. While companies such as Swiss Re have helped sponsor studies on climate change and health issues, more attention has been focused on climate risks and property/casualty insurance.[268]

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

Research on Climate Exposure and Socio-Economic Vulnerability of California Communities

Before funding for the CEC Public Interest Energy Research program sunset, it funded a number of studies on the exposure and vulnerabilities of California communities to climate impacts. These studies included studies of particular communities, like Fresno and San Luis Obispo, and the development of a climate vulnerability index to identify the areas of the State most vulnerable to climate impacts.[269] The climate vulnerability index combined 19 indicators into one overall climate vulnerability score and includes factors specifically related to climate impacts, such as air conditioner ownership, percentage of tree cover, and workers in outdoor occupations. [See Box 24 and Box 25 for State Climate Vulnerability Maps; also see the Public Health Chapter of this document for additional efforts to assess climate vulnerability.]

Box 24



Cooley, H., E. Moore, M. Heberger, and L. Allen (Pacific Institute). 2012. ***Social Vulnerability to Climate Change in California.*** California Energy Commission. Publication Number: CEC-500-2012-013.

Box 25



Cooley, H., E. Moore, M. Heberger, and L. Allen (Pacific Institute). 2012. ***Social Vulnerability to Climate Change in California.*** California Energy Commission. Publication Number: CEC-500-2012-013.

Climate Change in the State of California Multi-hazard Mitigation Plan

In 2007, CAL OES began to integrate linkages between hazard mitigation, climate adaptation and emergency preparedness into the State of California Multi-Hazard Mitigation Plan (SHMP).

The SHMP must be updated and approved by FEMA every five years.

The 2013 SHMP was approved as an Enhanced State Mitigation Plan; as discussed above, this makes California eligible for an increased amount of mitigation funding following a disaster declaration.[270] The 2013 SHMP continued the work of integrating climate change into the state's hazard mitigation efforts, and expanded climate risks considered in SHMP. The 2013 SHMP includes additional consideration of climate risks to public health, agriculture, and energy.

Adaptation Planning Guide

CAL OES in partnership with the California Natural Resources Agency (CNRA), and with technical support from California Polytechnic State University – San Luis Obispo (Cal Poly) and funding from Federal Emergency Management Agency (FEMA) and California Energy Commission, developed an Adaptation Planning Guide (APG). The APG, released in 2012, provides a decision-making framework intended for use by local and regional stakeholders to assist with planning for climate risks.[271] The APG implements key actions called for in both the 2010 California State Hazard Mitigation Plan (SHMP) and the 2009 California Climate Adaptation Strategy (CAS).

The APG is comprised of a set of four complementary documents, and provides guidance to support communities in addressing the unavoidable consequences of climate change. The APG introduces the basis for climate change adaptation planning and details a step-by- step process for local and regional climate vulnerability assessment and adaptation strategy development. The APG was developed to allow flexibility in the commitment of time, money, and scope.

The APG consists of the Planning Guide overview document and three companion documents for use in various combinations on an as-needed basis:

APG: Planning for Adaptive Communities This document presents the basis for climate change adaptation planning and introduces a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development. All communities seeking climate adaptation planning guidance should start with this document.

- APG: Defining Local and Regional Impacts - This document provides a more in-depth understanding of how climate change can affect a community. Seven "impact sectors" are included to support communities conducting a climate vulnerability assessment.

- APG: Understanding Regional Characteristics - The impact of climate change varies across the state. This document identifies climate impact regions, including their environmental and socioeconomic characteristics.

- APG: Identifying Adaptation Strategies - This document explores potential adaptation strategies that communities can use to meet adaptation varying needs. Adaptation

strategies are categorized into the same impact sectors used in the APG: Defining Local and Regional Impacts document. Communities seeking to understand their vulnerability to climate change and develop strategies to address the issue should refer to the APG.

Climate Change and Heat Emergencies

As noted above, in 2010, CAL OES released a *Contingency Plan for Excessive Heat Emergencies* that outlines the actions the State of California will take in support of local government when an extreme temperature event is anticipated or has occurred.[272] CAL OES is in process of updating the *Contingency Plan for Excessive Heat Emergencies* to reflect climate change impacts. The plan is a supporting document to the State Emergency Plan and although primarily designed to guide preparedness and response activities, also identifies mitigation actions to prevent life loss, including:

- Identifying the location of vulnerable populations;
- Establishing cooling centers;
- Issuing advisories and warnings; and
- Conducting pre-season public information campaigns.

As noted in the Public Health section of this document, CDPH and Cal/EPA have also released "Preparing California for Extreme Heat: Guidance and Recommendations".[273]

CaLEAP Planning Tool

As described in the Energy section of this document, the California Local Energy Assurance Planning (CaLEAP) web-based tool was launched in 2012.[274] CaLEAP is a CEC sponsored project to help local governments with preparations to make their communities more resilient in the face of disaster events that can interrupt energy supplies. The web-based tool was designed with local government end-users in mind. The tool is structured around CaLEAP methodologies, provides links and resources, can be used to identify needed materials, and can also act as a virtual office for planning teams in order to foster communication and coordination.

Amendment of California Insurance Code After 2003 Wildfires

In 2004, the California Insurance Code was amended to provide additional protections to victims of catastrophic losses such as those experienced in 2003 wildfires in southern California.[275] As noted above, despite additional laws that offer protections to insurance consumers in the face of natural disasters, the availability and affordability of private insurance may decline particularly where risks are too great or undefined, and there may be no viable public insurance alternative.[276]

Senate Bill 1241

Adopted in 2012, Senate Bill 1241 requires inclusion of additional wildfire safety considerations as part of local general plans in all State Responsibility Areas and Very High Fire Hazard Severity Zones, together with special findings of fact supporting local approval of new subdivisions in such areas.[277]

Box 26

Forecasting Extreme Events - Multi-Hazards Demonstration Project & Science Application For Risk Reduction project

An effort to integrate science and disaster management at the federal level, the Multi- Hazards Demonstration Project (MHDP) was initiated by the United States Geological Survey (USGS) with a five- year, pilot project in 2006. The project's goal is to improve California's resiliency to earthquakes floods, wildfires, tsunamis, and other hazards. The project engages emergency planners, businesses, universities, government agencies, and others in preparing for major natural disasters. The project also helps to set research goals and provides decision-making information for loss reduction and improved resiliency.

The first public product of the MHDP was the ShakeOut Earthquake Scenario published in May 2008, which detailed a hypothetical magnitude 7.8 earthquake on the San Andreas Fault in southern California. The next major project for MHDP was the ArkStorm scenario - a winter storm scenario for the U.S. West Coast for a storm estimated to produce precipitation that in many places exceeds levels only experienced on average once every 500 to 1,000 years.[278]

The Coastal Storm Modeling System (CoSMoS) was developed for the ARkStorm to incorporate atmospheric information (that is, wind and pressure fields) with a suite of state-of-the-art physical process models (that is, tide, surge, and wave) to enable detailed prediction of currents, wave height, wave runup, and total water levels for mapping the distribution of coastal flooding, inundation, erosion, and cliff failure.[279] The Coastal Storm Modeling System (CoSMoS) was developed by the USGS and a Netherlands-based research institute to predict coastal flooding caused by both sea-level rise and storms driven by climate change. CoSMoS modeling begins with feeding the results of the latest global climate models into a global wave model to predict wave conditions for the U.S. west coast through 2100.[280]

The Google Earth-based product output of CoSMoS is designed to provide emergency planners and coastal managers with critical information to increase public safety and mitigate damage associated with powerful coastal storms.[281] CoSMoS not only can serve as a long-term planning tool, but—when extreme storms are approaching—is capable of serving as a real-time warning system for emergency managers, lifeline operators, and resource managers.[282]

The ARkStorm study showed that an extreme winter storm in California could cost on the order of $725 billion - with total direct property losses of nearly $400 billion, of which $20 to $30 billion would be recoverable through public and commercial insurance, and business interruption costs of $325 billion.[283] For more information on monitoring and forecasting of "atmospheric rivers" (or the powerful winter systems, sometimes called "pineapple express" storms) in California, please the Oceans and Coastal Ecosystems and Resources section of this document. For additional information regarding floods, please see the Water section of this document.

In January 2012, the Multi- Hazards Demonstration Project evolved into a permanent project

known as Science Application for Risk Reduction (SAFRR) that has a similar mission and national purview. Under SAFRR's auspices, the USGS, National Oceanic and Atmospheric Administration (NOAA), California Geological Survey (CGS), and other entities are collaborating to develop a Pacific Basin Tsunami Scenario. The scenario focuses on ports, harbors and marinas.

ACTIONS NEEDED FOR IMPROVED EMERGENCY MANAGEMENT IN THE FACE OF CLIMATE IMPACTS

Improve Integration of Climate Impacts and Projections into All Phases of Emergency Management

Promote the implementation of the Climate Adaptation Planning Guide (APG) and Inclusion of Climate Risk Reduction in Hazard Mitigation Planning Efforts

The State will continue to promote APG implementation and principles of sustainability, resilience and hazard mitigation through collaboration with key public and private sector organizations through mechanisms including:

- Local hazard mitigation plans encouraged under federal law;
- Emergency operations plans required under federal law;
- Local general plan safety elements required by California law;
- Encouraging LHMP adoption into Local Government General Plan Safety Element;
- Sustainable Communities Strategies of metropolitan planning organizations;
- Local Coastal Programs under the California Coastal Act;
- Strategic Fire Plan for California;
- The Central Valley Flood Protection Plan;
- California Water Plan and other flood planning documents; and
- The Energy Assurance Plan.

These mechanisms relating to transportation planning, fire, flood, energy and coastal planning are discussed in their respective sections in this document.

Hazard mitigation efforts should consider the vulnerability of these community resources to climate risks:

- Essential Facilities – hospitals, medical facilities, police and fire stations, waste management facilities, emergency operations centers, shelters, schools, etc.
- Transportation Systems – airways, bridges, tunnels, roads, railways, waterways, etc.
- Lifeline Utility Systems - potable water, wastewater, landfills, oil, natural gas, electric power, communication systems.
- High Potential Loss Facilities - nuclear power plants, dams, military installations, etc.

- Hazardous Material Facilities
- Facilities Supporting Vulnerable populations
- Economic elements - major employers, financial centers, etc.
- Areas of special consideration – high-density residential or commercial development resulting in high death tolls/injury if damaged.
- Historic, cultural, and natural resources areas

Continue to support the integration of climate risks in state and local government emergency planning efforts and enhance capacity to respond and recover from climate risk

Emergency management grants, planning assistance and guidance, mutual aid agreements and post-disaster recovery and hazard mitigation, all play key roles in effective emergency management efforts. As California agencies plan for climate change, there may be opportunities for joint projects, information sharing, and shared funding opportunities with local and regional partners as well as with other States. Preparing for climate risks may also offer additional benefits for overall resilience in emergency situations; for example, increasing energy and water security to prepare for climate risks will help California better prepare and respond to earthquakes and terrorist attacks and will help to ensure first responders, the military and other emergency services can continue to operate during emergencies and disasters.

Support Risk Sharing Mechanisms

As noted above, public and private insurance and disaster relief provide important risk sharing mechanisms. Efforts to reduce climate risks through hazard mitigation activities, including but not limited to fire hazard reduction, minimizing new development in areas most vulnerable to hazards, and improved flood management, will be important to managing risks and supporting sustainable insurance and disaster programs. Specific recommendations regarding National Crop Insurance and the National Flood Insurance Program may be found in the Agriculture and Oceans and Coastal Resources sections of this document respectively.

Better Understanding of Climate Impacts on All Phases of Emergency Management

Assess adequacy of surge and response capacity in light of climate projections for more frequent and more severe weather events

Climate change is projected to increase the frequency and severity of natural disasters related to flooding, fire, drought, extreme heat, extreme cold, and storms (especially coupled when coupled with sea-level rise). This may require preparing for additional emergency surge capacity across the various emergency functions identified in the State Emergency Plan and for additional emergency response capacity. The State should assess the adequacy of its current emergency surge and response capacities. Funding for this type of assessment may be needed.

Research and monitoring

As discussed in this document, the State has already invested significant resources to conduct and support initial climate vulnerability and cost assessments in a variety of sectors. As noted

in the various sections of this document, additional research is still needed to continue to expand and refine information about the climate vulnerabilities of California's populations, infrastructure, property, food and agriculture, and biodiversity. Monitoring and research related to extreme weather events including flood, drought, heat, fire, and related losses will be especially important for emergency management and public safety. Coordination between sectors will help to maximize research and monitoring funding, information sharing, and will help facilitate well-integrated actions to build safe and healthy communities.

Climate Risk Communication and Education

Integrate climate projections into the MyHazards and MyPlan tools, and continue to update and maintain the MyHazards and MyPlan tools

As noted above, the MyHazards and MyPlan tools provide important information for individuals and local and regional governments to plan for hazards. As the climate changes, it will be important to integrate future climate projections into the tools. The Cal-Adapt tool, discussed in the Introduction to this document, is a climate projection visualization tool, and might be used to help integrate climate projections into My Hazards and My Plan. The tools will need to continue to be updated and maintained as new information and risk management strategies are developed.

Increase outreach efforts to prepare for extreme events

Increasing outreach efforts can help households and business better understand and prepare for climate risks and extreme events such as fires, floods, storms, drought, extreme heat and extreme cold. Funding may be needed for such outreach efforts, but prospective emergency planning can help lower emergency response risks and costs. The state should continue to support outreach to encourage emergency preparedness actions including the development of evacuation plans and preparedness kits. These outreach efforts should tailored to be culturally and linguistically relevant for California's diverse populations.

Training for first responders and other emergency managers on climate risks

First responders and other emergency managers play a key role in emergency management; and first responders are directly at risks from increasingly frequent and severe risks such as fire and floods. As noted in the Introduction to this document, state agencies and departments should be provided with the resources to enable climate training for staff. Climate training for emergency managers is critically important for both public health and safety and for the safety of first responders. Funding may be needed to support such training.

Box 27

California Emergency Management

California Governor's Office of Emergency Services (CAL OES)[284] CAL OES is responsible for the coordination of overall state agency response to major disasters in support of local

government. The Agency is responsible for assuring the state's readiness to respond to and recover from all hazards and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts. CAL OES includes the Public Safety Communications Office.

CAL OES accomplishes its mission of creating a safe and resilient California through leadership and collaboration. That collaboration includes important partnerships with federal, state, tribal and local entities, as well as with the private sector and individual citizens. For instance, in addition to deploying its own response resources to assist local government during major emergencies, CAL OES calls upon state, federal, local and private sector entities to assist based on their specialized capabilities and expertise.

While CAL OES plays a central role in California's emergency management activities, many other state agencies and departments have key roles to play as well. Some examples include:

California Department of Forestry and Fire Protection (CAL FIRE) and **State of California's Office of the State Fire Marshall (SFM)**. CAL FIRE's work in forest fire prevention is further discussed in the Forestry section of this document. SFM's role is also discussed in the Transportation section of this document. The mission of the State Fire Marshal is to protect life and property through the development and application of fire prevention engineering, education and enforcement.[285]

California Department of Housing and Community Development (HCD) was established in 1965 and works to provide leadership, policies and programs to preserve and expand safe and affordable housing opportunities and promote strong communities for all Californians. HCD administers a Disaster Recovery Initiative (DRI) as part of its State Community Development Block Grant program. The DRI was established in early 2010 to distribute federal funds to assist physical and economic recovery from wildfire disasters in 2008 that affected 14 California counties and two Indian tribes. In late 2010, HUD offered additional funds from the DREF to extend and improve the recovery, by offering incentives to eligible jurisdictions to mitigate the danger of future disasters (e.g., earthquake, flood, fire) through forward-thinking planning measures, such as updated building codes and code enforcement, creation of Local Hazard Mitigation Plans (LHMPs) and/or the adoption of Safety Elements of local General Plans.[286]

California Department of Food and Agriculture (CDFA) among other things, CDFA administers the Emergency Animal Diseases Management Program for the prevention, detection, immediate containment, and eradication of emergency animal diseases.[287]

California Department of Insurance (CDI) - CDI, headed by the Insurance Commissioner, licenses and regulates insurance companies, agents, and brokers in California. CDI works to foster an insurance market that is fair, competitive and accessible to all Californians. The CDI does this in a variety of ways including regulating insurance rates, ensuring that insurers are solvent and able to pay policyholders' claims, bringing enforcement actions against insurance companies, agents and brokers, and unlicensed individuals for violating the law, combating insurance fraud, and assisting consumers, including victims of wildfires, with their insurance issues.[288]

California Department of Transportation (CalTrans) provides a variety of emergency management services including administering the Federal Highway Administration Emergency Relief Program in California, providing assessments of transportation infrastructure and traffic conditions, establishing route priorities during recovery efforts, developing routing and directions for the movement of incident victims out of an impacted area and the delivery of necessary personnel and medical supplies to local medical facilities and shelters, preparing road information and displays, and helping the California Highway Patrol (CHP) and local traffic agencies.[289]

California Department of Water Resources (DWR) - DWR's work on flood detection and prevention are further discussed in the Water and Ocean and Coastal Ecosystem and Resources sections of this document. **California Division of Dam Safety –** works to protect people against loss of life and property from dam failure. The California Water Code entrusts this regulatory power to DWR which delegates the program to the Division of Safety of Dams**.**[290]

California Geological Survey (CGS) established in 1860, provides scientific products and services about the state's geology, seismology and mineral resources that affect the health, safety, and business interests of the people of California. These products include landslide inventory maps and seismic hazard zone maps.[291]

California Health and Human Services Agency (HHS) is the lead agency for Public Health and Medical activities and services statewide in support of local jurisdiction resource needs for preparedness, response, and recovery from emergencies and disasters.[292] HHS includes both the California Department of Public Health - Emergency Preparedness Office (CDPH EPO)- the state's lead on health emergencies and the Emergency Medical Services Authority (EMSA).

California Seismic Safety Commission (CSSC) established in 1975 pursuant to the Seismic Safety Act, works to investigate earthquakes, research earthquake-related issues and reports, and recommend to the Governor and Legislature policies and programs needed to reduce earthquake risk.[293]

Governor's Office of Planning and Research (OPR) was created by statute in 1970 and constitutes the comprehensive state planning agency. OPR provides General Plan Guidelines (GPG). The 2013 update to the GPG (GPG 2013) will be a resource for decision-makers, planners, and the public for the development and implementation of local general plans. The GPG 2013 will include advice on how general plans can address needed preparation for climate impacts.[294]

As noted above, CAL OES works closely with a number of federal partners. These partners include the **Federal Emergency Management Agency (FEMA)**, the **Center for Disease Control and Prevention (CDC)**, and the **U.S. Department of Defense (DOD).**

CAL OES also works closely with tribal and local entities, private sector partners, and individuals. For instance, to enhance emergency planning and response, CAL OES has a number of

Memoranda of Understanding (MOUs) in place with key private sector partners including an agreement with the **California Utilities Emergency Association**. During disasters, these partners also form the Business and Utility Operations Centers at CAL OES which are a critical component in emergency response and addressing the needs of impacted communities.[295]

ENERGY

INTRODUCTION

California's economy and its residents' quality of life depend on a sufficient supply of safe, affordable, and reliable energy services. The energy sector provides these services through a complex, integrated system involving production, transmission and distribution, and consumption in our homes, businesses, schools, hospitals, vehicles, and other facilities. Transformation of the energy sector is an essential component of successful mitigation strategies, since energy services account for roughly 85 percent[296] of California's greenhouse gas emissions. While the energy sector is a primary contributor to climate change, its supply and demand infrastructure is also vulnerable to climate change impacts such as those associated with extreme events, sea level rise, and heat waves. Ignoring the potential impacts to the energy sector, particularly during peak periods of higher-than-average energy usage, could lead to a shortfall in energy supply and potentially even power outages unless we adapt our planning processes.

Box 28



California Department of Forestry and Fire Protection, 2008 Humboldt Fire – Butte County

This chapter addresses the electricity and natural gas systems as well as other energy sources used in buildings. Transportation infrastructure (e.g., highways and bridges) is discussed in the Transportation chapter, while vehicles and transportation fuel with its infrastructure (e.g., refineries) are covered in more depth in this Energy chapter.

California's energy systems are vulnerable to a variety of climate impacts, as reported in the 2012 California Climate Change Vulnerability and Adaptation Study.[297] The primary climate impacts to the energy system in California are warmer temperatures, less snowpack, more frequent extreme weather events, and sea level rise. Electricity demand increases with rising temperatures, while the energy system becomes less efficient. Less snowpack means less hydropower during the peak demand period. Extreme events and sea level rise expose parts of the energy systems to greater risk of damage and outages.

Indirect vulnerabilities of energy infrastructure and operations may surface as adaptation strategies for other resources are implemented. For instance, meeting non-energy water demands in extreme drought years would impact hydroelectric generation and power plant cooling. Additionally, the growing interdependencies of infrastructure systems increase risk of cascade failure. As an example, sea level rise and flooding add stress on the levee system in the Delta (water system), where failure may render natural gas storage and pipelines more vulnerable. This in turn would threaten the natural gas supply for electricity generation as well as heating and cooking in homes and business and use in industrial processes.

Several state entities play an important role with respect to energy in California. The state also has important federal, local and private sector partners with respect to energy. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks. For more information, see Box 34 *California Energy below.*

Climate Change Impacts on Energy Services: Electricity

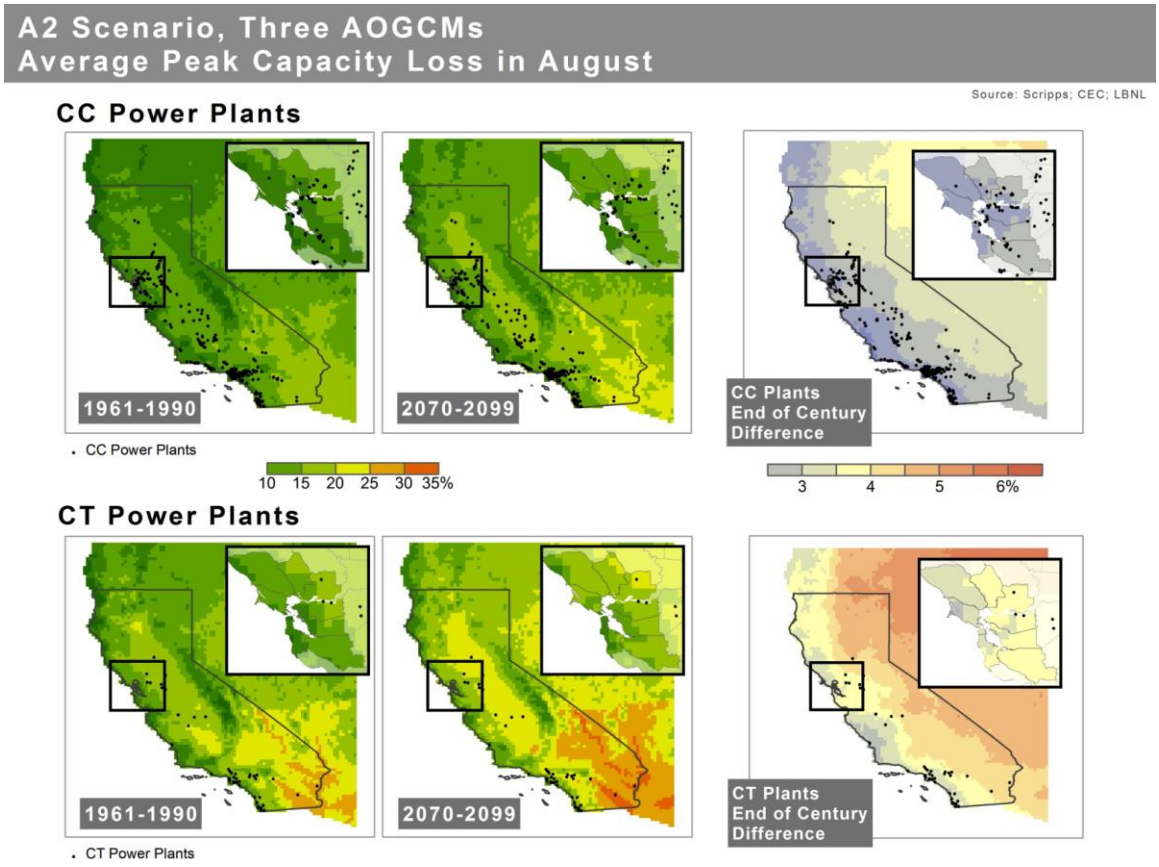
Climate change presents a variety of threats to California's energy infrastructure, including the supply of both conventional and renewable energy resources, electricity generation, fuel refining, and transmission and distribution. This section begins with a discussion of vulnerabilities in the electricity sector. A brief indication of risks to infrastructure associated with transportation fuels and natural gas follows.

Climate change could negatively impact the supply of renewable energy resources, especially water for hydroelectric power. Hydropower contributes about 15 percent of California's in-state generation on average and provides low-cost, low-carbon power in the hottest months of the year when electricity demand is at its highest. Mountain snowpack is essential to provide a steady flow of snowmelt water to hydroelectric reservoirs. Higher temperatures will mean that more precipitation falls as rain instead of snow, with remaining snowpack melting and running off earlier in the year. That means in the summer – when air conditioning demand and peak electrical loads are the highest – there will be less water in storage to be used to generate hydroelectric electricity. Potential reductions in annual precipitation would also reduce the

total amount of electricity generated from hydropower units, and alternative generation would need to be procured, likely at a higher cost.

Power plants that generate electricity are vulnerable to higher temperatures wrought by climate change. Higher temperatures decrease the capacity of thermal power plants (for example, natural gas, solar thermal, nuclear, and geothermal) to generate electricity, because power plant cooling is less efficient at higher ambient temperatures and this in turn reduces overall efficiency and the net amount of energy generated (Box 29 in this chapter).

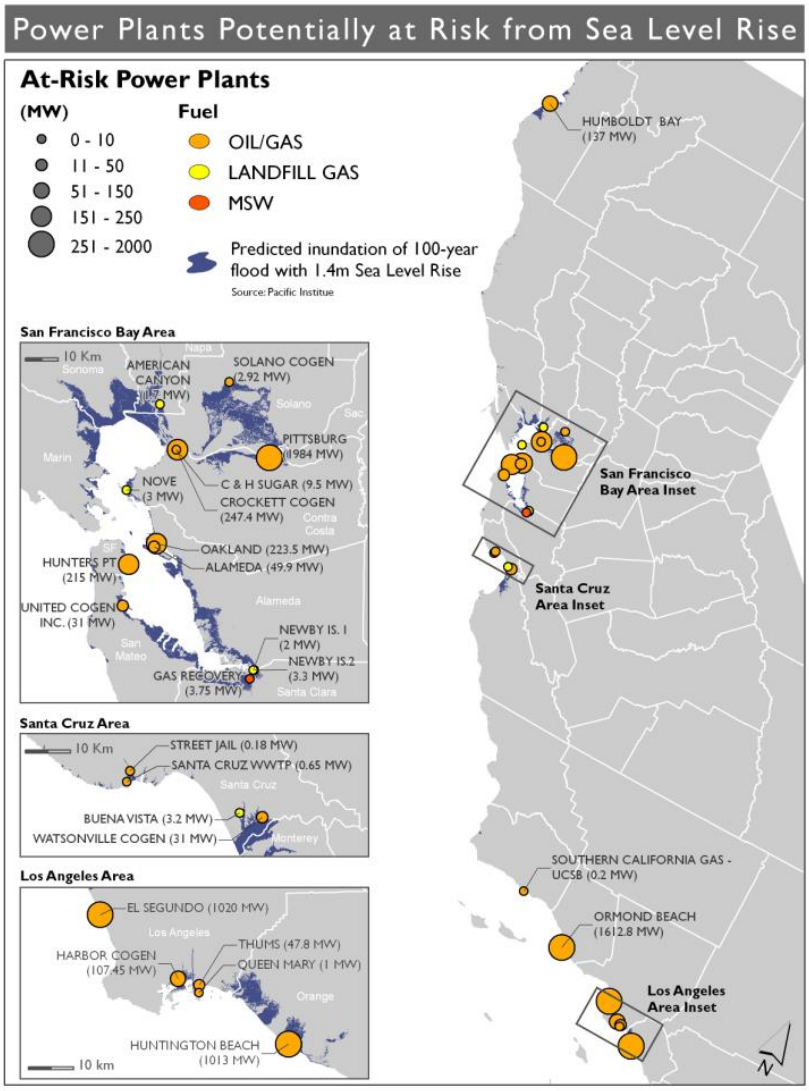
Box 29



Projected Change to Natural Gas-fired Simple-cycle Combustion Turbine (CT) and Combined-cycle (CC) Power Plant Peak Capacity: Average August loss for the recent past and end of century under the higher emissions (A2) scenario. Source: Sathaye et al. (2012).[298]

Sea level rise, as discussed more fully in the Ocean and Coastal Ecosystems and Resources section of this document, threatens about 20 existing coastal power plants (Box 30 in this chapter)**.** These low-lying power plants face the risk of flooding or partial flooding due to sea level rise and increased storm surges. Flood damage could remove these facilities from service and require electricity from other, often more expensive, sources.

Box 30

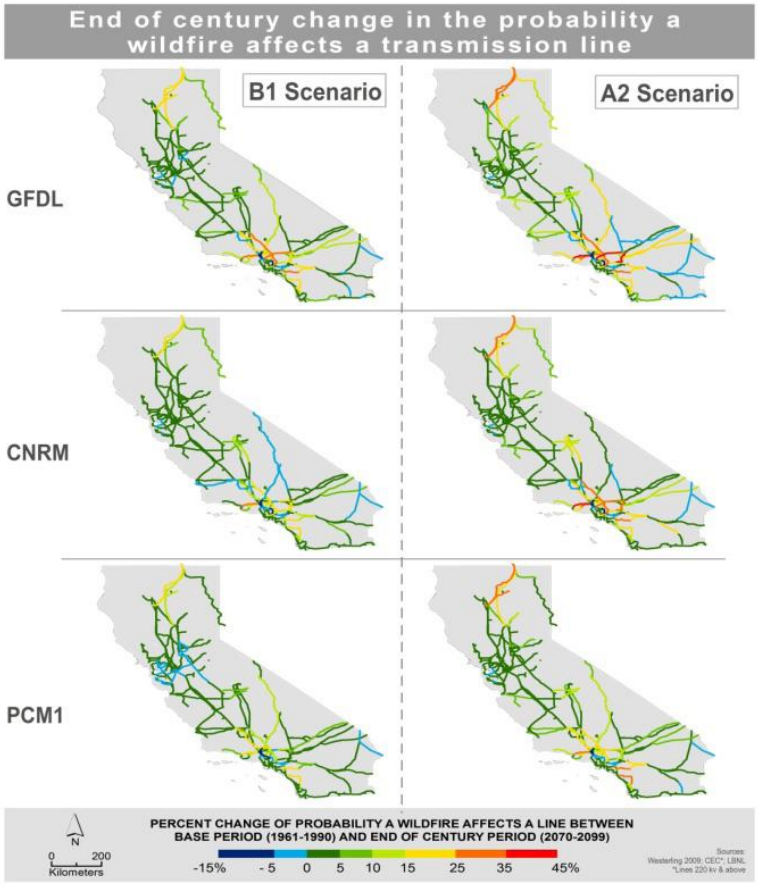


Power Plants Potentially at Risk to a 100-year Flood with a 1.4 m Sea Level Rise. Source: Sathaye et al. (2012).[299]

Similarly, transmission and distribution infrastructure is vulnerable both to increased temperatures and to increasing risk of flooding and wildfire. Higher temperatures would result in a reduction in transformer and substation capability, an increase in transmission and distribution line losses, and a decrease in the capacity of a fully loaded transmission line. For example, higher nighttime temperatures impede cooling of transformers, which renders them less efficient the next day. In the worst cases they may even fail. Thus, with high temperatures, less electricity is available for customers than if climate change had not occurred. Researchers

expect the likelihood of wildfires occurring near large transmission lines to increase dramatically in parts of California by the end of the century, including along the line that brings hydropower generation from the Pacific Northwest to California during peak demand periods (Box 31 in this chapter). A power line disabled by a fire can take days or weeks to repair and alternate power may need to be procured from other places.

Box 31



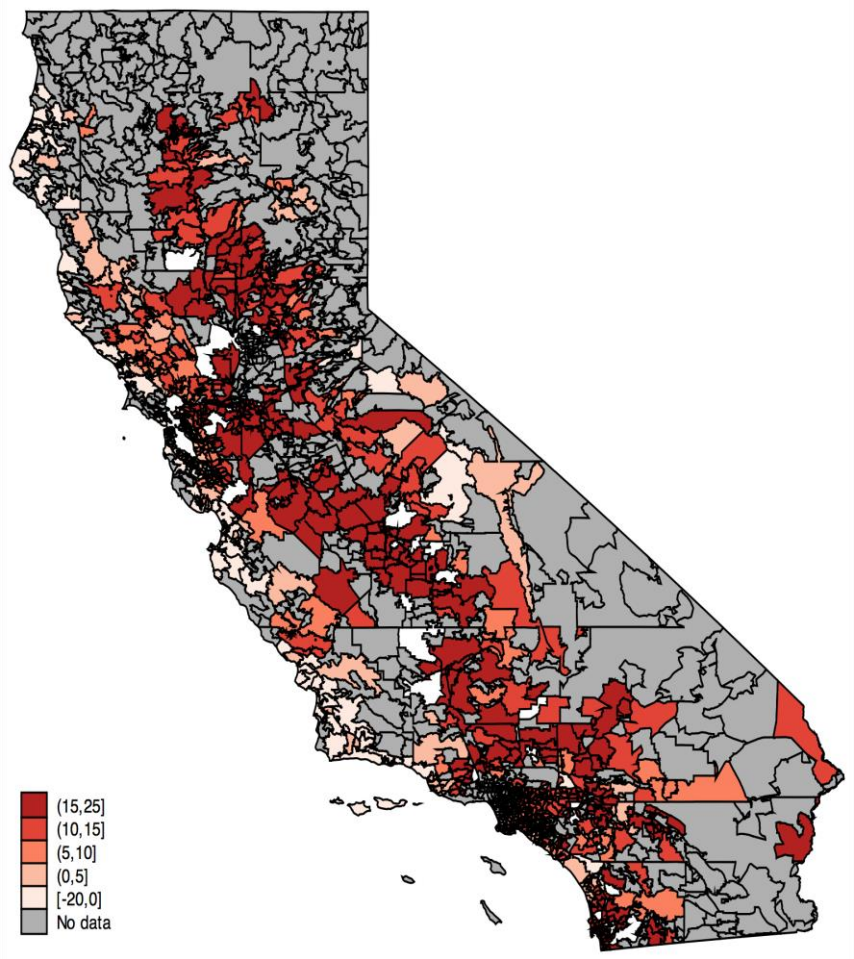
Projected Fire Risk to Transmission Lines for the lower (B1) and higher (A2) emissions scenarios with three climate models. Source: Sathaye et al. (2012).[300]

In addition, about eighty substations are at risk of flooding (or partial flooding) due to sea level rise. Natural gas pipelines and storage tanks are also at potential risk from flooding and sea level rise in the Sacramento-San Joaquin Delta where fragile, decaying levees are vulnerable to breaching.

Energy customers, the end users, would not only be subject to the costs and inconveniences of these potential impacts on the energy supply but also would be exposed to higher temperatures that tend to drive demand upward. Increasingly hot and longer summers are likely to increase demand for air conditioning, while warmer winters will decrease demand for

heating (mostly for natural gas) in the cooler season. Overall demand for electricity will increase with more frequent operation of existing air conditioners and as more air conditioners are installed in areas of the state, such as the coastal regions, where there are currently few. For example, high temperatures could increase peak demand by up to 1.6 Gigawatts (equivalent to two large power plants) in the next ten years. This peak demand will occur at the hottest time of day when thermal power plants may not be able to deliver at full capacity.

Box 32



Projected Percent Increases in Household Electricity Consumption 2080–2099 over 1961–1990 Average Consumption due to a Change in Temperature Increases (GFDLv3 model with SRES A2 (high emissions) Scenario. Source: Auffhammer and Aroonruengsawat (2012).[301]

Climate Change Impacts on Energy Services: Transportation Fuels and Fueling Infrastructure and Natural Gas

Just as the electrical grid is vulnerable to climate change, the transportation fuel infrastructure and associated facilities (e.g., refineries) that support transportation are vulnerable to extreme events, sea level rise, and coastal inundation or levee failure. Although electricity may provide a

substantial fraction, or even a majority, of transportation fuels by mid- to late century, it is imperative that the State evaluate and address vulnerabilities to refineries as well as transportation fuel pipelines in the meantime. The infrastructure that provides natural gas to our homes, industries, and power plants is also vulnerable to indirect impacts of climate change. Vulnerability assessments and adaptation studies for these parts of the energy system, however, remain to be examined in more detail. This will change as planned studies supported by the State of California are completed.

ELECTRICITY RELIABILITY

Maintaining a reliable energy system is vital to the health and well-being of California's residents and its economy. Reliable grid operation depends on meeting demand with adequate supply and ensuring uninterrupted delivery to customers.

The balance of this chapter focuses on the overarching goal of climate adaptation in the electricity sector, which is to ensure that the electrical system is resilient in the face of climate-induced impacts. To the extent that our system relies too heavily on any one resource or transmission pathway, we increase the likelihood of failure in the event of an extreme climate event. California must continue to increase the use of energy efficiency and demand response, renewable energy, microgrids, distributed generation, and other tools to improve the resiliency of the system. The following is a brief discussion of some of these elements.

Smart Grid

"Smart grid" generally refers to a class of technology people are using to bring utility electricity delivery systems into the 21st century, using computer-based remote control and automation. These systems are made possible by two-way communication technology and computer processing that has been used for decades in other industries. They are beginning to be used on electricity networks, from power plants and wind farms all the way to the consumers of electricity in homes and businesses. They offer many benefits to utilities and consumers -- mostly seen in improvements in energy efficiency and reliability.

An additional benefit of a smart grid is that the communication and control strategies embedded in a smart grid are enablers of transportation electrification.

Development of a smart grid is a cornerstone of California's strategy to maintain reliability in the electricity sector in the face of extreme weather events, higher peak demand, and other challenges posed by a changing climate.

Updating the aging electrical infrastructure to cope with weather-related and other disturbances is a critical and growing need, given that major local power outages in the United States increased from two to five per year from 1950 through the 1980s to several dozen per year in the past five years. Just as the smart grid in California will help to maintain continuous, reliable operations during earthquakes or extreme weather events, it can maintain grid reliability when stressed by intermittencies associated with renewable energy. Accordingly, the smart grid not only fosters adaptation to extreme weather events, but also helps support deployment of renewable energy and mitigation goals.

Microgrid

A microgrid is just as the name implies: a small self-contained electricity system where demand is met by onsite generation and dispatch control is at the distribution circuit level. Microgrids can be an ideal way to add reliability and resiliency by isolating disturbances and distributing generation at the point of consumption.

In a smart grid that connects microgrids, the high-voltage grid serves as a flexible backbone, linking the electricity system in a manner that enables smart communications and control, which in turn enables isolation of disturbances or allows the functioning of a microgrid when the rest or parts of the electricity system fails. For example, the University of California, San Diego's microgrid, which supplies 92% of its energy, is able to "island" from the larger grid to maintain power supply in an emergency, as in the case of the power blackout that struck parts of Southern California, Arizona and Mexico in September 2011.

Energy-Efficiency and Energy Resilience

Energy efficiency is a very cost-effective tool to reduce peak demand and total energy use and to mitigate greenhouse gas emissions. Accordingly, California needs to continue to support deep energy efficiency retrofits as well as new energy efficiency codes for existing and new buildings as they will play a significant role in the state's adaptation efforts. These programs will promote the use of more efficient heating, ventilation and air conditioning (HVAC) systems, lighting equipment, consumer appliances/electronics, building envelopes, industrial processes, and other energy consuming systems.

For instance, recently approved regulations for new buildings require increased levels of insulation (ceiling, floor and walls), increased energy-conserving window glazing to reduce solar heat gain, increased roof reflectance requirements for new construction and alterations, enhanced lighting controls, and improvements to HVAC systems and controls.[302] These 2013 Standards will use 25% less energy for lighting, heating, cooling, ventilation, and water heating than the 2008 Standards and are estimated to annually save 200 million gallons of water and avoid 170,500 tons of greenhouse gas emissions.[303] Research is underway to continue advancements of emerging energy efficiency technologies and tools that can provide for future "zero net energy" homes, businesses, communities and highly efficient existing buildings. Coupled with other smart-grid enhanced energy strategies such as demand response and energy storage, aggressive energy efficiency will improve the ability of the electricity system to respond to peak demands by shaving some peak demands.

Next-Generation Demand Response as a Smart-Grid Enabled Energy Resilience Strategy

The Federal Energy Regulatory Commission defines demand response (DR) as follows: "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." To date, California has made limited use of this tool, but is currently looking at ways to expand its use.

DR provides the ability to aggregate customers capable of reducing their electric demand (load) to decease impacts to the grid during times of stress. The use of DR can offer flexibility to adjust load in response to market schedules and dispatches. Although DR was not originally designed for the purpose of preparing for climate risks, it presents a powerful strategy for reducing peak energy demand and thereby boost grid resilience when, for example, extreme heat waves raise peak demand. Moreover, the communications associated with a smart grid enable the development of automated demand response, which can bring a larger contingent of residential, commercial, and industrial participants to DR programs than have been able to participate in past DR programs that required manual actions by customers.

By changing when and how electricity is delivered and consumed, demand response enables location of storage at strategic points around the grid to increase reliability, improve efficiency and minimize costly improvements to transmission infrastructure. Demand response can effectively reduce both overall demand and area-specific demand as needed.

Energy Storage to Improve and Maintain Grid Reliability

The smart grid will also enable integration of extensive energy storage, which will be an essential feature of California's future energy infrastructure as the state advances toward achieving multiple energy goals related to renewables and climate change. Energy storage will boost the stability and flexibility of the electrical grid, so that it can manage peak demand surges as well as increased variability in supplies due to an increase in the share of renewable energy. The stability and flexibility conferred by energy storage will thus help utilities minimize renewable energy curtailments, avoid large investments in transmission and sub-station upgrades, reduce reliance on conventional generation, and increase the return on investment of renewable energy generation.

The introduction of environmental policies to concurrently lower greenhouse gas emissions and increase the security and reliability of energy supplies will heavily influence the market rules and drivers for energy storage. Energy storage is an indispensable part of California's energy future, especially for the state to meet the 2020 goal of 33 percent of electricity derived from renewable sources.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

In compliance with the 2009 California Climate Adaptation Strategy, and in response to the current and anticipated effects of a changing climate, the State has initiated various adaptation measures. Below is a list of actions the Energy Commission, CPUC, and others have already implemented to date.

Incorporating Adaptation Measures into Energy Management Activities

Energy management supports adaptation by ensuring a reliable supply of energy despite a changing climate and during extreme weather-related events, outages, and other catastrophes. These activities let energy managers know how much energy demand there will be under these new conditions and how to manage energy more efficiently. Key adaptation accomplishments include the following:

- Assisted local agencies in preparing for all aspects of emergency situations that impact energy via the CEC-sponsored California Local Energy Assurance Planning (CaLEAP) project.[304] CaLEAP assists local governments throughout the State in preparing plans to ensure resilience of key assets to disaster events that impact energy. The CaLEAP project covers all aspects of Emergency Management (prepare for, respond to, recover from, and mitigate against).
- Considered higher temperatures due to climate change in the official energy forecasts produced by the Energy Commission as part of the Integrated Energy Policy Report (IEPR).
- Organized public workshops on April 30, 2012 and on June 4, 2013 as part of the IEPR proceedings about the vulnerability of the energy system to extreme weather events and climate change and about broader climate-related energy sector impacts and adaptation responses underway, respectively. The 2013 IEPR includes discussions and energy policy recommendations on these topics.
- Identified communities that are potentially vulnerable to increased electricity demand.
- Investigated the vulnerability of the hydropower system to climate change and explored adaptation options. For example, in collaboration with the Department of Water Resources and federal agencies, Energy Commission-funded researchers developed a decision support system designed to substantially improve the management of five major water reservoirs in Northern California. The researchers also showed that the same management system would substantially reduce the impacts of climate change by increasing water supply and electricity generation when compared to the performance of the same reservoirs under current management practices.
- Completed field demonstrations of distributed generation resources that manage customer energy demand and reduce their reliance on the utility grid. Distributed generation allows the utility grid to reduce the need to call on high peak demand generation resources, which historically have the highest levels of GHG emissions.

Support for Energy Efficiency and Demand Response as Climate Adaptation Strategies

Energy efficiency and demand response have long been a hallmark of California's energy policy, and the state has worked with many partners to promote such policies. (For more information about local efforts on energy efficiency and climate change, please see Box 33: **First Person Narrative: Climate Action is about Quality of Life By Brendan Reed and Ed Batchelder, City of Chula Vista** below) Energy efficiency and demand response are California's first priority energy resource, pursued for the economic and environmental benefits they provide, including as a mitigation strategy for climate change. However, they also represent a powerful adaptation strategy because they facilitate the development of a more sustainable and resilient energy system. The energy system and end users are most vulnerable during times of peak electricity consumption or emergencies when part of the supply is interrupted. Energy efficient buildings and appliances, and demand response, will both reduce demand and therefore reduce the likelihood of power outages during hot summer days. Here are some examples of activities in this adaptation area:

- Enhanced the CEC's Title 24 Building Efficiency Standards[305] and Title 20 Appliance Efficiency Standards[306], which are two of California's most important efficiency programs impacting both new and existing residential and commercial buildings and a variety of appliances including the growing use of plug loads. The following are examples:
    - Adopted new building energy efficiency standards in 2012 that are 25 percent more energy efficient than previous standards for residential construction and 30 percent better for nonresidential construction. Over the next 30 years, the standards will save the energy output equivalent to six modern natural gas-fired power plants. The standards ensure that better windows, insulation, lighting, HVAC systems, and other features that reduce energy consumption are installed in homes and businesses.
    - Adopted new appliance energy efficiency standards in 2012 that will reduce wasted energy by battery chargers commonly used to power cell phones, laptop computers, power tools, and other devices, saving nearly 2,200 gigawatt-hours each year – enough energy to power nearly 350,000 homes or a city roughly the size of Bakersfield. Previous appliance standards for televisions, external single volt power supplies, and battery chargers are projected to save Californians about $1.2 billion per year by 2020.
- Developed and implemented the CPUC's groundbreaking Long-Term Energy Efficiency Strategic Plan which presents a single roadmap to achieve maximum energy savings across all major groups and sectors. This comprehensive plan for 2009 to 2020 and beyond was the state's first integrated framework of goals and strategies for saving electricity and natural gas in government, utility, and private sector actions. The unifying objective of the plan is to compel a sustained market transformation that moves California beyond its historic reliance on short-term programs with limited market impacts and towards long-term, deeper savings achievable only through high-impact programs. The CPUC has continued to refine and update this plan through the development of action plans for specific high energy using target areas to enhance the scope and effectiveness of these programs.
- Provided energy efficiency research in both electricity and natural gas sectors through the Energy Commission's research programs. Current efficiency research includes development of technologies, tools and strategies for advanced HVAC systems (including controls), lighting systems, consumer and office electronics (plug loads) and controls, building envelopes, water heating and distribution, food service operations, zero net energy buildings and sustainable communities, and existing building retrofits especially for multi-family and low income.
- Funded energy efficiency programs through the American Recovery and Reinvestment Act (ARRA) stimulus, allowing the state to leverage more dollars and distribute the funds throughout the state more effectively in alignment with the intent of the federal legislation. The Commission's Energy Conservation and Assistance Account provides up to $3 million dollars at 1 percent to cities, counties, public care institutions, public hospitals, public schools & colleges, and special districts to install energy efficiency projects.

- Supported the development and demonstration of demand response actions that reduce peak electricity load during grid emergencies or in response to high energy prices during peak demand periods. Automated demand response (ADR) is triggered by a signal from a utility or grid operator to automatically reduce a user's load to a pre-agreed level. The Energy Commission has supported the development of OpenADR, which is a communication standard protocol to increase demand response availability in California. ADR substantially increases participation compared to manual systems. Implementation at the national level is occurring via the National Institute of Standards and Technologies (NIST).

Box 33

First Person Narrative: Climate Action is about Quality of Life

By Brendan Reed and Ed Batchelder, City of Chula Vista

"The city of Chula Vista is located at the center of one of the richest cultural, economic, and environmentally diverse zones in the United States. It is the second largest city in the San Diego region, with a population of nearly 250,000 and an area of about 50 square miles that includes bay front, canyons, rolling hills, and numerous other natural resources that contribute to a high quality of life.

Chula Vista has a long-standing history of being proactive with climate action. Our efforts have initial roots in our growth management thresholds from the mid-1980s, one of which pertained to air quality. These threshold standards evolved into our Growth Management Element in our General Plan update in 1989. We fully incorporated these requirements by ordinance in 1991, and the air quality provisions obligated the development community to address what we now think of as climate mitigation issues. For example, major development plans were required to produce Air Quality Improvement Plans and emission reductions through smart growth planning (compact mixed-use development, pedestrian and transit orientation, open space preservation, etc.) and other actions. As greenhouse gas emissions became a larger focus of air quality regulations, it was a natural progression to integrate climate action measures into our planning process.

The city further institutionalized its climate-related activities in 2001 by adopting a formal "Climate Action Plan." The plan has continued to evolve; the plan's mitigation measures were updated in 2008 and climate adaptation strategies were added in 2011. Over the years, our climate action planning process has always relied on an extensive community stakeholder engagement process; we have not turned anyone away from the table. Critical voices came from within our community through residents, civic associations, the business and development community with additional input from San Diego Gas & Electric, and other regional partners. We have certainly had robust dialogue, but we have always managed to have support from the community. Historically, certain voices questioned the ability of projects to meaningfully address local air quality improvement in a regional basin or to be economically

feasible. *Were we disadvantaging ourselves with additional requirements related to outcomes that were beyond our control? What about imported air pollution? Do projects become financially inviable due to the new requirements?* Our community leadership trusted the process and input, and saw value in Chula Vista effecting incremental change and looking at long-term cost benefit scenarios. Also, community members recognized the numerous co-benefits from climate-oriented planning such as cleaner air, less traffic, lower consumer utility bills, and improvements to human and environmental health.

Another key element of success was, and is, the support of the elected officials, as they see climate planning as an important quality of life issue for our community. As such, city leadership have made this a priority and ensured that city staff is accountable to these goals. Staff must report twice per year to the city council on our progress implementing the Climate Action Plan, which keeps our commitment at the forefront of everyone's mind. Because the Climate Action Plan incorporates very discreet tasks, it is also easier for staff to track and manage its implementation. In particular, there has been much interest in the implementation of our Mitigation Measure #4, which is our Green Building Standard, and our Adaptation Strategy #10 Sea Level Rise and Land Development Codes integration.

Mitigation Measure #4 directed staff to adopt regulations requiring new and renovated residential and non-residential projects to incorporate green building practices, and to create an energy "reach code" that requires projects to be more energy efficient than the 2008 Building Energy Efficiency Standards of Title 24. In addition, the measure directed city staff to implement a green building awareness program and establish regulatory provisions that incorporate sustainable practices at a community-scale.

Our green building efforts started with the early adoption of the state's Department of Housing and Community Development's California Green Building Standards Code, known as "CalGreen." Early adoption of the CalGreen standard was the result of community discussion that addressed a few approaches to accelerating green building in our community. We investigated the possibility of creating our own standard, or the possibility of using a third party standard such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) green building rating system. The decision was made to move early on CalGreen for commercial, residential and tenant improvements with specific requirements that made sense for our location and development patterns. We also felt it was important to link the design and construction process to ongoing building operations and maintenance.

Over the coming decades, local sea levels are expected to increase 12 to 18 inches higher than their current levels. Higher sea levels can result in increased erosion, more frequent flooding from storm surges and increased property damage. Additionally, loss of wetland habitats, ecosystem services and reduced waterfront public access options is also anticipated. Adaptation Strategy #10 Sea Level Rise and Land Development Codes direct staff to amend our land development codes and California Environmental Quality Act (CEQA) guidelines to incorporate climate change-related sea level rise into future development and municipal infrastructure projects. Specifically, the components of this adaptation strategy include revising

the grading ordinance to consider a project's vulnerability to future sea level rise and flooding events, modifying the Subdivision Manual to ensure that storm water/drainage infrastructure can address future sea level rise and flooding impacts, and ensuring that environmental review and CEQA procedures are consistent with these changes.

Linking land development and climate change is especially important in the planning of the Chula Vista Bayfront project on the South San Diego Bay. This redevelopment project, in partnership with the Port of San Diego, represents a significant waterfront development opportunity in Southern California. As this project re-connects our community to our waterfront, we want to ensure that the project will serve our residents and businesses for many future generations. To that end, the Chula Vista Bayfront Master Plan EIR was one of the first in the state to incorporate an analysis of sea level rise, and the project approvals incorporate extremely progressive energy conservation and pollution reduction requirements. For example, new buildings along the bay front will be designed to be resilient to 50 years of projected sea levels and to have 50 percent higher energy performance than traditional structures by extensively incorporating efficiency and renewable energy technologies. The new Chula Vista Bayfront will be another on-the-ground example of Chula Vista's Climate Action Plan positively contributing to the community's long-term sustainability and high quality of life."

Brendan Reed is the environmental resource manager for the city of Chula Vista where he is responsible for the development of sustainability programs and policies dealing with energy management, water conservation, and global climate change. As part of these efforts, Reed coordinates a multi- department team tasked with implementing the city's Climate Action Plan to help lower greenhouse gas emissions and to reduce future risks from climate change impacts.

Ed Batchelder currently serves as the advance planning manager for the city of Chula Vista overseeing long-range planning operations. Batchelder is also responsible for administering environmental and resource planning efforts and the development of energy conserving and carbon reducing community and site design provisions as part of the city's Climate Action Plan.

<u>Support for a Diversified Energy Supply and Demand Response to Reduce Vulnerability to Extreme Weather Related Events and Climate Change</u>

A more diversified energy system will reduce the negative impacts of climate-related events. For example, hydropower generation is a key source of electricity during peak demand periods in the hot months of the year. However, because climate change is expected to reduce electricity generation from hydropower units during the summer, this shortfall could impact electricity supply reliability. A diversified portfolio of electricity generating units, including photovoltaic (PV), thermal solar power plants, wind energy, geothermal units, biomass, and conventional power plants will be able to cover for the expected shortfall. Here are some examples of actions taken so far:

- California is aggressively procuring renewable generation to ensure that 33% of total procurement comes from renewable energy resources by 2020, one of the most ambitious renewable standards in the country. California is currently on track to meet

its interim requirements of 20% renewables by 2013 and of 25% renewables by 2016, and is well positioned to meet 33% by 2020.

Over 7,000 megawatts (MW, nameplate) of renewable generation capacity have been awarded a contract of 10 years or more with a California Investor Owned Utility and achieved commercial operation under the RPS program between 2003 and 2013.[307] More than 790 MW of renewable capacity came online in the first and second quarters of 2013, and another 2,385 MW of capacity is forecasted to reach commercial operation by the end of the year. The 3,175 MW of renewable generation capacity forecasted to come online in 2013 would represent the largest year-to-year increase in capacity since the beginning of the program.

- The California Solar Initiative (CSI) is overseen by the CPUC and provides incentives for solar system installations to customers of the state's three investor-owned utilities (IOUs): Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E). The CSI Program provides upfront incentives for solar systems installed on existing residential homes, as well as existing and new commercial, industrial, government, non-profit, and agricultural properties within the service territories of the IOUs.[308] In July 2013, the CPUC issued its annual report on the progress of the CSI, showing that the program has installed 66 percent of its total goal, with another 19 percent reserved in pending projects. This equals an estimated 1,629 megawatts (MW) of installed solar capacity at 167,878 customer sites in the investor-owned utility territories through the end of the first quarter of 2013, enough to power approximately 150,000 homes and avoid building three power plants.

  CSI highlights include:
  - A record 391 MW were installed statewide in 2012, a growth of 26 percent from 2011.
  - Pacific Gas and Electric Company achieved the most installations in the non-residential sector of any investor-owned utility, having met 70 percent of their non-residential installation goal.
  - Applicants to the low income portion of CSI, known as the Single-Family Affordable Solar Homes program, have received $64 million in support for their residential solar systems while the Multifamily Affordable Solar Housing (MASH) program has completed 287 projects representing a total capacity of 18.4 MW. There are an additional 83 MASH projects in process, for a total capacity of 11.3 MW. Virtual Net Metering[309] has allowed thousands of tenants to receive the direct benefits of solar as reductions in their monthly electric bills.
  - In just over three years of operation, the CSI-Thermal program has received 1,215 applications for $56.3 million in incentives.
  - All but 92 MW, or 6 percent, of solar capacity in the state is signed up for Net Energy Metering (NEM) tariffs. Pursuant to Assembly Bill 2514 (Bradford, 2012) and CPUC Decision 12-05-036, the CPUC has initiated a study on the costs and benefits of NEM to ratepayers.

- The CPUC's Self-Generation Incentive Program (SGIP)[310] - with 544 completed projects for a total capacity of 252 megawatts - is one of the longest-running and most successful distributed generation incentive programs in the country. In 2011 alone, these facilities provided over 760,000 MWh of electricity to the California, enough electricity to meet the needs of over 116,000 homes. The program continues to make strides towards a cleaner, distributed-energy future.

  The SGIP was initially conceived of as a peak-load reduction program in response to the energy crisis of 2001. Assembly Bill 970 (Ducheny, 2000) designed the Program as a complement to the California Energy Commissions' Emerging Renewables Program, which focused on smaller systems than the SGIP. Since 2001, the SGIP has evolved significantly. It no longer supports solar photovoltaic technologies, which were moved under the purview of the California Solar Initiative after its launch in 2006. It has also been modified to include energy storage technologies, to support larger projects, and to provide an additional 20% bonus for California-supplied products.

- Created the first Desert Renewable Energy Conservation Plan (DRECP).[311] The DRECP working group – consisting of the Energy Commission, California Department of Fish and Wildlife, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service – is developing guidelines to identify areas suitable for renewable energy projects and transmission corridors, while developing long-term natural resource conservation areas that protect fragile desert ecosystems. (See also Box 11: Innovative Land Use Planning to Balance Multiple Objectives in the Biodiversity and Habitat section of this document.)

- Implemented several programs and planning activities that support policies and incentives and that will help spur distributed generation and on-site renewable energy generation systems.
  - The Renewables Program in the Energy Commission's research program successfully implemented the Renewable Energy Secure Communities (RESCO) program[312], which is supporting community-scale renewable energy projects at three stages of development: exploratory, pilot, and implementation.
  - The Community Renewable Energy Deployment (CRED) program with a similar goal is a cost-share program with the Department of Energy under the American Recovery and Reinvestment Act of 2009.
  - Another program supports renewable-based decentralized advanced power generation and combined heat and power.
  - The Energy Commission released a follow-up research program for community-scale renewable energy development, deployment, and integration projects that demonstrate optimized community-specific renewable energy systems and develop tools and models to quantify impacts and benefits of increasing local renewable energy penetrations in California.

- Provided web-based tools on planning and permitting resources for renewable energy systems that will help streamline permitting of renewable energy projects. Also, the Energy Commission worked with other state agencies, stakeholders, and local governments to develop a model ordinance to help streamline permitting for distributed generation solar photovoltaic systems in California, which was adopted by the California County Planning Director Association in 2012.

- Published an Energy Commission staff report in April 2011 (*Developing Renewable Generation on State Property: Installing Renewable Energy on State Buildings and Other State-Owned Property*) to encourage expansion of such development. The report recommended a goal of 2,500 MW of renewable energy on state properties.

- Published the *Renewable Power in California: Status and Issues* report in 2011, which, along with the recent IEPR, recommended overarching strategies for achieving the Renewable Portfolio Standard requirement of 33 percent renewable energy by 2020, achieving the Governor's goal for 12,000 MW of localized renewable energy resources and increasing investment in renewable energy in California.

- The Energy Commission's research program has funded projects designed to develop tools for improved environmental (ecological) evaluations and for the identification of sites that would minimize environmental impacts in order to streamline renewable energy permitting. Some of the research data and siting tools are already in use and additional research is on-going or will start in the near future.

- Demand Response continues to grow with over 2,300 megawatts of available load reduction capacity created by state utility reliability and price-responsive programs.

- The Energy Commission, California Public Utilities Commission and California Independent System Operator have been collaborating on efforts to significantly increase the amount of DR available to offset the need for additional fossil generation. This collaboration has resulted in a number of targeted efforts to achieve this goal:

    - The Energy Commission, in the 2013 IEPR[313], builds on prior policy direction on DR that reduces peak load to focus near-term efforts that expand "fast-response" DR that can provide additional ramping and ancillary services capacity that will be needed as more renewable resources come online.
    - The CPUC released a new Demand Response OIR (R.13-09-011)[314] that is intended to review and rethink the current utility DR program designs and coordinate CPUC direction on procurement rules and program design with emerging system needs and CAISO market products as they are developed
    - The CAISO has released a "Roadmap" for expanding DR and EE participation and is has initiated a number of working groups to develop market products that are

more aligned with customer load reduction capabilities and emerging system needs.[315]

- In February 2013, CPUC released "A Review of Current Issues with Long-Term Resource Adequacy".[316]

- Under direction of the CPUC, SCE is developing and executing a resource plan and regulatory strategy to meet reliability needs in the Los Angeles basin resulting from the retirements of existing generators with once through cooling systems ("OTC") and the San Onofre Nuclear Generating Station ("SONGS"). The plan includes developing a framework for integrating preferred resources, such as Energy Efficiency, Demand Response, and Distributed Generation along with Energy Storage, transmission and conventional generation into local reliability planning. This effort to replace the lost generating capacity from SONGs with preferred resources is their "Living Pilot Program".[317]

  SCE's plan involves a collaborative effort with the California Public Utilities Commission ("CPUC"), Energy Commission, California Independent System Operator ("CAISO") and other stakeholders to develop and implement the "Living Pilot Program" to procure up to 400 MW of additional, competitively priced preferred resources, including demand response, to meet local reliability needs in the areas impacted by the retirement of the region's coastal plants. The pilot will include CAISO determined performance attributes to support reliability needs; metrics, measurement, and evaluation protocols to report the efficacy of the various preferred resources; and methods for applying lessons learned for future improvements.

- The California Public Utilities Commission (CPUC) has been implementing the provisions of Assembly Bill 2514 (AB 2514)[318] to continue momentum for energy storage by Adopting a 1,325 MW Energy Storage Procurement Target by 2020 which is approximately 2 percent of statewide peak demand. The Decision continues a number of legal, regulatory and policy efforts in California to encourage the development and growth of energy storage technologies and markets. In 2009, the CPUC added advanced energy storage projects to the technologies eligible for Self-Generation Incentive Program payments. AB 2514 also requires the state's publicly owned utilities to consider adoption of energy storage procurement targets. Gov. Brown's June 2010 Clean Energy Jobs Plan[319] called for adding approximately 3,000 MW of energy storage to the grid to meet peak demand and support renewable energy generation.

- Demonstrated the ability of microgrids to increase the penetration of renewables, improve energy efficiency and accelerate the integration of electric vehicles onto the grid. These features were demonstrated on actual microgrids located on the campus of the University of California San Diego[320], the Santa Rita Jail, and on the distribution networks of San Diego Gas and Electric and the Sacramento Municipal Utility District[321]. Microgrids also allow for continuous local operation during power outages.

Supporting Energy-Related Research

In the last decade, the Energy Commission research programs have been the state's premier energy RD&D programs. They have advanced science and technology in the fields of smart grid, energy efficiency, renewable sources of energy, distributed generation, energy storage technologies, pipeline safety, and climate vulnerability and adaptation for the energy sector. To accomplish this, the Energy Commission enlisted businesses, utilities, energy companies, public advocacy groups, and world-class scientists at California's universities and national laboratories. In the last 15 years the Energy Commission has invested more than $830 million to bring to market energy technologies that provide environmental and economic benefits to California's ratepayers. Even though primarily designed to improve efficiency, lower cost and reduce environmental impact of energy use, these innovations can also help reduce vulnerability of the energy sector to climate change by improving energy management, increasing efficiency, and developing and demonstrating a diverse suite of energy technologies as noted in the other energy adaptation sections. The following are among the many research highlights:

- Supported research on natural gas safety. For example, a research project is currently investigating the vulnerability of the natural gas infrastructure in the Delta to sea level rise.
- Participated in and helped fund a multi-state agency contract with the National Academies of Science to conduct a Sea Level Rise Assessment for the West Coast.[322] The study produced sea-level rise projections for California, Oregon, and Washington for 2030, 2050, and 2100. This study corroborated the results from prior Energy Commission studies on this topic.
- Assessed the impacts of climate change on the electricity system through a research project with Lawrence Berkeley National Laboratory for the 2012 California Climate Change Vulnerability and Adaptation Study[323]. This is the most comprehensive study conducted in the United States and suggests that the current electricity infrastructure is more vulnerable to climate change than previously believed but that a rapidly evolving electricity system offers an opportunity to substantially reduce its vulnerabilities.
- Identified the following key findings relevant to the energy sector in the 2012 California Climate Change Vulnerability and Adaptation Study:
    - Higher temperatures – Higher summer temperatures will notably increase the annual and peak household electricity consumption for air conditioning. Because inland areas will warm more, and are often home to less wealthy populations, energy use will grow most in the hottest areas where those who can least afford it reside. Power outages during extreme heat waves could put some groups (particularly elderly and small children) at greater risk when access to air conditioning fails. Increased temperatures would also reduce the efficiency of thermal power plants, substations, and transmission lines, leading to less available electricity for ratepayers.
    - Reduced snowpack – Hydropower contributes on average about 15 percent of the in-state generation in California and provides critical low-cost power in the hot months of the year during peak electricity demand. The snowpack in the Sierra Nevada has played a central role in hydropower generation because it acts as a

natural water reservoir with relatively predictable flow. Decreased snowpack would reduce hydropower generation, even with seasonal adjustments in dam operations.

- Sea level rise – About 20 coastal power plants and about eighty substations are at risk of at least partial flooding due to sea level rise. Petroleum refinery and storage facilities occur primarily in coastal areas subject to higher maximum high tides. Sea level rise combined with increased winter flows into the Sacramento/San Joaquin Delta will also increase the potential for levee failures, especially after 2050. There are substantial energy infrastructures – such as substantial underground natural gas storage facilities, gas pipelines and electrical transmission lines – in the Delta that could be affected.
- Extreme events (heat waves, wildfires, flooding) – The probability of exposure to wildfire on some transmission lines is expected to increase by as much as 40 percent as a result of warmer temperatures. Extreme heat and high electricity demand caused a local power line in Ohio to sag into trees, which helped trigger the massive 2003 blackout in the northeastern U.S. and Canada that affected 55 million people. Transformers are also more likely to fail in these conditions. Climate change in California is expected to increase the frequency and magnitude of extreme heat events and therefore the risk of blackouts.

The Water-Energy Nexus

Water delivery, treatment, and use constitutes one of the largest sources of energy demand; at the same time, energy generation consumes large amounts of water. Therefore, conservation and efficiencies in one resource can leverage great savings in the other. The Air Resources Board's (ARB) 2013 Scoping Plan includes recommendations for further reducing water-related greenhouse gas emissions.[324] Recommendations for enhanced water use efficiency are further discussed in the Water section of this document.

ACTIONS NEEDED FOR SUFFICIENT, RELIABLE AND SAFE ENERGY

The state will need to continue enhancing California's energy adaptation efforts and ensure that California has a sufficient, reliable, and safe energy infrastructure to meet current and future energy demand as well as the state's clean energy goals. In implementing any of the adaptation strategies, consideration will also be given to other socio-economic and environmental objectives, such as habitat protection, ecosystem services, environmental justice, public health, and economic feasibility. Further collaborative work that is needed includes the following:

Protect existing energy facilities and consumers from impacts of climate change

- Conduct vulnerability and adaptation studies for the energy sector in coordination with private entities managing energy resources with the goal of generating actionable research products; make research results available with a geographical context via Cal-Adapt.
- Support the energy component of local cross-sector adaptation efforts, such as expanding the CaLEAP (California Local Energy Assurance Planning) website.

- Promote use of sustainable woody biomass materials for power generation to reduce fire risks to transmission lines and hydropower watersheds consistent with the 2012 Bioenergy Action Plan.
- Install smart grid and microgrid technologies to better protect reliable operation of the grid during extreme climate-related events.
- Evaluate the cost effectiveness of potential measures to maintain the efficiency of thermal plants during heat waves or other extreme climate-related events.
- Evaluate hydropower adaptation options to accommodate reduced or increased runoff and storage and evaluate operational changes or investment options (e.g., more pumped storage) to maintain the value of California hydropower resources even with climate change.
- Continue development of the Integrated Forecast and Reservoir Management (INFORM) project in coordination with private entities and DWR to demonstrate its ability as a modern decision support system for management of major water reservoirs to both private entities and DWR.
- Investigate strategic use of high temperature, low sag conductors for transmission lines where climate change impacts make conventional conductors vulnerable.
- Explore the use of seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation for the forthcoming summer season (*Summer Electricity Supply and Demand Outlook* – a CEC annual publication).

<u>Diversify energy supply to reduce vulnerability to extreme weather-related events and climate change</u>

- Diversify the energy supply portfolio as needed by: (1) enhancing the local utility distribution grids with smart grid features and expanding distributed generation; (2) exploring and developing energy storage technology applications; (3) evaluating state properties and buildings (and other government properties) for distributed and centralized power generation options; (4) encouraging in-state and out-of-state transmission system expansion and upgrades to reduce vulnerability to extreme events and long-term changes; and (5) expanding transmission access to renewable resource areas in preferred geographic locations consistent with the Renewable Action Plan developed as part of the 2012 IEPR Update proceeding.
- Explore post-2020 greenhouse gas emissions targets for the energy sector (including transportation, electricity generation, and the rest of the energy system) that are compatible with the 2050 goal of reducing GHG emissions by 80 percent from 1990 levels.
- Improve our understanding of the environmental and public health implications of potential energy scenarios for California to avoid unintended consequences, such as negative impacts to wildlife, habitats, air quality, and water quality.
- Adopt environmentally benign and cost-effective options to maintain the efficiency of thermal power plants during heat waves. Improve environmentally acceptable and cost

effective approaches for dealing with the efficiency of thermal power plants on extreme hot days.
- Improve our understanding of how climate change impacts the estimation of energy demand and assessments of energy supply (e.g., availability of hydropower in the summer).

Promote energy demand side measures that facilitate climate adaptation

- Investigate all available measures that will allow the delivery of high quality energy services at the lowest costs and with the minimum amount of energy feasible, such as deep energy efficiency retrofit programs with an integrated regulatory paradigm across water, electricity, and natural gas, green buildings, cool roofs, cool pavement, cool vehicles, urban greening, demand-side management and automated demand response, smart grid, permanent load shifting (from peak to off-peak), energy conserving land use practices, and zero net energy homes.
- Promote the expanded use of smart energy meter data to provide residential and commercial customers better access to their energy use profiles and allow them to take advantage of improved energy management systems that promote higher energy efficiency and better overall energy management. Suitable protections and policies should be put in place to protect vulnerable and low-income households from cost impacts, including time-of-use pricing, in order to ensure, among other things, access to air conditioning for heat emergencies.
- Broaden the use of automated demand response capabilities and systems to make it easier for future residential, commercial, and industrial end users to participate in demand response programs and tariffs.
- Retrofit existing buildings through the Energy Commission's AB 758 program.
- Implement Executive Order B-18-12 that directs state agencies to take immediate steps to green the state's buildings, reduce greenhouse gas emissions, and improve energy efficiency.
- Explore the feasibility of considering climate change in cost-benefit analyses of energy efficiency standards for buildings (Title 24) and appliances (Title 20), such as increased ambient temperatures in the 16 climatic zones used to set building standards rather than the current practice of using historical climate data.

Enhance energy-related climate change research

- Coordinate climate change research with all the state agencies supporting or using climate change science via the Climate Action Team (CAT) Research Working Group.[325] The Energy Commission will continue to provide leadership to the CAT Research Working Group. This group will also assist with the coordination of research activities with federal agencies.
- Continue to support and enhance the State Climate Change Research Catalog, which will provide basic information about past and current climate change research projects that have been or are supported by the State.

- Specify energy-related research in the California Climate Research Plan (the Research Plan) being developed by the CAT Research Working Group. This plan will represent a unifying vision on how the different state agencies intend to support climate research, forming a well-coordinated and integrated overall research program for California. Likely energy-related topics will be to:
    - Continue climate monitoring, analysis, and modeling for development of down-scaled climate change scenarios for California to support improved vulnerability assessments for energy and other sectors, better energy forecasts, and adaptation planning by local governments and private entities.
    - Improve vulnerability assessment methods for existing energy infrastructure and update assessments to inform more targeted adaptation options in the short- and medium-term based on the revised climate change scenarios.
    - Continue development and testing of supply and demand forecasting methods, such as seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation and new hydroelectric supply forecasting methods.
    - Continue the legacy of research, development, and demonstration for successful adaptation that also reduce GHG emissions, strengthen the green economy and maintain California's leadership in energy technology innovation, including transportation. Examples include energy storage, renewable energy efficiency, microgrid resilience, and efficiency improvements for buildings and vehicles, and low carbon transportation fuels. The discussion in the Research Plan will be fully compatible with efforts in this area in the Energy Commission and the CPUC via the Electric Program Investment Charge (EPIC) and research supported by the Air Resources Board and others on this topic. The strength of the Research Plan will be in its capability to show how the different programs support each other.
    - Identify and find solutions to regulatory, legal, institutional, and socio-economic barriers that can hamper the implementation of promising adaptation measures.

Box 34

California Energy

Several state entities play an important role with respect to energy in California. The state also has important federal, local and private sector partners with respect to energy.

- California Energy Commission (CEC) is the state's primary energy policy and planning agency. CEC is primarily responsible for forecasting energy needs, promoting energy efficiency, supporting public interest energy research, developing renewable energy resources, licensing thermal power plants larger than 50 megawatts, and planning for and directing state response to energy emergencies.
- California Public Utilities Commission (CPUC) regulates privately owned electric and natural gas companies. The CPUC serves the public interest by protecting consumers and ensuring the provision of safe and reliable utility service at reasonable rates.

- California Independent System Operator Corporation (CAISO) is a nonprofit public benefit corporation that manages the flow of electricity across the high-voltage, long-distance power lines that make up 80 percent of California's power grid.
- California Department of Conservation (DOC) regulates the operation of oil and natural gas wells and geothermal resources in California mainly through its Division of Oil, Gas and Geothermal Resources.
- Office of the State Fire Marshal (SFM) regulates the safety of approximately 5,500 miles of intrastate hazardous liquid transportation pipelines and acts as an agent of the federal Office of Pipeline Safety with respect to the inspection of more than 2,000 miles of interstate pipelines. This office also has operational oversight regarding restoration of petroleum product pipeline service following temporary closures associated with pipeline failures or leaks.
- California State Lands Commission (SLC) develops and oversees compliance with Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS). These standards apply to all existing and new marine oil terminals in California, and include criteria for inspection, structural analysis and design, mooring and berthing, geotechnical considerations, and fire, piping, mechanical, and electrical systems. The purpose of these standards is to increase the integrity of existing facilities to better withstand earthquakes and tsunamis, thus reducing the risk of petroleum spills and temporary loss of the ability to receive and export transportation fuels at marine terminals.

California has an number of important federal partners, including:

- Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas (LNG) terminals and interstate natural gas pipelines. FERC also licenses hydropower projects.
- Nuclear Regulatory Commission (NRC) formulates policies and develops regulations governing nuclear reactor and nuclear material safety and security.
- U.S. Department of Energy (DOE) is responsible for establishing national energy policies and for the safe handling of nuclear materials. DOE is one of the major sponsors of energy research and conducts research through multiple national laboratories.

FORESTRY

INTRODUCTION

Forests can help absorb carbon dioxide and counteract the emissions that cause climate change, but, as further described below, California forests are also in need of protective actions to prepare them to withstand mounting climate threats such as increasing temperatures, drought, increasing risk of pest infestations, and increasing risk of severe wildfires. Studies are currently underway to investigate fire and frequency trends. Furthermore, forests can provide many other benefits, besides absorbing carbon dioxide, which will assist with climate problems. For instance, trees and forests help anchor soil and absorb rain and snowmelt, so flooding and landslides are less severe. Forests also help regulate the timing and magnitude of water runoff and water flows; and they have very significant impacts on water quality, because they provide a filtering function that prevents impurities from entering streams, lakes, and groundwater. *(See* Box 35 *"Ecosystem Services" – Smart Land Use to Save Money and Create More Sustainable Communities)* In addition, forests provide critical habitat for wildlife and fish that will be increasingly stressed by climate impacts (see Biodiversity and Habitat chapter). Sustainably managed forests may also provide forest products like lumber that provide long-term carbon storage, as well as woody material or 'biomass' for energy production. Trees in urban environments, or 'urban forests', capture and store carbon dioxide and are capable of providing significant shading and other cooling benefits that can reduce urban temperatures and energy needs. Urban forests can also help filter air pollutants and can help absorb rainfall that would otherwise run over streets and wash pollutants into nearby waterways that are already under increasing stress from climate threats.

California forests are managed by a number of different entities including federal, state, local and private land owners. In many cases, forest management activities are regulated by a variety of federal, state, and local agencies. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. For more information, see Box 43Box 43 labeled "California Forestry" at the end of this chapter. Management of wildfire risk and post-wildfire recovery are further discussed in the Emergency Management section of this document.

Box 35

"Ecosystem Services" – Smart Land Use to Save Money and Create More Sustainable Communities

There is a growing trend in the United States for cities to invest in improving the management of rural watersheds where drinking water supplies for those cities originate. This trend not only offers significant cost savings over other approaches (i.e. building and operating urban water treatment plants), but can also offer other environmental benefits (such as habitat restoration and flood protection) and economic benefits (such as providing

materials to support bioenergy production). These programs serve as an important way to identify the value that rural ecosystems provide for urban areas and to direct payment for those services (so called "ecosystem services") to rural landscapes, in a mutually beneficial exchange that promotes a more sustainable future for both rural and urban communities. Following are examples of communities or organizations that have successfully developed and implemented ecosystem services approaches or are actively engage in development of approaches to valuing ecosystem services.

The City of New York signed an agreement in 1997 that included rural communities in the Catskill/ Delaware watersheds.[326] The Catskill/Delaware watershed covers 1,600 square miles and provides about 90% of New York's water supply.[327] New York City chose to implement a comprehensive watershed protection program to preserve and restore natural filtration services as a more cost effective means of maintaining water quality than building a filtration facility estimated to cost $8-10 billion to construct and $1 million per day to operate and maintain.[328] Enhancements to natural watershed filtration were combined with other measures such as upgrades to wastewater treatment systems.[329] After five years, 93% of Catskill farmers were participating in the program, utilizing more environmentally friendly farming techniques and reducing farming-related water pollution, and the significant cost savings played a critical role in helping to stabilize water and sewer tariffs, providing major benefits to low-income, urban households.[330]

Similarly, the Denver Water utility, which provides water for the 1.3 million people in the Denver, Colorado metropolitan area, is taking an active role in collaborating in watershed protection efforts. Denver Water's key collection and delivery infrastructure receives water from snowpack and streams on U.S. Forest Service lands, and is highly dependent on healthy forests and watersheds. A partnership has been established between Denver Water and the Rocky Mountain Region of the U.S. Forest Service, Department of Agriculture, to support mutual efforts to improve forest and watershed conditions. Denver Water plans to match the U.S. Forest Service's $16.5 million investment, totaling $33 million, toward forest treatment and watershed protection projects over a five-year period in priority watersheds critical to Denver Water's water supply. Forest treatment and watershed protection activities can help minimize sedimentation impacts on reservoirs and other water infrastructure by reducing soil erosion and the risk of wildfires, thereby protecting water supplies and water quality. This work will also provide other public benefits such as wildlife habitat and recreation opportunities. Colorado and Wyoming contain headwaters for rivers that supply water to 13 Western states, including California.[331]

The San Francisco Public Utilities Commission (SFPUC) also has a 10-year, $50 million Watershed and Environmental Improvement Program. SFPUC is a department of the City and County of San Francisco that provides retail drinking water and wastewater services to San Francisco and wholesale water to three Bay Area counties. The Program includes the Peninsula, Alameda, and Upper Tuolumne Watersheds, and manages watershed activities and resources to protect source water quality and protect and restore terrestrial and aquatic species and their habitats. The Program is funded in part by Water System Improvement

Program Measure A bond funds and in part by operating funds.

Climate Change Impacts and California Forests

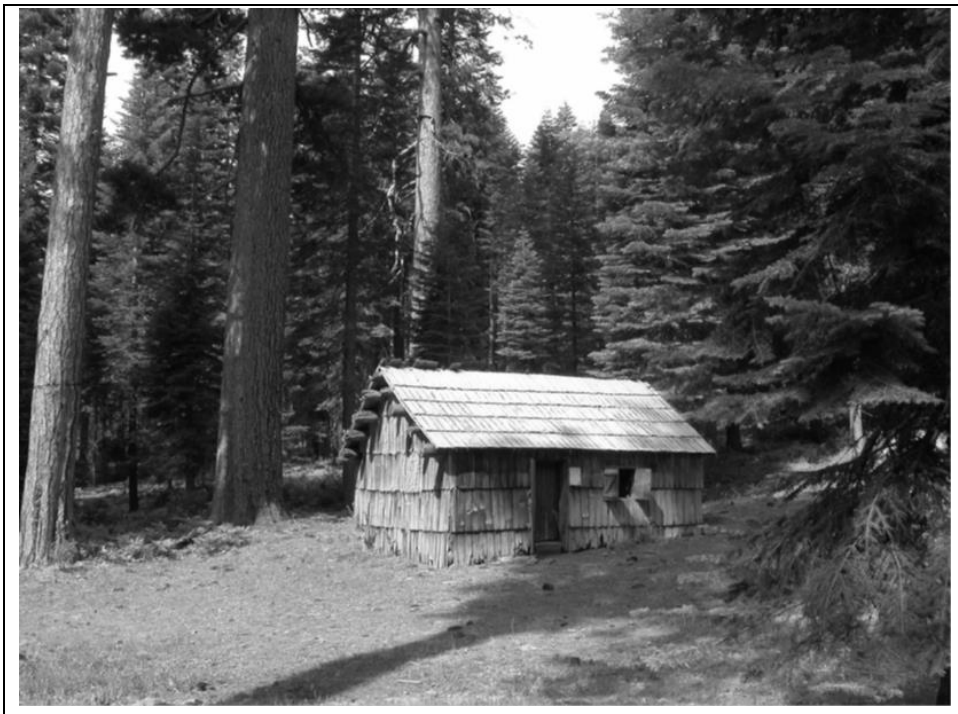
Climate change threatens California forests with more frequent and severe wildfires, pests, disease, increased temperatures, and changing precipitation and water availability. As described below, these threats may decrease forest growth, cause geographic shifts in tree distribution and forest types, and result in forest loss and tree mortality. These threats also overlay traditional pressures for the conversion of forested lands to alternate land uses and fragmentation. In addition, fire suppression activities and lack of fuels management have left California forests in a particularly vulnerable and weakened state *(See* Box 36 *"Forest Science: Evolving Understanding of Fire and Forest Landscapes").* Forest losses due to climate change not only threaten carbon storage and emissions from forests but also threaten water resources, energy transmission (as further discussed in the Energy section of this document), the survival of fish and wildlife, and human health -- such losses will also negatively impact tourism, recreation opportunities, and the timber industry. Efforts to improve forest health not only make forests more capable of withstanding climate impacts (and avoids the negative impacts associated with forest losses), but those efforts will also increase the long-term carbon storage capacity of forests and aid in fighting climate change.

Box 36

Forest Science: Evolving Understanding of Fire and Forest Landscapes

California's forested landscapes evolved with fire over thousands of years. This pre-European, forested landscape was created by the full range of fire regimes from low-intensity/severity, slow-spreading wildfires to high intensity/severity, fast spreading fires and a mixture of both extremes. Plant and animal species in the forest evolved with fire, and many of these plant and animal species depend on wildfires to reproduce and grow. For instance, low-intensity, slow-spreading wildfires can help keep tree density at optimal levels for tree growth and productivity, fire can help return nutrients from plant matter back to soil, the heat from fire is necessary to the germination of certain types of seeds, and remnants left behind by fires can create habitat conditions that are beneficial to wildlife. The ecological function of fire in naturally fire-dependent or fire-adapted landscapes was poorly understood for much of the 20th century. Vigorous fire suppression programs were implemented with the belief that such programs would protect property, human life, and forests. Fire suppression programs, combined with a lack of active forest management activities to reduce vegetation, contributed to a situation in which high frequency fire regime forests became unnaturally dense, often with many, smaller trees crowded between older, larger trees (Collins et al 2011).





Bear Creek Guard Station, Plumas National Forest, top photograph taken in 1915 (showing surrounding forest prior to fire suppression) and bottom photograph taken 2002 (showing surrounding forest after years of fire suppression).

Source: USDA Forest Service

Overcrowded or 'overstocked' forests are susceptible to a number of threats. First, an overcrowded forest contains far more flammable material, with little spacing between trees; fires that do start in these conditions tend to be higher-intensity, fast-moving, harder to contain, and generally more catastrophic to both plant and animals species and to human communities.



Source: National Interagency Fire Center (showing forested landscape after catastrophic fire)

Secondly, trees in overcrowded forests compete for scare water, soil nutrients and sunlight. Overall tree health and resilience may decline, and overcrowded forests are additionally more vulnerable to the spread of tree diseases and tree pests (Oliver and Larson 1990).

Climate change in California presents new threats to forests with longer, hotter summers, changing water availability, the spread of invasive species, and more tree mortality due to the spread of pests that were previously kept in check by colder, longer winters. These climate changes will likely contribute toward a longer, more challenging fire season in California and this will present escalating danger to homes and people located near forest wildland areas, particularly in the vicinity of forests that may be overcrowded due to past fire suppression practices and lack of management activities.

There are a variety of techniques for returning overcrowded forests to a healthier, more natural state. Prescribed burning is one method. In prescribed burning, a fire is planned, ignited and managed by professional fire managers. Prescribed fire is only undertaken with appropriate conditions, such as appropriate weather conditions. Steps can be taken to minimize smoke impacts from prescribed fires on nearby communities. Other techniques for addressing overcrowded forests include measures to reduce density by 'thinning' the forest (typically by removing brush and smaller trees), either using mechanical means or by hand. Sometimes, it may be appropriate for overcrowding to be addressed using a combination of management techniques. Treatments may need to be repeated periodically to maintain desired conditions. Reducing overcrowding in forests is sometimes referred to as 'fuel reduction' because plant materials that fuel catastrophic wildfires are being removed.

As noted below, California forests are located on a mix of federal, state, and private lands. Any successful fuel reduction program in the state will be heavily dependent on coordinated action among federal, state and private forest land owners. Fires do not respect political or legal boundaries, and any overstocked lands will present a threat to any adjacent forested lands and any nearby structures. Overcrowded stands are found on the lands of all forest ownership classes. There is a good track record of using multi-agency and private landowner collaborative planning processes to identify strategic opportunities to reduce fuels and maximize fire hazard reduction benefits. While public agencies for the most part have adequate authorities to conduct fuels reduction projects, funding is a significant barrier for both initial treatments and follow-up maintenance treatments. Sustainable biomass energy programs that utilize materials from forest thinning may be part of the solution for redressing overcrowding caused by past forest fire suppression programs.

The role of forests in California climate solutions and the need to protect forest resources from climate threats has been recognized in the 2006 Scoping Plan and the 2009 Climate Adaptation Strategy. As described below, some progress has been made with respect to preparing for climate risks to California forests, but a more comprehensive forest climate strategy and the resources to implement such a strategy are needed in order to fully prepare for the myriad threats posed by forest and tree loss due to climate change.

Ownership of California Forestlands: California has 33,387,000 acres of forestland, which cover about 32% of the State. Predominantly held by the federal government (over 57%), these forest resources are located on state, federal, and private lands (Box 37). This distribution of land owners means that coordination between the state, private land owners, and federal agencies will be important to the success of any comprehensive forest climate strategy in California.

Box 37

California forestland ownership.

Ownership Category	Acres of Forestland	Percentage
Private	13,131,000	39.3 %
Federal	19,171,000	57.4 %
State	711,000	2.1 %
Local	374,000	1.1 %
Total	**33,387,000**	**100 %**

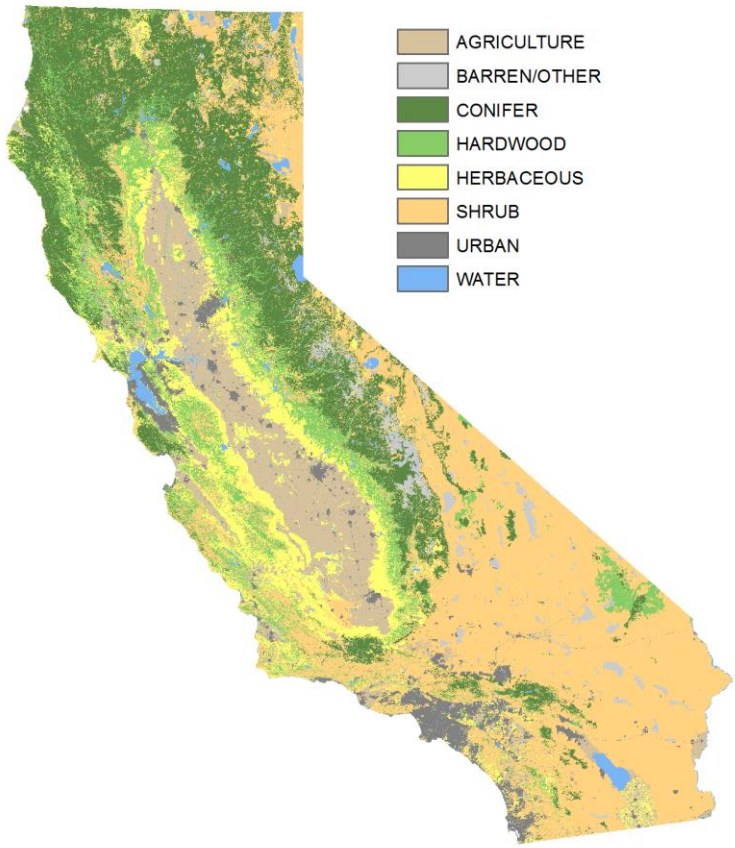
California Department of Forestry and Fire Protection 2010.

Box 38

National Forest Watersheds: The 20 million acres of National Forests in California play a crucial role in providing California's water. These lands, while comprising about 20 percent of the area of the state, provide almost half of the State's surface water supply, owing to their location in mountainous headwaters.[332] Stewardship of these lands to protect water quality and quantity will become increasingly important as California's water supply comes under stress from climate impacts including loss of snow pack, changing precipitation patterns, increased temperature and drought. For more information on climate impacts to California's water, please see the Water section of this document.

California Tree Types and Geographic Distribution: California is also home to a wide variety of tree species including, but not limited to, many types of conifers (e.g. Douglas-fir, ponderosa pine, sugar pine, incense-cedar, redwood, giant sequoia, etc.) and also many types of oaks (e.g. blue oak, coast live oak, etc.) (Box 39) Not all California tree species will be equally affected by climate change. For instance, in the Sierra Nevada, scientist predict that tree growth may decrease by as much as 19% by 2100 - but white fir, cedar and Douglas-fir are expected to decline the most, with smaller reductions in growth rates for ponderosa pine and sugar pine.[333]

Box 39

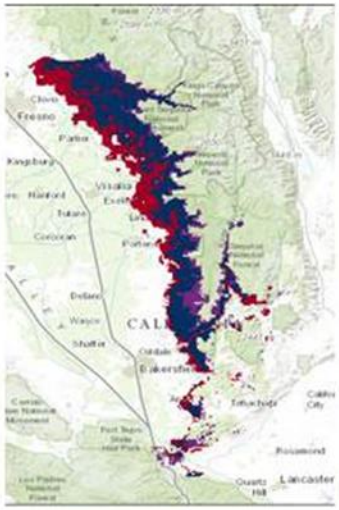


Distribution of California conifer and hardwood forest and other vegetation types

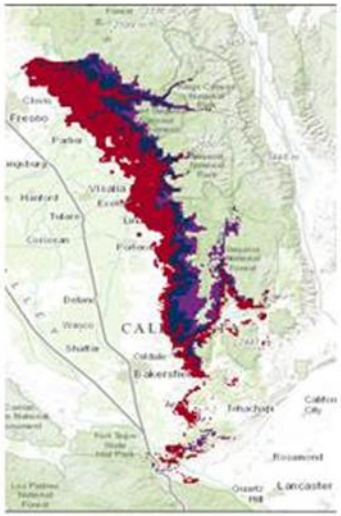
As average temperatures and precipitation patterns change, the climatic conditions suitable for different types of tree species in any given region will also change - and this will lead to geographic shifts in tree distribution and forest types. In general, geographic shifts will tend to be northward and toward higher elevations as average temperatures rise, although the Southern Sierra may be a particularly significant area of refuge due to the higher elevations found there (for more information on the importance of refugia in the era of climate change – please see the Biodiversity and Habitat section of this document). High elevation tree species that are dependent on historical temperature ranges at those elevations will be particularly

vulnerable to species loss and extinction. Although estimates of the magnitude and direction of geographic shifts continue to be refined and improved over time, some modeling of these types of trends and predictions has been done for certain species. [See Box 43: Southern Sierra - Blue Oak Climate Scenarios courtesy of The Nature Conservancy] Some California timber companies are already preparing for these types of impacts in their long range planning efforts. [See Box 41: Mendocino Redwood Company and Humboldt Redwood Company - Climate Change and Forest Management Considerations in the Redwood Region.]

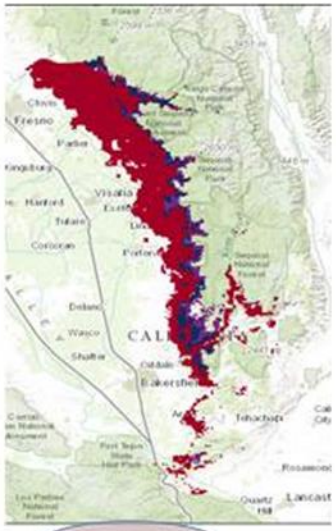
Southern Sierra Nevadas – Blue Oak Climate Scenarios



Warm Dry



Hot Dry



Hot Wet

The top three maps show blue oaks under possible 'hot-wet', 'warm-dry', and 'hot-dry' climate scenarios. Red areas indicate potential future climate stress. Blue areas indicate potential stable climate zones (i.e. refugia). Purple areas indicate expansion of potentially new suitable climates.



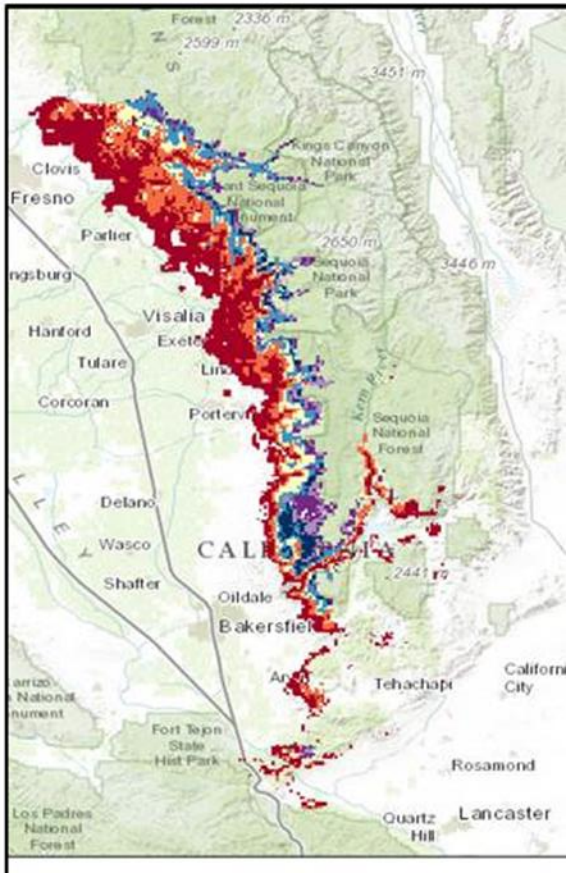
Color saturation indicates level of agreement between 11 Global Circulation Models (A2).

The larger map on right is an ensemble forecast, which considers the potential responses of blue oaks to a wide range of climate futures simultaneously (2045-2065).

These forecasts suggest that blue oaks in the southern Sierra may be climate stressed in the lower elevations; however large tracts of potential climate refugia are also identified at mid elevation. Additional work is needed to better understand potential management that may facilitate adaptation to changing climates.

Credit: Jason MacKenzie, The Nature Conservancy

Ensemble



Box 40

Box 41

Mendocino Redwood Company
Humboldt Redwood Company

Climate Change and Forest Management Considerations in the Redwood Region
By Mike Jani – Chief Forester and President of Mendocino Redwood Company

Foresters, by nature and training typically think and plan in terms of decades and generations, as trees take a much longer time to grow than traditional row crops. This is further enhanced in the redwood region of California, where we are dealing with a tree species that can live thousands of years and has the capacity to regenerate itself, once cut or burned, by resprouting, and regrowing its genetic duplicate. Planning for climate change manifests around a few central themes. Even with all the uncertainties over the exact regional effects of climate change, a number of immediate responses to these themes appear to be prudent. These responses may, in time, prove to be beneficial both ecologically and in terms of long-term economic stability for our region.

Fire

Projections for the eastern portions of our ownership indicate hotter, drier summer weather patterns and increasing winds leading to higher fire risk. We are taking the following measures to mitigate for this:

-Over the entire property, we are growing significantly more than we harvest. This leads to larger diameter trees over time. Larger trees are far more fire resilient, especially redwoods.

-In our tree improvement program, we are selecting for trees that appear to have drought tolerance.

-Pre-commercial and commercial thinning to optimize spacing of our trees. This leads to increased growth (see point above), but also keeps forest canopy below a density where it can support catastrophic crown fire. Also, research being done in the region suggests that the projected increase in carbon in the atmosphere has added to the growth of large, old redwood trees, perhaps even resulting in a doubling of their growth over the last 50 years.

-Treatment of hardwood species in understory to break up dangerous ladder fuels and restore organic layer in soil mantle (water holding capacity).

-Construction and maintenance of shaded fuel breaks from which to be able to fight and stop fires.

-Maintenance of road network in passable condition for firefighting equipment.

Unpredictable weather patterns

Highly variable weather fluctuations caused by climate change lead to unpredictable rainfall patterns and intensities (which might include both more extended dry periods and more severe storms). We do the following to offset these impacts:

-Increase the miles of road surfacing with rock to reduce sediment generation and water quality degradation.

-Road upgrades: increasing stream crossing openings to be able to handle higher peak winter flows.

- Out-sloping roads to quickly move water off road surfaces.

Changing in-stream conditions

Drier weather projections may lead to lower stream flows and higher stream temperatures leading to degradation of water quality for fish. We have implemented the following:

-Maintaining very high tree canopy adjacent to flowing streams to maintain low stream water temperatures.

-Drill and utilize wells to reduce the need for drafting water out of streams for road watering and construction.

-Construct off-stream water tanks for storage to reduce need for drafting from fish-bearing streams.

Forest Carbon Storage

The largest portion of commercial redwood forests in California are Forest Stewardship Council certified and are growing significantly more than is being harvested. Add to that all the redwood forestland that has been put into parks and preserves, including thousands of acres of old-growth forest, and you have a tremendous carbon sink, providing that we can protect it, and manage it in such a way that it does not burn up in a catastrophic forest fire. Our forests at the Humboldt Redwood Company and the Mendocino Redwood Company are already storing over one million tons of forest carbon each year. What's more, wood products from harvested trees can continue to store carbon for decades to come (and many redwood forest products and by-products are particularly long-lived).

Climate change is not to be ignored. In the redwood region, decisions and actions that we undertake today, will have significant impacts over many decades to come. Our business view is to manage the impacts of climate change in a positive fashion, including storing more carbon annually for years to come. Just as managing a commercial forest for ecological health is good business, so too is planning for the effects of climate change for the future.

Mendocino Redwood Company, LLC (MRC®) and Humboldt Redwood Company, LLC (HRC™) collectively manage 440,000 acres of redwood and Douglas-fir forestlands along the north coast

of California. From the beginning, MRC and HRC's stated purpose has been to demonstrate it is possible to manage productive forestlands with a high standard of environmental stewardship, and also operate as a successful business. The company names were chosen to reflect the nature of the business and to pay homage to the important role of the local community associated with a timber business. MRC and HRC protect old growth trees in their forest, harvest through selective logging whenever feasible, and are managing for the unknown but expected future effects of climate change.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

Following the adoption of the 2008 Scoping Plan, an Interagency Forest Working Group was established (the "IFWG") to help provide technical assistance and recommendations for achieving the forest sector goals discussed in the 2008 Scoping Plan. The IFWG has included the following participating agencies: the California Board of Forestry and Fire Protection, the California Department of Forest and Fire Protection ("CAL FIRE"), the California Department of Fish and Wildlife, the California Department of Water Resources, the Sierra Nevada Conservancy, the California Energy Commission, the California Natural Resources Agency, the California Air Resources Board, the California Environmental Protection Agency, and the U.S. Forest Service.

Forest Carbon Inventory

The California Air Resources Board maintains a forest sector greenhouse gas emission inventory as part of its responsibility to prepare and maintain a statewide inventory of greenhouse gas emissions. The forest sector inventory tracks the net carbon balance from the forest sector in California. The inventory includes both the absorption of carbon dioxide by California forests and rangelands, and the release, or emission, of carbon dioxide and other GHGs associated with fires, harvesting materials from forests, the conversion/development of forested land for other land uses, and the decay and decomposition of woody materials.

A 2004 California Energy Commission study helped provide the first forest sector carbon balance data. That study focused on the period from 1994 to 2000 and was geographically limited to the northern part of the state, with statewide estimates extrapolated from the available data. Since 2004, there has been one update to the forest inventory. That update was issued in 2011 and included data gathered from 2000-2009.

In 2011, ARB contracted with researchers from University of California (UC) Berkeley to develop a new data-driven methodology for assessing carbon stock changes for all land in California except agricultural and urban areas. The new methods use California specific land based data sets and satellite remote sensing data. The covered ecosystems include forests, woodlands, shrub lands, grasslands, and wetlands. Data sources for the new method include Forest Inventory and Analysis (FIA) ground-based data (vegetation type, tree species and dimensions, percent canopy cover, etc.) from the USDA-Forest Service, remote sensing products from

NASA's MODIS sensor, geospatial vegetation data (vegetation community type, canopy height, percent canopy cover) from the federal Landscape Fire and Resource Management Planning Tools Project (Landfire), geospatial fire and harvest occurrence data from CalFIRE, and ancillary data on shrub lands and grasslands.[334]

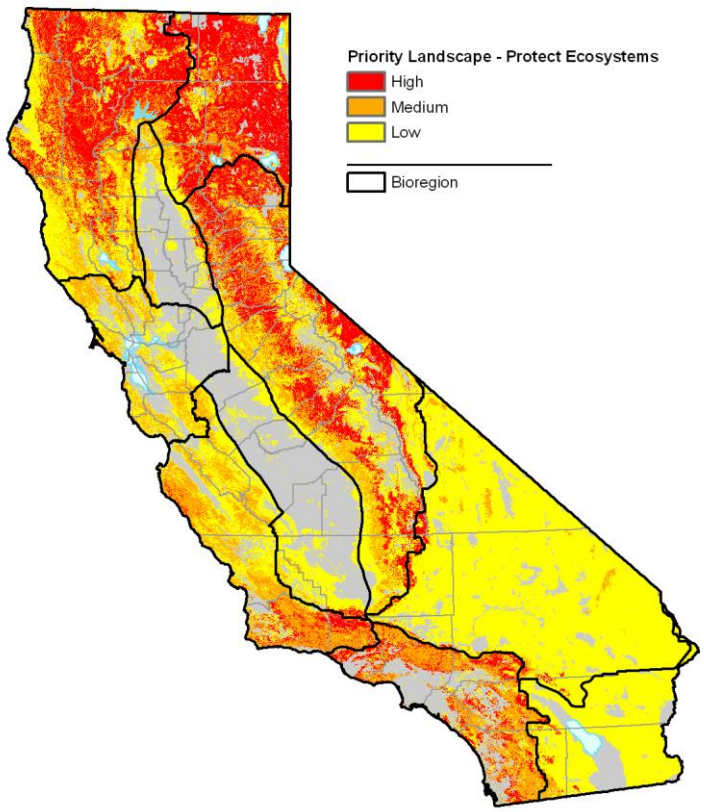
The new data-driven method enables analysts to retrospectively assess ecosystem carbon stock changes resulting from fire, human activities, and other processes. It will enable monitoring of changes on the land over time and periodic quantification of the GHG flux associated with changes in ecosystem carbon stocks. The research has generated a wealth of new data to support a planned update to the GHG inventory.

Additional work is needed to evaluate the data provided by the UC Berkeley research, to incorporate additional new data, and to identify further research needed to expand use of these tools. The sources and methods for quantifying ecosystem carbon and GHG flux in this sector are complex. Continued refinements will advance carbon quantification, attribution of GHG flux by disturbance process, and reduce uncertainty.

<u>Broader Forest and Rangeland Resource Assessments – including vulnerability assessments</u>
The California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP) produces periodic assessments of the state's forest and rangeland resources, on both private and publically managed lands. Like prior assessments, the 2010 Forest and Rangeland Resources Assessment[335] included extensive information regarding fire threats, socio-economic conditions, working lands, threats from pests and disease, and water quality and quantity protection and enhancement. However, for the first time, the 2010 Assessment included a dedicated chapter on climate change threats and opportunities, as well as a chapter on the role of urban forests and trees in energy conservation and air quality.

Through the FRAP forest and rangeland assessment process, the Department of Forestry and Fire Protection has identified priority landscapes where high value carbon stocks and forest ecosystems are at risk (see Box 42). The results of the assessment suggest that California forests will continue to grow and provide net carbon storage through mid-century. In the later decades of this century, climate models are less certain, but model predictions suggest dramatic warming will add additional stress on California forests. Absent changes in management, the National Forests in California could become a net emitter of carbon dioxide in the second half of the century as a result of expected increases in wildfire, diseases, and other disturbances.[336] Carbon emissions from wildfires, insects and diseases are expected to be much greater than carbon loss due to the conversion of forested lands to other land uses.

Box 42



Priority landscape for preventing wildfire threats to maintain ecosystem health (California Department of Forestry and Fire Protection 2010)

Healthy forests, that are most resilient against the spread of pests, tree diseases, and catastrophic fires, have an optimal tree density. Wildfires serve a function in high frequency fire regime forest ecosystems to maintain such optimal tree density. However, in the past, the function of wildfires in a natural fire regime was poorly understood, and wildfires were "suppressed" or put out. This has led to many high frequency fire regime forests in the American West being "overcrowded" or filled with trees beyond the optimal forest density. As a result of trees being crowded together, pests and diseases are able to spread more rapidly. In addition, when wildfires do start and burn in overstocked forests, the fires consume much more woody material ("fuels") and the fires are larger and more severe. Thinning overstocked forests and using prescribed fire can help restore the forests to a more natural fire regime and healthy state. Forest resilience is especially important in the face of expected climate impacts such as increased temperatures, drought, and spreading pests and tree diseases

Analysis by CAL FIRE of Forest Inventory and Analysis ("FIA") plot data collected by the U.S. Forest Service indicates that there may be as many as 1.2 million acres of forested land in

California that would benefit from thinning. In addition, FIA data indicates that there may be as many as 3.1 million acres of timberland in California on which replanting or "reforestation" could occur in order to boost forest sector productivity and carbon storage.

CEQA Guidelines on Climate Change & Timber Harvest

In 2007, Senate Bill 97 ("SB 97") was enacted to require the development of CEQA Guidelines to address the analysis and mitigation of greenhouse gas emissions. The CEQA Guideline amendments adopted pursuant to SB 97 required that CEQA lead agencies make a good-faith effort, based on available information, to estimate the greenhouse gas emissions resulting from a project. The lead agency has discretion to select a model or methodology for calculating such emissions, provided it supports its decision with substantial evidence and explains the limitations of the model or methodology. To this end, CAL FIRE developed a Greenhouse Emissions Calculator which is available online for those preparing timber harvest plans. The Calculator is designed to assess short-term and long-term emissions from a single project, and it can also be used to estimate greenhouse gas emissions associated with a series of harvests under a management plan.[337]

2010 Strategic Fire Plan for California

The 2010 Strategic Fire Plan was the first fire plan ever released for public review and comment during development; the plan benefited from excellent stakeholder input. The Plan recognizes the threat climate change presents for more frequent and severe wildfires, and presents a vision for a natural environment that is more resilient and man-made assets that are more resistant to the effects of wildland fire through local, state, federal and private partnerships.[338]

2012 Bioenergy Action Plan and Sustainable Forest Biomass Utilization Guidelines

The 2012 update to the Bioenergy Action Plan included the goals of increasing environmentally and economically sustainable energy production from biomass residues, including but not limited to forest-derived wood waste, while also reducing the risks and impacts of wildfires in forested regions.

Within the framework of the IFWG, the California Energy Commission has been soliciting stakeholder input and funding research to help define scientifically-based guidelines for achieving sustainable forest landscapes when woody materials from forests or "forest biomass" is utilized for energy or fuel production.

State Tree Nursery Program

The purpose of the State Nursery Program is to provide an adequate, reliable supply of seed and seedlings to safeguard the genetic variety of California tree species, provide insurance against poor seed crop years, and assist in the restoration of native trees lost to wildfire, insects, disease, and other climate impacts. Unfortunately, at a time when climate impacts on California forests are accelerating, and more tree loss and extinction is threatened, capacity in the State Nursery Program has been dwindling. The Magalia Reforestation Center in Butte County closed in June 2011 and nursery services have been suspended, although seed processing and storage continues at the L.A. Moran Reforestation Center located in Yolo

County in Davis, California. The L.A. Moran Reforestation Center stores more than $4 million worth of seed owned by the State of California and by private companies. CAL FIRE staff at the L.A. Moran Reforestation Center continues to provide seed for reforestation purposes and technical assistance to government agencies and private landowners on cone and seed matters and seed collection activities. CAL FIRE is also working with federal and local partners, such as the USDA Natural Resources Conservation Service, the U.S. Forest Service, and the Placer County Resource Conservation District, as well as private reforestation nurseries, to increase the availability of appropriate reforestation stock.

Forest Management and Fire Hazard Reduction Assistance

CAL FIRE works to foster health and sustainability of private forestlands through its forestry management assistance and fire hazard reduction (so called "fuel treatment") programs. Through these programs, such as the California Forest Improvement Program, CAL FIRE provides technical assistance, grants, and, at times, direct project assistance for activities such as the development of sustainable forest management plans, implementation of forest improvement projects such as thinning or tree planting, and reduction of high levels of vegetation that pose a significant fire hazard.

Urban Forestry

The CAL FIRE Urban and Community Forestry Program promotes the expansion and improved management of trees and vegetation in communities throughout California. Urban trees directly capture CO_2 and provide long-term storage of carbon. As noted above, trees in urban environments, or 'urban forests', are capable of providing significant shading and other cooling benefits that can reduce urban temperatures and energy needs. Urban forests can also help filter air pollutants, prevent soil erosion, and absorb rainfall that would otherwise run over streets and wash pollutants into nearby waterways that are already under increasing stress from climate threats. In addition to providing public health benefits, and benefits to air, soil and water, urban forests can also provide habitat for wildlife and improve property values for communities.

Urban forestry is also otherwise being incentivized through the Urban Forest Projects Compliance Offset Protocol in the California cap-and-trade program. Grants and technical assistance in support of urban tree planting, urban tree inventories, urban forest management plans, educational and innovative urban forestry projects also have been provided by the California Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84) and the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002 (Proposition 40). However, this funding ended in June, 2013.

In December 2012, CAL FIRE's Urban and Community Forest Program, along with USFS and EcoLayers (a web-based platform for integrated resource planning), also launched a web-based tool, ecoSmart Landscapes (www.ecosmartlandscapes.org) that allows homeowners to calculate present and future carbon and energy impacts of existing and planned trees. As further discussed below and in the Public Health and Energy sections of this document, urban

tree planting can offer significant, cost-effective energy and public health benefits which will become increasingly important in the face of anticipated climate impacts. The ecoSmart Landscapes tool uses a Google Maps interface, and its carbon calculations are based on the Climate Action Reserve's Urban Forest Project Protocol. In addition, the Strategic Growth Council's Urban Greening program coordinates with CAL FIRE and other agencies on urban forestry investments.

Improved Forest Management, Fire Risk Reduction, Forest Conservation and Reforestation

The Board of Forestry has adopted regulations to create a modified timber harvesting plan for fuel hazard reduction.[339] The availability of the modified timber harvest plan for fuel hazard reduction is meant to encourage forest landowners to manage their forests to increase spacing between trees and reduce fuels in the understory with the objective of reducing the rate of spread, duration and intensity of any future fires and creating more fire resilient forests.

The Compliance Offset Protocol for U.S. Forest Projects in the California cap-and-trade program is providing market based incentives for projects including improved forest management projects, avoided conversion projects, and reforestation projects.

The Forest Conservation Program, administered by the Wildlife Conservation Board ("WCB") with funding from Proposition 84, has also provided funding for forest conservation and restoration, with additional consideration given to projects that can demonstrate an ability to reduce forest carbon emissions or promote additional forest carbon storage. CAL FIRE's Forest Legacy Program, conducted in partnership with the US Forest Service, works in concert with the WCB to develop working forest conservation easement projects and provide funding for easement purchase.

Proposition 40, now fully expended, provided cost-share funding for private, non-industrial forestland landowners for the development of forest management plans and the implementation of management practices to reduce the threat of wildfire, enhance watershed function, and improve forest health.

Forest Resources: Carbon Sequestration (Assembly Bill 1504 or "AB 1504")

AB 1504 was signed into law in 2010, recognizing the "unique role forests play in combating climate change" by helping to store carbon emissions. The bill requires BOF to ensure that its rules and regulations for harvesting commercial species consider the capacity of forest resources to meet or exceed the carbon goal for the forest sector specified in ARB's 2008 Scoping Plan.

Forest Resource Management Bill (Assembly Bill 1492 or "AB 1492")

AB 1492 was signed into law in 2012. Among other things, AB 1492 established an assessment on certain wood products to be deposited in a Timber Regulation and Forest Restoration Fund; upon appropriation by the Legislature, the moneys in the fund are to be used for administrative costs, supporting timber project/permit reviews, restoration and forest improvement, fire hazard reduction , and certain grants, including grants to local and state governments, tribes,

and non-profits for reducing greenhouse gas emissions and promoting adaptation or preparation for climate impacts.

State Responsibility Area (SRA) Fire Prevention Benefit Fee (Assembly Bill X1 29 or "AB X1 29")
AB X1 29 was signed into law in July 2011. The law established a new annual Fire Prevention Fee to pay for fire prevention services within the State Responsibility Area (SRA). The fee is applied to all habitable structures within the SRA. This fee funds a variety of important fire prevention services within the SRA including brush clearance around communities on public lands, along roadways and evacuation routes; and activities to improve forest health so the forest can better withstand wildfire.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA FORESTS

As discussed above, California's forests provide a broad range of benefits including clean water, clean air, flood protection, carbon storage, wildlife habitat, shading in urban settings, and recreational opportunities. However these benefits are imperiled by climate impacts such as increased temperature, declining snowpack and changing water availability, and increased risk of more frequent and more severe wildfires. Despite the success stories highlighted above, significant action is still needed to protect and maintain forest ecosystems and ecosystem processes on both protected and working forests to improve resilience and prepare California forests for climate risk. Sustainable management strategies should aim to maintain forest complexity and protect forests from human and natural agents of disturbance.

Funding support by grants, bonds, and fees for existing forest programs has, to date, been inadequate to support the types of innovative stewardship and restoration actions (further described below) which are needed to adequately prepare the forest sector for projected climate impacts. While AB 1492 and AB X1 29 may provide some new funding for these types of risk reduction efforts, as noted above, other funding sources for needed forest management, such as Proposition 40 and 84, will no longer be available; the continued availability of federal forest climate support (including research and forest management work) may also otherwise be imperiled by the government's fiscal state (which may itself be imperiled by climate impacts – see, for example, Box 48: "Flood Insurance" in the Ocean and Coastal Ecosystems and Resources section of this document). Additional, stable funding sources are needed to support actions to reduce climate risks to forests and to promote forest health and resilience. As further described below, market based solutions, such as cost-effective forest watershed investment programs, may offer a partial funding solution; however, additional funding sources will likely be required.

Improve Forest Management Practices and the Capacity of the Forest Sector to Withstand and Recover from Climate Impacts In Order to Protect the Value and Continued Productivity of Forest Resources

(1) Continue and Enhance Coordinated Efforts to Reduce Wildfire Risks and Promote Fire Safe Communities

As called for in the 2010 Strategic Fire Plan, the State continues to reduce wildfire risks and promote fire safe communities in a number of ways including:

a) By identifying, mapping, evaluating, and monitoring fire hazard threats under current and projected climate conditions;
b) Helping to articulate and promote the use of land use planning to help reduce fire risk;
c) Assisting in the development of local county and regional plans that address fire protection and landowner objectives and responsibilities;
d) Increasing awareness regarding wildfire risks and safety precautions (such as using fire resistant building materials and clearing vegetation and other fire hazards near buildings) in individuals and communities;
e) Working with federal and local partners to integrate fire management practices with community and landowner priorities;
f) Calibrating the level of resources devoted to protecting assets from wildfire risk according to community values identified in planning efforts; and
e) Addressing post-fire recovery actions to restore natural resources, minimize flooding, address impacts of silt, sand, gravel from denuded slopes on water quality (so called "sedimentation").

The State must continue to refine understanding of how climate impacts will change wildfire risk. As that understanding develops, education efforts to communities and individuals must reflect the best available science regarding anticipated climate impacts and the state of wildfire risk in California. A cost-benefit analysis should be performed to estimate the probability and magnitude of loss of property, injury and loss of life to wildfire, as well as the necessary investments and actions to reduce wildfire risk in the face of expected climate impacts. This type of analysis might be done as part of updates to the Strategic Fire Plan. Funding to support this type of expanded climate and cost analysis may be necessary, and collaboration with partners and stakeholders would be necessary.

Wood waste from needed fire hazard reduction efforts might be used for biomass energy. The Electric Program Investment Charge (EPIC), which is further described in the Energy section of this document, might help provide funding to support utilization of biomass generated from forest fire hazard reduction efforts, perhaps focusing on development of small distributed power/heating facilities that could utilize existing sawmill infrastructure as well as the workforce in rural communities. Any such funding would have to be consistent with the current EPIC investment plan.

(2) Provide Funding to Support, Maintain and Expand Seed Banks and Revive State Tree Nurseries

As noted above, at a time when climate impacts on California forests are accelerating, and more tree loss and extinction is threatened, capacity in the State Nursery Program has been diminishing, with the suspension of nursery services. In order to ensure the ability to undertake restoration work following fires, to maintain the genetic diversity of California forests, and to

protect tree species, including iconic species like the giant - continuing support for the State Nursery Program is critical. Seed processing and storage does not take the place of nursery production of seedlings (small immature plants); the availability of seedlings is particularly important for reforestation efforts following a fire.

With adequate funding, the State Nursery Program could:

- Maintain or expand seed banks to preserve genetic material from representative California tree species;
- Continue to promote the use of genetically appropriate native species in reforestation efforts; and
- Continue or expand work with the Natural Resources Conservation Service, Resource Conservation Districts, the US Forest Service, and private reforestation nurseries to increase the availability of reforestation seedlings available to small landowners.

More information about seed preservation efforts is contained in the Biodiversity and Habitat section of this document as well as the Agriculture section of this document.

(3) Assess and Implement Cost-Effective Forest Watershed Protection and Restoration
As noted in the above (for instance in Box 35: "Ecosystem Services" - Smart Land Use to Save Money and Create More Sustainable Communities), forests provide a broad range of ecosystem services, including flood protection, improving the quantity and quality of water supplies for downstream communities, shading and energy savings, and improvements to air quality. Investments in forest protection and restoration can be a cost-effective way of protecting communities from the impacts of climate change such as more extreme weather and changing water availability.

The State should help incentivize best management practices for land management for better upper watershed protection, and encourage further cost-benefit analyses; while such cost-benefit analyses would require funding and staffing support, implementation of cost-effective ecosystem investment programs could be self-sustaining.

The Department of Water Resources and CAL FIRE might work together to identify potential areas for collaboration, such as further cost-benefit analyses and integrated regional water management plans.

(4) Improve Understanding of Trade-offs Between Different Management Responses to Expected Forest Climate Impacts
As described in more detail in the Biodiversity and Habitat section of this document, the rapidly shifting impacts and conditions associated with climate change are fundamentally altering long-standing paradigms for natural resource management. Species are not only changing in response to climate change, but geographic locations of suitable habitat are also changing as temperatures and precipitation patterns change. Natural resource management efforts must

now occur in the context of these multiple shifting variables; various types of natural management approaches in response to unfolding climate changes are further described in the Biodiversity and Habitat section of this document. Continued research into the relative strengths and weaknesses of possible forest management approaches is needed and will help inform forest land owners, managers and regulators on how to best protect forest health and productivity in the face of climate impacts.

Certain public lands, such as National Forest System Experimental Forests[340] and CAL FIRE Demonstration State Forests[341], are particularly suitable for near-term and longer-term research into the efficacy of various forest management approaches in the face of climate change. These experimental and demonstration forests function as living laboratories for forest scientists. Enabling funding is needed to support necessary research into forest management options to protect forest health and resilience in the face of climate risks.

Iterative refinements to chosen management strategies will be necessary as both climate science continues to improve and knowledge about natural resource management in the face of climate change also improves (this type of iterative refinement is sometimes referred to as "adaptive management").

Statewide Assessment of Potential Cost Savings from Urban Forestry Investments

As noted above, urban forests provide myriad benefits, including cooling benefits that can reduce urban temperatures, public health impacts from climate change, and energy needs. Although research has been done on the quantification of potential benefits at the residential, project and city level, a thorough statewide assessment of potential opportunities, has yet to be done. A thorough assessment should include an evaluation of potential benefits as well as the cost of achieving such benefits. While the assessment would require funding, it could identify opportunities for urban forestry investments that might generate significant energy and cost savings for the State and California communities. A 2003 study by the USFS, Pacific Southwest Research Station, suggested that there were significant, cost-effective urban forest investment opportunities.[342] According to the 2003 study, planting 50 million trees in California to shade east and west facing walls could reduce peak energy demand by 4.5% over 15 years, for a savings of $7.6 billion (with projected cost of 50 million trees estimated to be $2.5 billion). The California Energy Commission is well positioned to lead this type of statewide assessment, in coordination with CAL FIRE, the California Department of Public Health and the California Environmental Protection Agency. Funding for a CEC assessment of this sort might come from the EPIC program, but would have to be consistent with the current EPIC investment plan. Any cost-justified recommendations suggested by the assessment would require funding support for implementation. CAL FIRE might help implement the urban forestry investments through its Urban and Community Forestry Program. CAL FIRE might also develop additional tools to help local and regional governments utilize urban forestry data for making planning decisions.

Improve Understanding of Forest Climate Impacts to Support Improved Forest Management Responses

(1) Improve Monitoring

Both the Forest Carbon Inventory and FRAP rely on data generated by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA), which is the nation's on-going forest census program. FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership.[343] FIA data necessarily has error estimates as results are extrapolated from sampled forest plots and measurements are only taken at periodic intervals; however, greater accuracy can be obtained by increasing the number of sampled forest plots (this is called "densification" of survey plots) and/or by measuring more frequently. State support for densification and increased frequency of FIA measurements of California forests would allow for better forest management that is more responsive to changing climate impacts. For instance, better data would allow for improved mapping of pest outbreaks, spread of invasive species, and tree mortality – which has implications for wildfire risks and forest management interventions. As noted below, improved monitoring will also aid in evaluating different management options that might be used to address expected climate impacts. Current estimates of carbon stocks on forest lands are highly variable and additional monitoring and research to refine methods are needed.

(2) Better Modeling of Vulnerabilities and Climate Impact Trends

As noted above, some research has been done to understand how expected climate impacts (changing temperatures, changing water availability, more frequent and severe wildfire, changes in pests and invasive species) will affect the geographic shifts of tree species in California, but more of this type of trend analysis is needed. This analysis will have important ramifications not only for California's commercial tree species, but also for California's biodiversity and habitat more generally. Better understanding of climate impacts and geographic shifts in tree species will help inform and improve forest management options. Having a better understanding of the potential cost ramifications of expected forest climate impacts (i.e. impacts to forest health and forest productivity, loss of property/injury and other health impacts/and loss of life from wildfire risks, impacts to water supplies, etc.) and better cost-benefit analysis of investments to make the forest sector more resilient against the impacts of climate change would also be helpful for prioritizing forest sector climate strategies.

As FRAP (the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program) already produces periodic assessments of the state's forest and rangeland resources and carbon stocks, FRAP could be enabled to undertake necessary forest climate vulnerability (including relevant economic analyses) and trend analysis to support improved California forest management. Additional funding or staffing may be necessary to enable this type of work.

(3) Identify Priority Landscapes and Support Actions to Increase Forest Resilience

As climate changes rapidly over the coming decades, species (including trees) will be stressed and forced to adapt to new conditions. Some areas of the state may be able to serve as safe havens, or areas of refuge (also called "refugia") for climate stressed species. For instance, as

the Southern Sierra Nevadas – Blue Oak Climate Scenarios map in Box 39 illustrates, the mid-elevation areas of the Southern Sierra may be such an area of refuge for tree species that are unable to survive in higher temperature conditions that will start to occur in the lower elevation areas of the State.

CAL FIRE, through FRAP and in coordination with partners, should continue to identify potential niches in existing landscapes that may provide refugia for plants and wildlife in light of expected climate impacts. Listed species habitat requirements and diverse gene pool preservation needs to be considered to allow for species to respond to climate change. As noted in the Biodiversity and Habitat section of this document, preserving the biodiversity and limiting habitat fragmentation has important economic, public health and social dimensions. Additional funding or staffing may be necessary to enable this additional work to identify priority landscapes for protection.

Information Sharing and Education

As noted throughout this section, California has many key partners and stakeholders with respect to its forest resources. These partners and stakeholders include: the USFS, USDA Natural Resources Conservation Service, Resource Conservation Districts, local governments, industrial and non-industrial timberland owners, numerous nongovernmental organizations, and residents who enjoy and use California forests and forest resources. Information sharing and coordination with partners and stakeholders will continue to be important in order to monitor and protect forest resources in the face of growing climate threats such as fire, increased temperature, pests and invasive species, and changing water availability. Coordination may take the form of collaboration on research and management strategies, including fire risk reduction plans. Given the substantial federal ownership and management of California forest lands, coordination with federal partners, including USFS, will continue to be particularly important as climate impacts escalate.

Interagency collaboration on forests will also continue to be important, and should be reflected in the State's many on-going climates and energy related policy efforts and programs with a forestry nexus; these include the:

- California Forest and Rangelands Strategy Report and Assessment (CAL FIRE),
- Bioenergy Action Plan (California Energy Commission),
- Assembly Bill 32 Scoping Plan and Forest Carbon Inventory (California Air Resources Board),
- California Wildlife Action Plan (California Department of Fish and Wildlife),
- State Water Plan (Department of Water Resources),
- Public health and air quality programs which may be impacted by particulate matter from wildfires, and
- California Climate Research Plan and 4th Climate Assessment.

In order to assist incorporation of expected climate impacts into forest management decisions, education must be made available to forest land managers. With enabling funding, CAL FIRE and/or the University of California Cooperative Extension program could offer this type of technical, education assistance to forest managers.

Box 43

California Forestry

Several state entities play an important role with respect to forestry in California. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. (The work of entities, such as the Governor's Office of Emergency Services and the California Department of Insurance, that play an important role in management of wildfire risk and post-wildfire recovery is discussed in the Emergency Management section of this document.)

Board of Forestry and Fire Protection (BOF) The Board's mission is to lead California in developing policies and programs that serve the public interest in environmentally, economically, and socially sustainable management of forest and rangelands, and a fire protection system that protects and serves the people of the State.

California Department of Forestry and Fire Protection (CAL FIRE) is dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. In addition, the Department provides varied emergency services in 36 of the State's 58 counties via contracts with local governments. CAL FIRE's mission emphasizes the management and protection of California's natural resources; a goal that is accomplished through ongoing assessment and study of the State's natural resources and an extensive CAL FIRE Resource Management Program. CAL FIRE oversees enforcement of California's forest practice regulations, which guide timber harvesting on private lands. The department also supports sustainable management of private forestlands and reduction of wildland fire hazards through technical assistance, grants, and project collaboration. CAL FIRE manages eight Demonstration State Forests that provide for commercial timber production, public recreation, and research and demonstration of good forest management practices. CAL FIRE also supports "urban forestry", increasing the number and health of trees planted in cities (urban forestry is further described in the Public Health section of this document).

California Department of Parks and Recreation (California State Parks or CSP) manages 1.5 million acres of California landscape within 280 park units. Twenty percent of this land area is forested with iconic stands of coast redwood, sierra sequoia, and Torrey pines as well as mixed-conifer, mixed hardwoods, and forested riparian communities. CSP manages its forested lands using a variety of tools, including prescribed fire, to restore ecosystem processes, control exotic plant species, restore and maintain native plant assemblages, reduce fuel accumulation, and maximize biologic diversity. CSP also works with Cal FIRE, the United States Forest Service, and the National Park Service to protect cultural and natural resources during wildfire events.

Office of State Fire Marshall (OSFM) The mission of the State Fire Marshal is to protect life and

property through the development and application of fire prevention engineering, education and enforcement. The Office of the State Fire Marshal supports the mission of the CAL FIRE by focusing on fire prevention, including providing statewide direction for fire prevention within wildland areas.

State Conservancies A number of State conservancies are also involved in forest protection and management activities. These include the **Sierra Nevada Conservancy (SNC)** which initiates, encourages, and supports efforts that improve the environmental, economic and social well-being of the Sierra Nevada Region, its communities and the citizens of California and the **California Tahoe Conservancy**, which is focused on restoring and sustaining a balance between the natural and the human environment and between public and private uses at Lake Tahoe, and has worked on forest fire hazard reduction in the Tahoe Basin.

As further discussed above, the federal government holds a significant amount of forested lands in California. Federal agencies, including the **United States Forest Services (USFS)**[344] and the **Bureau of Land Management (BLM)**, are important partners for the State of California with respect to forest management, wildland fire protection, and research. There is also very significant private ownership of California forest lands, and both industrial and non-industrial private owners are important partners for the State.

OCEAN AND COASTAL ECOSYSTEMS AND RESOURCES

INTRODUCTION

The policy guidance in this chapter is meant to help inform state decision makers regarding ocean and coastal issues when preparing for climate risks.[345] Three quarters of California's 38 million people live near our iconic 1,100 miles of coastline and San Francisco Bay's additional 500-mile[346] shoreline. Because of this geographic reality, a vast number of people can potentially be impacted by the ocean through rising sea levels brought on by climate change and direct impacts of human activities. A rising sea brought on by climate change puts vital infrastructure at risk. This includes roads, highways, bridges, commercial and residential buildings, sewage treatment plants, gasoline pipelines, power plants and power grid infrastructure, several of the busiest ports and airports in the world, and even emergency facilities like hospitals. Sea-level rise, coastal storms and erosion are also impacting natural and recreational assets such as beaches and tidal wetlands that are valued by Californians as part of the attraction of living in and visiting the coast and bay regions. That is why a multitude of federal, state, regional and local entities are working together to educate and advise decision makers on methods to prepare and plan for these large-scale, multi-decade changes. In order to lower vulnerability and exposure to economic losses and public health and safety risks, it is critical that California take actions now to ensure resilient communities.

While less visible, the impact of runoff, pollution, and carbon absorption on the ocean is a real and timely threat to waters that provide an abundance of seafood to not just our state, but places all over the world. What's more, the threat of fouling our waters isn't just a local one – it is a global crisis that can only be addressed through both local actions and work on all scales to reduce the pollution that is causing higher temperatures and changes in ocean chemistry.

Actions to address these threats have already started. California is tackling carbon pollution through a suite of climate policies to reduce greenhouse gas emission pursuant to the California Global Warming Solutions Act of 2006 (Assembly Bill 32 or "AB32"). Some progressive local and regional governments and state agencies have been working on innovative shoreline management plans including managed retreat (discussed further below) and investments in tidal wetlands which can provide cost-effective flood protection. The State has also developed guidance for incorporating sea-level rise, storms and shoreline change into planning and decision making for projects in California. Continued investments in climate-smart Ocean and coastal management can help protect the public health and welfare of Californians and bolster the resiliency of natural resources on which our communities depend.

More than forty years ago, grassroots environmental activism led to California passing some of the nation's first and strongest coastal management laws. These laws established that the coast and bay shoreline are important natural resources for the benefit and enjoyment of all of the people of California and that "it is the policy of the State to preserve, protect, and where possible, to restore the resources of the coastal zone for the enjoyment of the current and succeeding generations". California's commitment to protection of our shared coastal resources is at the heart of California's Coastal Management Program which has been hailed as a national and international model for coastal resource management. The state agencies who make up the Coastal Management Program include the Coastal Commission, San Francisco Bay Conservation and Development Commission and the Coastal Conservancy. All three of these state agencies are engaged in significant projects that integrate consideration of climate change into decision-making and providing leadership for reducing risks and preparing for changing conditions.

Many different entities play an important role with respect to protecting and managing California's ocean and coastal ecosystems and resources. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate impacts to help in identifying management gaps or determining which agency should take specific actions in the future. The key state agencies for management of coastal and ocean resources are listed at the end of this chapter, in Box 52. In addition, coastal assets and infrastructure are under the purview of various federal, state, regional and local agencies, and there are significant coastal assets under private ownership and management. As further discussed in various chapters throughout this plan, local governments have primary responsibility for land use planning and local infrastructure and play a key role in emergency management efforts; thus they have an important role with respect to California's ocean and coastal ecosystems and resources. Management and planning for climate impacts requires a high degree of coordination.

The 2009 California Climate Adaptation Strategy identified the following guiding principles for decisions on actions to address the impacts from climate change in the ocean and coastal regions:

- California must protect public health and safety and critical infrastructure.
- California must protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well-being depend.
- California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources.
- New development and communities must be planned and designed for long-term sustainability in the face of climate change.
- California must look for ways to facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time.
- California must begin now to adapt to the impacts of climate change. We can no longer

act as if nothing is changing.

As described later in this chapter, the state plans on engaging in a public process to review these guiding principles and integrate them into a framework for improved action to reduce risks and support vibrant, healthy coastal and bay communities and natural landscapes.[347]

This chapter on ocean and coastal ecosystems and resources is organized as follows:

- Climate change impacts on ocean and coastal ecosystems and resources;
- Highlights of steps taken to date and success stories;
- Actions needed for safeguarding ocean and coastal ecosystems and resources;
    - Better understanding of climate impacts on ocean and coastal ecosystems and resources;
    - Improve management practices for coastal and ocean ecosystems and resources and increase capacity to withstand and recover from climate impacts;
    - Better understanding of evolving trends that may impact ocean and coastal ecosystems and resources; and
    - Information Sharing and Education.
- Box 52 – California Ocean and Coastal Ecosystems and Resources (description of state entities that play an important role with respect to California's ocean and coastal ecosystems and resources).

CROSS REFERENCES: While this section of the Safeguarding California Plan raises many topics relating to ocean and coastal resources, some of these topics are further described within the context of cross-related sections of this Plan. For instance, sea-level rise impacts relating to transportation infrastructure are further discussed in the Transportation section of this document. Flood hazard preparation is further discussed in the Emergency Management section of this document. Sea-level rise as the cause of salt water intrusion into drinking water supplies is further discussed in the Water section of this document.[348] Sea-level rise impacts on energy infrastructure are discussed in the Energy section of this document. Toxic releases, floods and other public health issues related to sea-level rise are further discussed in the Public Health section of this document. Climate impacts on ocean and coastal ecosystems are also discussed in the Biodiversity and Habitat section of this document.

Climate Change Impacts on Ocean and Coastal Ecosystems and Resources

Climate change presents new threats to ocean and coastal ecosystems and resources including, but not limited to, sea-level rise, extreme events, and ocean acidification.

<u>Sea-level Rise, Storms and Erosion: Infrastructure and Property Damage, Permanent Submersion of Coastal Lands, Toxic Releases, and Risks to Water Supply</u>

Climate change is causing global average temperatures to increase. This warming trend causes sea-level rise in three ways: 1) the oceans are warming, which causes sea water to expand, increasing ocean volume, 2) glaciers on land are melting and transferring water to the oceans, and 3) sea ice is melting.[349]

According to a 2012 report by the National Research Council[350], for the California coast south of Cape Mendocino, sea level is projected to rise approximately 5 to 24 inches by 2050 (relative to 2000) and 17 to 66 inches by 2100[351]. Communities, public and private property, infrastructure, natural habitats (including wetlands and marshes), coastal agriculture[352], and important cultural resources will be at increased risk from storm surges and flooding, permanent inundation and erosion. [See Box 44: Rising Seas Threaten California's Coastal Past] The risks to California's economy, its people, and its natural resources are substantial; and populations that are socially and economically vulnerable will bear a disproportionate burden. As discussed in the NRC study, it is the combination of sea-level rise and extreme events that are most likely to cause significant damage in the near term. As one example, the map in Box 45 shows the companies just in the Silicon Valley that are located in areas vulnerable to projected sea-level rise by the end of the century.[353]

Box 44

Rising Seas Threaten California's Coastal Past
by Molly Samuel (used with permission)



A site with evidence of more than 1,000 years of occupation is eroding due to high tides

hitting the base of the cliff. (Photo: Mike Newland)

On a sunny day earlier this summer at Point Reyes National Seashore, I scrambled behind Mike Newland as he clambered across gullies and bushwhacked through thigh-high lupine. Once we got to the spot he was aiming for, on the edge of a sandy beach-side cliff, he stopped and started to pick through shells and stones.

"You can see, we've got sort of a handful of little guys here, popping out of the ground," he noted. "Some of these that we're going to see, they weren't here a year ago, when I came here last time."

Newland, an archaeologist at Sonoma State University and the president of the Society for California Archaeology, was hunting for Native American artifacts, clues about what life was like in coastal California before Europeans arrived. It was easy for him to find them; wind, rain and tides have eroded these cliffs and exposed the ancient trash piles and stone tools.

This site and these cultural resources — some of them a thousand years old or more — might not be around for much longer. These pieces of California's history are in danger of disappearing as the Pacific Ocean claws at the base of this cliff. Sea level rise is accelerating the problem.

It's not just that the tides will be higher. The cliffs are so soft, they could recede hundreds of feet back, with just a few feet of sea level rise.

"You know, this isn't just gonna be a matter of, the ocean's going to pop up and cover it up and then we can get back to it later," Newland said. "These sites are toast. And we're essentially losing them all at once."

Nick Tipon, a retired high school teacher and member of the Federated Indians of Graton Rancheria, whose territory includes Point Reyes, said he became aware of the extent of the erosion several years ago.

"In one part of the park, there's a layer of soil that indicates human habitation in that spot, and sticking out from the side of a cliff was a human skull," he said. When human remains are disturbed or exhumed, tribal policy is to rebury them as close as possible to where they were found. "So then we thought, 'How far inland do we have to go away from the cliff to find stable soil? So we don't have to do this 100 years, 200 years again? So that literally our ancestors can rest in peace?'"

Newland says there is evidence that people have lived in California for at least 11,000 years, and the soft sandstone cliffs on the coast have always been susceptible to erosion. Traditionally, Tipon said, the tribe would have let the ocean take burial sites, since it was

a natural process. But now, with two million or so people visiting the park every year, they can't leave human remains exposed.

Meanwhile, climate change threatens to expose more of them. A tide gauge in the nearby Golden Gate has recorded eight inches of sea level rise in the past century. Scientists' project it could rise three feet in the next.



Just looks like a rock, right? Archeologist Mike Newland says, "This is a crypto-crystalline silicate cobble that was broken by native peoples, probably to get material for making stone tools. It comes from a high-risk site along the western edge of Point Reyes National Seashore." (Photo: Mike Newland)

Point Reyes contains more than 120 Coast Miwok settlement sites. (The Federated Indians of Graton Rancheria includes both the Coast Miwok and the Southern Pomo people.) The National Park Service works closely with Native Americans to protect graves and other important objects or sites. And the Park Service supports and conducts climate research and has programs to help mitigate and adapt to changes coming to the parks. But Mark Rudo, a National Park Service archaeologist, said the Park Service isn't prepared to deal with the scale of the threat that sea level rise presents.

"At the same time that we're trying to figure out what the impacts are, we're also trying to identify what we can do about them, so it's not an easy situation to work in," he said. It's a special challenge with archaeological sites. While it may be possible for natural resources, plants and animals, to migrate**,** Rudo pointed out that cultural resources, like archaeological sites that remain in the ground, can't be moved, even with help. "We're stuck," he said. "We can't hide or run away from the problem, or adapt to it."

But the park does have help measuring the extent of the problem. Newland is recruiting archaeologists from all over the state in a volunteer effort to survey sites along the coast in Marin, Monterey, San Diego and Del Norte Counties, and he hopes to continue expanding the project, to study the thousands of sites up and down the California coast.

"We have to be honest. Most of the sites are going to be destroyed," he said. "But we should at least know what we're going to lose. That's my goal." At Point Reyes alone, Newland has found that 54 of the 160 sites he studies are in danger of being erased in the next century, and most of the others face some level of threat from other climate change impacts. And he emphasized, this is going to be a problem everywhere. "We are in the process of losing all of our maritime sites as a species. Every place that we've launched off to go explore the world through the ocean is now at risk," Newland said.

Tipon, who's a tribal liaison to the parks, said they'll have to decide what to try to protect on a case-by-case basis, but he's less concerned about any given object than with people and culture. And that won't be washed away as easily.

"One of the questions I get asked a lot when I give speeches is, 'How long have your people been here?' And I go, 'Well, you know, the archaeologists say that it's 3,000 years, 7,000 years, 11,000 years,'" he said. "But the cultural response is: we've been here forever. So how long are we going to be around? We will be here forever."

Molly Samuel joined KQED as an intern in 2007, and since then has worked at KQED as a reporter, producer, director and blogger. Before becoming KQED Science's Multimedia Producer, she was a producer for Climate Watch. Molly has also reported for NPR, KALW and High Country News, and has produced audio stories for The Encyclopedia of Life and the Oakland Museum of California. She was a fellow with the Middlebury Fellowships in Environmental Journalism and a journalist-in-residence at the National Evolutionary Synthesis Center. Molly has a degree in Ancient Greek from Oberlin College and is a co-founder of the record label True Panther Sounds.

Sea-level rise will result in the inundation of some beaches; for gently sloping beaches, the general rule of thumb is that 50 to 100 feet of beach width will be lost for every foot of sea- level rise. Beaches and bluffs also will be exposed to greater and more frequent wave attack, due to the elevated seas as well as to a possible increase in the frequency and severity of storm waves. When the means of protecting existing structures involves building sea walls or other "hard armoring" of the coast, there will be an inevitable additional loss of beaches as a result. This is because shoreline protective devices halt the landward migration of the back of the beach, and continued flooding of the seaward beach results in a reduction in beach width, and its eventual loss entirely. The loss of beaches due to armoring and sea-level rise will in turn result in loss of public beach access, tourism losses, losses of marine mammal haul-out area and sandy beach habitat, and loss of beach buffering capacity against future bluff erosion.[354] By virtue of California's sovereignty, the public owns all of the coastline three nautical miles from what is known as "the mean high tide line."[355] The California Constitution mandates that these lands are held by the State in trust for the people and public access is a key part of that mandate. As sea levels continue to rise, there may be jurisdictional shifts over areas of the California coast line; areas that were once beaches will become submerged lands and strategies will need to be developed to protect public access.

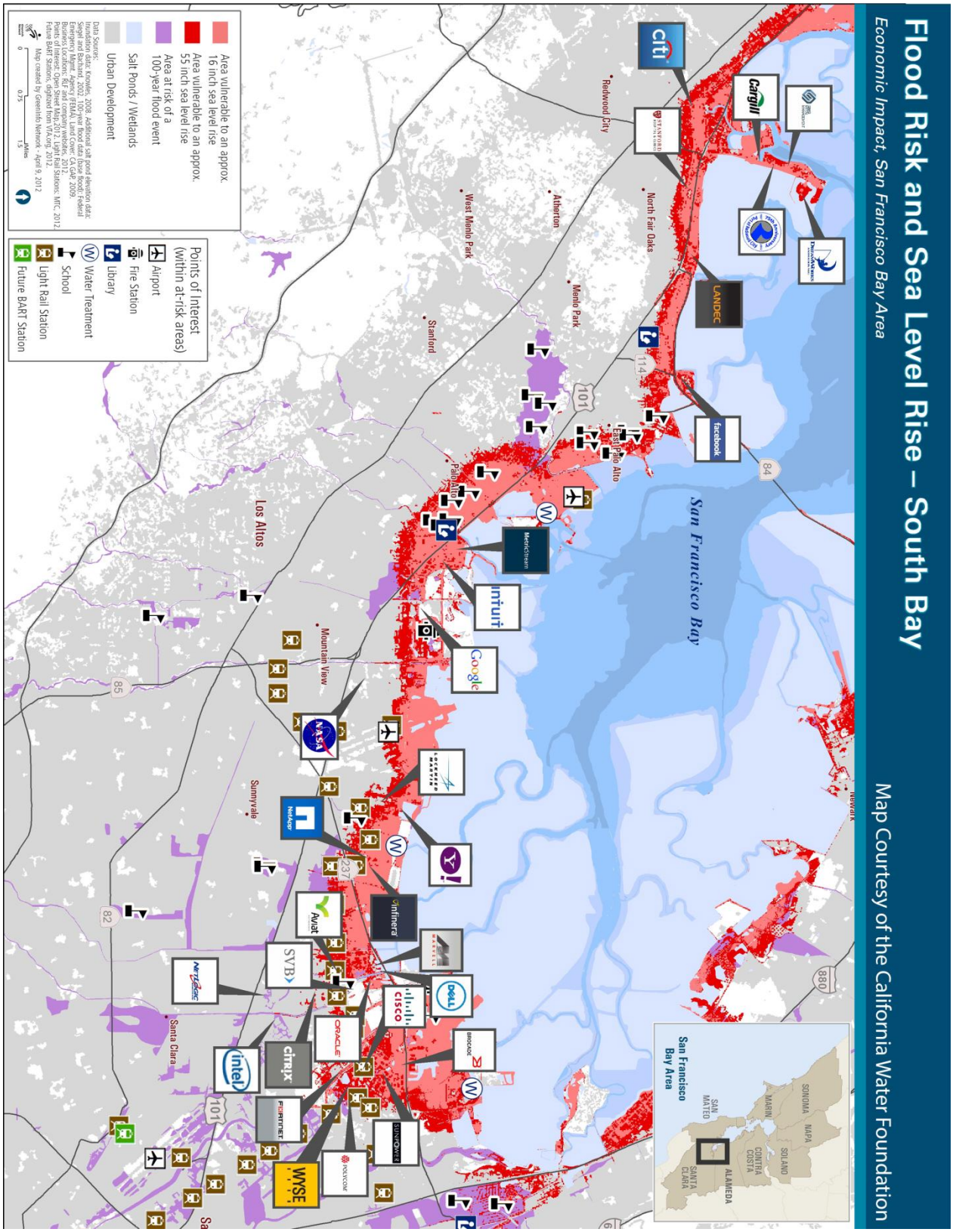
As noted in the Transportation section of this document, sea-level rise and coastal erosion also threaten ports and low lying airports, roads and highways, bridge supports, transit systems, and energy and fueling infrastructure. This has major implications not only for critical emergency evacuation routes and public health, but also for goods movement and the economy. For further discussion of these issues, please see the Transportation and Water section of this plan.

Sea-level rise and extreme events also threaten water supply and delivery, through salt-water intrusion into fresh water sources and through impacts to the Sacramento-San Joaquin Delta. Saltwater intrusion in groundwater supplies is caused by the landward and upward movement of sea-water and is further discussed in the Water section of this document. The waterways in the Delta are at sea level and are affected by ocean tides. The Delta consists of a network of channels and sunken "islands" that cover—together with Suisun Marsh—about 1,300 square miles. This combination of islands and channels support not only water supply conduits, but also other important infrastructure elements: major arteries of the state's electrical grid; natural gas fields, storage facilities, and pipelines; highways and railways; and shipping channels, all surrounded by an increasingly urban landscape. Inundation and higher flood risk associated with sea-level rise and storm events might affect operations of the Central Valley Project and State Water Project, impacting water supply and delivery. Communities within the Delta are at high risk from sea-level rise; the Surging Seas study by Climate Central showed that with four feet of sea-level rise, Stockton has the largest total exposed population in the state and Sacramento is the city with the fifth largest exposed population. This same study concluded that the counties with the largest total exposed populations included the following Delta counties: San Joaquin (2nd), Sacramento (5th), and Solano (10th).

Sea-level rise and coastal erosion also threaten other infrastructure and property including wastewater treatment and storm water management facilities[356], hospitals, schools, and homes and businesses. For more on the state's hospital preparedness program, please see the discussed in more detail in the Public Health chapter. Sea-level rise presents very significant fiscal risks.[357]

The presence of facilities or land containing hazardous materials in coastal areas susceptible to either flooding or permanent inundation presents toxic exposure risks for human communities and ecosystems. Hazardous materials can contaminate flood waters, drinking water supplies, buildings and property, and ocean-based food sources. For more information on public health risks from climate change, please see the Public Health section of this document. A 2009 CEC PIER funded study evaluated sites containing hazardous materials at risk from sea level rise in California.[358] The study evaluated a range of sites monitored by the U.S. Environmental Protection Agency for hazardous materials including: "Superfund" sites and brownfields (regulated under the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]), hazardous waste generators, facilities required to report emissions for the Toxic Release Inventory, facilities regulated under the National Pollutant Discharge Elimination System, and facilities with permits under Title V of the federal Clean Air Act for hazardous air pollutants. In 2009, 130 such sites were already located in high flood risk areas, but with a 55- inch sea level rise, the high risk flood area along the California coast will expand - and the number of sites at risk will increase 250% - with an estimated 330 hazardous waste facilities and sites at risk.[359] A more recent 2013 report from the Adapting to Rising Tides ("ART"), a project led by the San Francisco Bay Conservation and Development Commission that worked collaboratively with local governments to "field test" planning to be resilient to sea level rise found that there were eight types of contaminated lands within the ART San Francisco Bay Area sea-level rise study area alone, primarily concentrated in Oakland and Emeryville; these lands include two Federal Superfund sites, 450 leaking underground storage tanks, 112 Department of Toxic Substances Control (DTSC) sites and 24 active and closed landfills.[360]

Box 45


Flood Risk and Sea Level Rise – South Bay
Economic Impact, San Francisco Bay Area
Map Courtesy of the California Water Foundation
Area vulnerable to an approx. 16 inch sea level rise
Area vulnerable to an approx. 55 inch sea level rise
Area at risk of a 100-year flood event
Salt Ponds / Wetlands
Urban Development
Points of Interest (within at-risk areas)
Airport
Fire Station
Library
Water Treatment
School
Light Rail Station
Future BART Station
San Francisco Bay
Redwood City
Atherton
West Menlo Park
North Fair Oaks
Menlo Park
Stanford
East Palo Alto
Palo Alto
Los Altos
Mountain View
Sunnyvale
Santa Clara
Newark
SONOMA
MARIN
NAPA
SOLANO
CONTRA COSTA
ALAMEDA
SAN MATEO
SANTA CLARA
San Francisco Bay Area
citi
Cargill
LANDEC
facebook
MetroStream
intuit
Google
NASA
NetApp
Avaat
SVB
Infinera
CISCO
DELL
ORACLE
citrix
intel
FUJITSU
WYSE
SUNPOWER
POLYCOM
101
84
85
82
237
880
114

Box 46

Imagining California's Future Coastline - California King Tides Initiative

A "king tide" is a popular term used to describe a phenomenon that occurs when the orbits and alignment of the Earth, moon, and sun combine to produce the greatest tidal effects of the year.[361] King tides are a normal occurrence several times a year in coastal areas.

Because king tides can reach 6 or 7 feet, they are useful for envisioning future everyday water levels expected to occur as a result of climate-driven sea level rise. King tides can cause flooding and can be particularly damaging if coupled with storms and strong waves.

Coastal communities around the world including communities in Australia, British Columbia, and in a variety of U.S. states, have begun documenting king tides in photographs to inspire action to reduce coastal hazards and impacts from sea-level rise. The California King Tides Initiative is such an initiative and engages citizens to photograph king tides, or the highest winter tides, along the entire California coast, including bay areas.[362]



Vista Del Mar, December 24, 2011 by Cassidy Teufel. Photo courtesy of California King Tides Initiative – license to use this photograph does indicate an endorsement of this document.

Box 47

"Wetlands" - Nature's Flood Protection

Wetlands are transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is often covered by shallow water during some parts of the year. There are many types of wetlands, but some major categories of wetlands include: tidal wetlands, freshwater wetlands, and freshwater forested wetlands (including meadows).[363] Sea-level rise will result in changes to some coastal ecosystems, including by converting some freshwater wetlands into more salty tidal wetlands by changing the elevation of the freshwater- saltwater interface.[364]

It is now understood that wetlands not only provide habitat for fish, birds and other species, but wetlands also play an important role in water quality, water supply, flood control, and, in some cases, aid in the storage of greenhouse gas emissions. Wetlands absorb and filter pollutants that could otherwise degrade ground water or the water quality of rivers, lakes, and estuaries. Some wetlands recharge aquifers that provide urban and agricultural water supplies. Wetlands also absorb and slow flood waters, reducing the size and destructiveness of floods.[365]

In the past, the function of wetlands was poorly understood and such lands were viewed as marginal, unproductive lands or breeding grounds for mosquitos and malaria. As a result, many wetlands were drained, filled, and converted to other uses. Estimates of wetlands that historically existed in California range from 3 to 5 million acres. The current estimate of wetland acreage in California is approximately 450,000 acres; this represents an 85 to 90 percent reduction - the greatest percentage loss in the nation.[366] The World Bank has estimated that the drainage of 1,800 km2 (about 450,000 acres) of wetlands in the Sacramento – San Joaquin Delta alone has released some 0.9 GtCO2 (Giga tons, or billion tons of carbon dioxide), a mass of about one quarter of the total above ground pool of carbon in Californian forests, over the last century.[367]

A 2013 report by the Bay Institute[368], an environmental organization, studied the potential for integration of tidal marshes in to multi-purpose shoreline management regimes in the San Francisco Bay Area in the light of expected climate impacts. According to the study, hybrid levees which fortify traditional earthen levees in The San Francisco Bay with tidal marsh restoration are not only extremely cost effective, they offer many additional benefits. Because plant root systems in marshes expand over time, the marsh can function as a "self-maintaining levee" which grows vertically over time and can help the entire system keep pace with sea-level rise assuming marsh restoration efforts are initiated in a timely way. Tidal marshes also provide significant flood protection benefits by reducing destructive wave energy during storms, and marshes provide significant habitat benefits as well.

As further discussed below, there are some exciting projects underway to restore

wetlands to aid future generations in coping with climate change stressors like impacts to water quality, changing water availability, and increased threat of floods. See South Bay Salt Pond Restoration Project description below and DWR's Twitchell Island Project in the Biodiversity and Habitat section describing how wetlands can reduce subsidence in the Delta and in turn reduce pressure on levees that can lead to levee failure and flooding. Many more opportunities for additional wetlands protection and restoration work still exist.

Box 48

Flood Insurance

The availability of private flood insurance is extremely limited, since private sector insurance companies have long viewed the risk of flood events as uninsurable.[369]

The National Flood Insurance Program (NFIP), established in 1968, is a Federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses. Participating in the NFIP is based on an agreement between communities and the Federal Government. The program is administered by FEMA and provides flood insurance protection to property owners, renters, and business owners in communities that participate in the program.[370] Homes and buildings in "high-risk" flood areas with mortgages from federally regulated or insured lenders are required to have flood insurance. High-risk flood areas have a 1% or greater chance of flooding in any given year, which is equivalent to a 26% chance of flooding during a 30-year mortgage. (See Box 18: "What is a 100-Year Storm or a 100-Year Flood" in the Emergency Management section of this document.) However, homes and buildings in moderate-to-low risk areas file over 20% of NFIP claims and receive one-third of disaster assistance for flooding. (Disaster relief is further discussed in the Emergency Management section of this document; as noted in that section, disaster relief funds, when available, must generally be repaid with interest.)[371] Although NFIP collects over $3 billion dollars in premiums annually[372], in four of the past eight years, claims will have eclipsed premiums - in 2005, the year of Hurricanes Katrina, Rita and Wilma, claims totaled $17.7 billion.[373]

In July 2012, The Biggert-Waters Flood Insurance Reform Act was signed into law, reauthorizing NFIP through 2017, and instituting some premium reforms and provisions for updated flood mapping.[374] The intent behind the 2012 reforms was, in part, to ensure more accurate assessment of flood risk so that investment in infrastructure and real property that is or will be underwritten by the Federal Government is not based on flawed or outdated hazard analysis. The 2012 reforms authorized increasing insurance premiums based on the new risk assessments in an effort develop a solvent fund source that could reliably respond to flood disasters. As part of the 2012 reforms, a new Technical Mapping Advisory Council, made up of federal, state, and local experts, was formed to review current flood hazard risk mapping standards and to recommend new standards to FEMA based on evolving new scientific and technological data. FEMA is required to report annually to Congress on how it is acting on those recommendations

and whether it has deferred action on any recommendation.[375] As of November 2012, NFIP debt was approximately $20 billion, no principal has been paid on the debt since 2010, and premiums are not likely to generate sufficient funds to repay the debt.[376]

According to the Congressional Research Service, although the full economic cost of Hurricane Sandy, which occurred in October 2012, will not be known for years - NFIP payouts are estimated to be between $12 billion and $15 billion. "In the immediate aftermath of Sandy, this amount quickly exceeded the $4 billion in cash and remaining borrowing authority from the Treasury Department [for NFIP]. By January 2013, the NFIP had processed more than 140,000 claims for Sandy-related damages totaling about $1.7 billion. To protect the financial integrity of the NFIP and ensure that the NFIP has the financial resources to cover its existing commitments following the devastation caused by Sandy, the Obama Administration requested that Congress pass legislation to increase the NFIP's borrowing authority. On January 4, 2013, Congress passed, and the President two days later signed into law, H.R. 41 to provide a $9.7 billion increase in the NFIP's borrowing authority, from $20.725 billion to $30.425 billion, to pay flood claims related to Hurricane Sandy."[377]

The U.S. Government Accountability Office (GAO) has added limiting the federal government's fiscal exposure to climate change to its 2013 list of high-priority areas.[378] As of August 2012, California had 260,000 NFIP policies in force, representing coverage of $68 billion of assets.[379]

Repetitive Loss

Structures built and rebuilt in flood prone areas may be vulnerable to being damaged or destroyed multiple times; in many areas, climate impacts will increase the likelihood of such 'repetitive loss'. In 2004, a program was instituted to try to reduce the repetitive loss of structures insured under NFIP. The Severe Repetitive Loss (SRL) grant program provides Federal cost-share funding for States, Territories, and Federally-recognized Indian tribes for strategies for addressing existing properties subject to repetitive loss and preventing the building of new structures in areas prone to repetitive loss.[380]

As further described below, some California coastal communities are already developing, new innovative approaches to managing the many risks of sea level rise. (See Highlights of Steps Taken to Date: Innovative Shoreline Management in California and accompanying Box 51: Innovations in Shoreline Management in California) As noted below, additional work remains to reduce the risk of loss of life and property.

In addition to these planning efforts, the California Environmental Quality Act (CEQA) requires environmental impact reports "evaluate any potentially significant impacts that could result from locating development in areas susceptible to hazardous conditions (e.g., floodplains, coastlines, wildfire risk areas) as identified in authoritative hazard maps, risk assessments or in land use plans addressing such hazards areas."[381] If there are

potentially significant direct and indirect impacts to the environment as a result of locating a project in high risk areas, these impacts must be considered and where feasible, mitigated.

For more information on insurance and climate risks, please see Climate Change and Insurance in the Emergency Management section of this document.

In addition to sea-level rise and its associated impacts, there will be additional impacts to ocean and coastal ecosystems and resources. These include changes in temperature, more extreme weather, potential increases in water contamination, ocean acidification and hypoxia. These impacts are further described below.

Changes to ocean function affecting global climate regulation & more extreme weather

As noted above, oceans play a key role in the global climate system, storing and moving heat and carbon, and also playing an important role in the water cycle. Ocean circulation is central to global climate regulation (and is also important to the distribution of nutrients in the ocean), and is influenced by a number of factors, including temperature and salinity. Climate models generally predict that there will be large changes to ocean circulation as a result of continued greenhouse gas emissions and associated temperature changes and ice sheet melting (which affects ocean salinity).[382]

For every 1-degree C (1.8 degrees Fahrenheit) rise in temperature, the amount of moisture that the atmosphere can contain rises by 7 percent; the increased moisture in the atmosphere means more rain, and climate models predict that there will be more extreme rain events.[383] But precipitation is not spread evenly around the globe, and some places might actually get less precipitation than they used to get due to shifts in air and ocean currents.[384] Extreme storm events coupled with sea-level rise will intensify flooding risks, salt water intrusion and erosion[385] and could also negatively impact coastal tourism.

More Extreme Weather: Increase in Pollution Runoff & Ocean Water Contamination

As noted above, sea-level rise may lead to flooding, especially when coupled with extreme storm events, and flooding may lead to water pollution. Extreme storm events may also increase pollution run off from urban, suburban and rural lands (e.g. oil, pesticides, litter, nitrogen fertilizers, etc.). Polluted storm water runoff in ocean water can cause serious public health problems including earaches, sinus problems, diarrhea, fever and rashes,[386] as well as illness, death and reproductive failures in marine species.[387] Runoff of fertilizers can also result in algae blooms; algae blooms can produce toxins or deplete oxygen levels in ocean water; this may cause illness or death in marine species, including fish and shellfish species that are consumed for food.[388]

Extreme storm events may also increase releases of raw sewage into marine environments either due to accidental spills from aging, cracked, and leaking sewer systems or due to overflows of untreated or partially treated wastewater from combined sewer systems.[389]

Salt water draining into sewer lines as part of extreme weather flooding may poison the biological systems at treatment plants and result in further releases of sewage.[390] Accidental spills and overflows can contain untreated human and industrial waste, toxic materials, and debris; this can, in turn, cause serious public health risks and ecological damage.[391]

As further discussed below, enhanced monitoring, infrastructure relocation, repair or redesign (including use of green infrastructure), continued work to control sources of land-based pollution, and public health risk communications programs will be important to address these issues.

Ocean Acidification

The chemistry of the world's oceans are changing as increasing carbon dioxide, and other waste gases from human activities, are absorbed into the surface water. This results in a decline in pH, a process known as ocean acidification. Ocean acidification is considered a global threat to marine ecosystems, and has the potential to impact various economic sectors (e.g. fisheries, aquaculture, tourism) and coastal communities in California, and may also have indirect effects on food security and biodiversity. The current rate of ocean acidification is unprecedented over the past hundreds of millions of years; similar past events have been accompanied by major marine extinctions.[392] While oceanic uptake of carbon dioxide from the atmosphere provides a valuable service to human societies by moderating the severity of climate change, it is having a profound long-term impact on marine chemistry and biology.[393]

In addition to atmospheric gas absorption, small-scale processes like nutrient runoff into coastal waters from land-based sources can lead, through biological processes, to especially low pH (and hypoxic – see section below) water at very local scales.[394] The coastal regions off the west coast of North America are also strongly influenced by seasonal upwelling, a natural process that brings carbon dioxide-rich, offshore waters to the surface ocean. With decades of human inputs of carbon dioxide to the atmosphere, the water that upwells now (which has been out of contact with the atmosphere for approximately 50-100 years), has even lower pH than in the past, resulting in localized "hotspots" of ocean acidification around upwelling regions. For example, the acidification conditions in upwelling-driven northern California coastal waters in 2008 were similar to what are predicted to occur in open-ocean surface waters in 2050.[395]

Many biological processes, such as growth, reproduction, and survival of many species are affected by shifts in seawater pH.[396] For instance, with increasing ocean acidification, many calcifying organisms have difficulty forming and maintaining their shells and skeletons (See Box 8: Ocean Acidification; Implications for Biodiversity in the Biodiversity and Habitat section of this document.) Calcifying organisms such as coral reefs, shellfish and zooplankton are among the first to experience impacts, and early life stages of marine

organisms may be particularly vulnerable. However, there is significant variation in the sensitivity of marine organisms, and a growing body of evidence to suggest some species may have the capacity to adapt to future ocean chemistry.

There is potential for ocean acidification to impact wild fisheries that are of great economic importance to California. The first direct impact on humans may be through declining harvests and fishery revenues from shellfish and their predators.[397] (See Box 49: First Person Narrative: Seeing is believing: shellfish growers confront ocean acidification.) Overall, marine crustaceans (crab, lobster, shrimp) appear broadly tolerant to the seawater acidification expected by 2100. Urchins may be more sensitive to acidification due to the vulnerability of their early stages, though new research indicates they may be able to adapt. Fished species are also embedded in marine food webs that are sensitive to changes in environmental conditions. Evidence suggests that the demographics, size, and nutritional content of some species can change in response to changing carbonate chemistry; these effects are likely to influence food web structure and function. The abundance of fished species can vary as the food web changes. A project linking spatially and temporally explicit ocean chemistry forecasts from regional ocean models with scenarios of the response of species in the California Current ecosystem to acidification will be completed in December 2015.[398]

Box 49

FIRST PERSON NARRATIVE: Seeing is believing: shellfish growers confront ocean acidification

By Mark Wiegardt [used with permission]

"My family has been farming Pacific oysters for five generations. We know good and bad seasons are normal. But we never dreamed that the seawater itself would start killing our oysters in their first days of life.

At that age, oysters, clams and mussels are tiny and vulnerable. That's why scientists and shellfish farmers learned to rear young shellfish in tanks until they are hardy enough to survive, when they are then transferred to the wild. At the Whiskey Creek Shellfish Hatchery in Oregon, we sell larvae by the tens of millions to growers up and down the West Coast. When wild oysters have a bad reproductive season, a handful of hatcheries like ours have kept farms in business. The tasty shellfish end up on dinner plates all over the country—perhaps even yours.

But in 2007, batch after batch of oyster larvae died in our tanks. Our business was on the verge of bankruptcy. Shellfish growers feared they would be next; without seed, a farm can last only a few years. Nobody knew what was clobbering the young oysters.

Alan Barton, an oceanographer by training and manager at Whiskey Creek, solved the mystery. He knew the fish in his home aquarium tank were sensitive to changes in water

chemistry, so he began measuring pH in the water we pumped into our hatchery from the ocean. When the acidity was high, our larvae died.

I was skeptical at first – how could the very water we depend on now bring us to our knees? But scientists from Oregon State University and the National Oceanographic and Atmospheric Administration (NOAA) confirmed Barton's insights. Their findings appear in a new scientific paper[399] published last week.

Thanks to this experience, I've learned that our business is on the front line of what scientists call ocean acidification. Carbon dioxide from smokestacks, tailpipes and chimneys is pumped into the air and absorbed by the ocean, reacting with the sea water and making it more corrosive. The scientists have showed us that the acid resulting from increasing fossil fuel emissions combines with natural acid in the deep, carbon-rich water that upwells along the Pacific Northwest. The combination kills young oysters.

Lately some writers are looking for ways to dismiss ocean acidification as no big deal. I wonder how good these experts are at keeping tiny young oysters alive in corrosive water. This isn't theory or speculation—this is happening right now, to my livelihood. And it's not just one business. In Washington alone, the shellfish industry employs 3,200 people and is worth $270 million to the state's economy.

At Whiskey Creek, we've learned that when you're fighting to save your business—and your seafood supplies— it helps to know what you're up against. We now carefully monitor the acidity of the water, and avoid spawning oysters when carbon dioxide concentrations are high enough to kill them; we also treat the water to reduce its acidity. This has enabled us to stay in business for now.

But there are other signs of concern. Barnacles and wild mussels used to clog our pipes so fast that we had to replace them three times every summer. Now the pipes barely need cleaning; a worrying sign that changes in ocean chemistry impacts more than oysters.

We need more states to learn from those of us on the front lines of ocean acidification. The governor of Washington recently convened an expert panel of scientists, stakeholders and policymakers to advise the state's leaders on how to understand, mitigate and adapt to acidification. That's a good beginning and it's a model that other states can follow, to address ocean acidification head on."

Mark Wiegardt and his wife Sue Cudd run the Whiskey Creek Shellfish Hatchery near Tillamook, Oregon

Expansion of Areas of Low Oxygen ("Hypoxic") Waters

Hypoxia (low oxygen levels) can have profound effects on marine ecosystems leading to large-scale die-offs, local damage to fisheries, and long-term loss of biodiversity. While some areas of hypoxic waters – particularly in deep ocean waters – are natural and important parts of marine ecosystems, climate change and other human activity may now expand hypoxic waters into areas closer to the ocean surface.[400] Multiple factors may contribute to this phenomenon:

- Increasing sea-surface temperatures results in less oxygen taken up at the ocean surface and hinders mixing into the deeper ocean.
- Nutrient inputs into coastal waters, including nitrogen (both from air pollution emissions and water pollution runoff from land), can lead to especially hypoxic and acidified water at very local scales.

Expanding hypoxic zones have been occurring off the California coast during the past 20 years.[401] Effects on marine species and ecosystems include altered microbial processes, changes in predator-prey dynamics, and shifts in the abundance and accessibility of commercially and recreationally fished species. Increases in the frequency, duration, intensity, and spatial extent of rapid intrusions of hypoxic waters are also likely; and tracking these events and their impacts will be important.[402]

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

In the last five years, there has been significant action on many scales to address climate impacts to ocean and coastal resources. Almost all coastal and bay counties are involved in some level of climate-related planning initiatives and efforts, some more broadly focused than others. There are a number of guidance documents, modeling and mapping, vulnerability assessments, and funding opportunities that are emerging in tandem with regional climate change collaboratives that support research, monitoring, and implementation at multiple scales including local, regional, and state wide efforts. Some actions with wide-ranging policy impacts that have been taken by the State are highlighted below.

Sea-level Rise Studies Funded by the California Energy Commission's Public Interest Energy (PIER) Program - PIER was not reauthorized in 2011, but during its existence, it helped to fund a number of critical studies relating to sea-level rise in California. In addition to the August 2009 report on anticipated sea-level rise scenarios for California discussed above, there was also a companion report entitled The Impacts of Sea Level Rise on the California Coast which identified vulnerabilities and cost impacts of anticipated sea-level rise. That report included demographic analysis that indicates large numbers of Californians are at risk from impacts of sea-level rise, including low-income households and communities of color. The report also found nearly $100 billion (in year 2000 dollars) worth of property, measured as the current replacement value of buildings and contents, at risk from a 100-year flood event with a 55 inch sea-level rise if no actions are taken -

with an overwhelming two-thirds of that property concentrated on San Francisco Bay and the majority of the at-risk property is residential. [403]

Follow-up PIER studies produced reports on The Impacts of Sea Level Rise in the San Francisco Bay,[404] Characterizing Uncertain Sea Level Rise Projections to Support Investment Decisions,[405] Impacts of Predicted Sea Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region,[406] City of Santa Barbara Sea Level Rise Vulnerability Study,[407] Coastal Flooding Projections: 2000-2100,[408] and Adapting to Sea-Level Rise: A Guide for California's Coastal Communities.[409]

2012 Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future - National Research Council Report ("NRC report") - California Executive Order S-13-08 directed state agencies to plan for sea-level rise and coastal impacts, and it also requested the National Academy of Sciences to establish a committee to assess sea-level rise to inform these state efforts. The states of Washington and Oregon, the U.S. Army Corps of Engineers, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey joined California in sponsoring a study to evaluate sea-level rise in the global oceans and along the coasts of California, Oregon, and Washington for 2030, 2050, and 2100. The results of the study were released in 2012, and have informed California's Sea-level Rise Guidance Document (described below).

2013 State of California Sea-level Rise Guidance Document - The Coastal and Ocean Working Group for the California Climate Action Team (CO-CAT) has developed guidance for incorporating sea-level rise projections into planning and decision making for projects in California. The guidance document recommends scenario-based planning and decision-making aimed at reducing risk.

Sea-level Rise Resolution - On March 11, 2011, the OPC unanimously adopted a Sea-Level Rise Resolution to support state agency integration of sea-level rise into decision-making. Outreach was conducted to over 45 state agencies, commissions, and other governmental bodies and entities implementing projects or programs using state funding or on state property, including on lands granted by the Legislature. It was urged that consideration of the risks posed by sea- level rise are incorporated into all decisions regarding areas or programs potentially affected by sea-level rise. The work of integrating of sea-level rise considerations has begun at entities like the Sacramento-San Joaquin Delta Conservancy, the Strategic Growth Council, and other entities named in this document; however, additional integration is still needed.

Coastal Commission Sea-Level Rise Policy Guidance - In October 2013, the California Coastal Commission released a Draft Sea-Level Rise Policy Guidance document which provides recommended steps for addressing sea-level rise in Coastal Commission planning and regulatory actions. The guidance document will be finalized in 2014.

Guidance on Incorporating Sea Level Rise in Transportation Project Planning – These types of guidance documents developed by Caltrans are further described in the Transportation section of this document.

First-of-its-kind Statewide Network of Marine Protected Areas - On December 17, 2012, 19 Marine Protected Areas (MPAs) became effective in the Northern California coastal region, completing the nation's first statewide coastal system of marine protected areas. The key agencies leading MPA development and oversight are CDFW, FGC, OPC, State Parks, and Parks and Recreation Commission.

The coastal portion of the statewide network of MPAs now includes 119 MPAs of varying designations, five recreational management areas and 15 special closures, that combined cover approximately 16 percent of all open coast state waters. Approximately half of California's new or modified MPAs are multiple use areas, with the remaining in no-take areas. The MPAs were developed to be consistent with California's landmark Marine Life Protection Act (MLPA), the first statutory mandate of its kind in the nation. The MLPA required that California's MPAs be redesigned based on the best available science, with identified goals and objectives, and with the advice and input of stakeholders and experts to create a statewide network.

The north coast MPA regulations include a provision for federally recognized tribal members to continue harvesting and gathering fish, kelp and shellfish as they have been doing since time immemorial. The provision will allow non-commercial take to continue where there is a record of ancestral take by a specific tribe, consistent with existing regulations, in MPAs other than State Marine Reserves.

Because climate impacts such as ocean acidification, changing ocean temperatures, rising sea levels, and changes in oxygen levels are compounding other stressors on marine and coastal habitats such as pollution and overfishing - MPAs are increasingly recognized as a key tool for aiding marine and coastal habitats. MPAs are also important areas for continued scientific research on climate impacts on marine and coastal ecosystems.

OceanSpaces is an online community that has been developed to steward and share MPA monitoring data and results, and better facilitates communication among the diverse audiences interested in the health of California's ocean.[410]

[See Box 50: Aerial photo sequence below by Charles C. Benton of restoration images from 2008 – 2010; used with permission.]

Box 50

South Bay Salt Pond Restoration Project - Under the leadership of Senator Dianne Feinstein, the South Bay Salt Ponds were purchased in 2003 from Cargill Inc. Funds for the purchases were provided by federal and state resource agencies and several private foundations. The 15,100 acre purchase represents the largest single acquisition in a larger campaign to restore 40,000 acres of lost tidal wetlands to San Francisco Bay. CDFW, California State Coastal Conservancy, and the U.S. Fish and Wildlife Service conducted a four-year public process to design a restoration plan for the property. The final plan was adopted in 2008 and the first phase of restoration started later that year. This large restoration effort is designed to establish a thriving wetland ecosystem, provide a critical natural buffer against the effects of climate change and sea-level rise, and provide carbon storage benefits.

Aerial photo sequence by Charles C Benton of restoration images from South Bay Salt Pond A21 Plateau. Used with permission.



April 2008 Sept 2009 May 2010 Oct 2010

Installation of Equipment to Aid Flood Monitoring and Forecasting DWR's Enhanced Flood Response and Emergency Preparedness program and NOAA's Hydrometeorology Test bed program and have collaborated in a $25 million project to improve monitoring and forecasting of "atmospheric rivers" (or the powerful winter systems, sometimes called "pineapple express" storms) that are responsible for most of California's major floods. Construction of four coastal observatories in 2013 – in Eureka, Bodega Bay, Big Sur, and Santa Barbara – will improve flood watch and flood warning information that can be provided to local emergency responders. The Western States Water Council has called for West-wide of expansion of this 21st century observing system for extreme precipitation, recognizing the value of what has been installed in California and the potential for additional West Coast offshore observations to further improve forecasting capability.

California Coastal Commission - Local Coastal Programs (LCPs) are basic planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs are submitted to the Coastal Commission for review for

consistency with California Coastal Act requirements. The Coastal Commission is working with local governments to address climate change through LCPs and planning to reduce risks from climate change. Recent certified LCPs that have incorporated policies to minimize risks from sea-level rise impacts include Dana Point, Marina Del Rey, and Redondo Beach. The Coastal Commission is in the process of developing more specific guidance for addressing sea-level rise and other climate change related land use and coastal resource protection issues into LCPs. In addition, the Ocean Protection Council has approved $2.5 million in grant funds for local governments to update LCPs to address sea-level rise and as of June 2013, the Conservancy, OPC, and Coastal Commission are in the process of administering the new grant program. In addition, Governor Brown and California Legislature approved an augmentation of $4 million to the fiscal year 13-14 budget of California Coastal Commission ($3 million for state operations and $1 million grant to local governments) for local governments and the Coastal Commission to prepare, update, amend and review Local Coastal Programs including an emphasis on climate change issues. The Coastal Commission is working with the Administration to provide information to support long-term funding to address the critical need to update LCPs and include climate change adaptation. Continued funding for this work is necessary to be successful.

Bay Conservation & Development Commission-Sea Level Rise Vulnerability Assessments
The San Francisco Bay Conservation and Development Commission was one of the first coastal management agencies in the country to work collaboratively with the U.S. Geological Survey and the PIER program to prepare regional vulnerability assessment to rising sea levels that included evaluating public policy implications and identification and adoption of enforceable policies regarding resilience to sea level rise as part of its permitting process.

California Current Acidification Network (C-CAN) is a collaboration of interdisciplinary scientists, resource managers, industry and others from local, state, federal, and tribal levels dedicated to advancing understanding of ocean acidification and its effects on biological resources of the U.S. west coast.

The West Coast Ocean Acidification and Hypoxia Science Panel - California and Oregon have signed a Memorandum of Understanding to jointly sponsor a high-level science panel to help address the issue of ocean acidification and hypoxia. The panel will provide state-level decision makers with the knowledge needed to evaluate and develop action plans for these complex issues. The science panel will also identify the research and monitoring needed to contribute to a West Coast-wide assessment of ocean acidification and hypoxia, and address information and data gaps critical to resource management decisions.

Monterey Bay Shoreline Management Planning
The Monterey Bay National Marine Sanctuary (MBNMS) is a federally-protected marine area offshore of California's central coast and encompasses 276 miles of shoreline. The Sanctuary must authorize and can place conditions on any Coastal Commission permit for sea wall or

"armoring" projects below mean high tide. MBNMS convened a workgroup in 2003 with representatives from the Coastal Commission, U.S. Geological Survey, Caltrans, California Department of Boating and Waterways, U.S. Army Corps of Engineers, and scientists from local institutions to develop an action plan for a proactive, holistic, regional approach to coastal armoring. The plan includes a pilot program to investigate and assess environmentally sound alternatives to coastal armoring.[411]

Box 51

INNOVATIONS IN SHORELINE MANAGEMENT IN CALIFORNIA

Managed retreat at Surfer's Point

The Surfers' Point Shoreline Managed Retreat project is an effort in the City of Ventura to remove infrastructure near the coast and restore the natural beach. The project will provide more beachfront area for recreational use and function as a natural storm buffer. The California State Coastal Conservancy helped plan and fund the construction of this project. Other important project partners that worked with the City were Surfrider Foundation, State Parks, Ventura County Fairgrounds, and the Coastal Commission. Federal transportation funding helped construct the project. The project is a comprehensive response to severe shoreline erosion in the face of sea-level rise. The project is in the City of Ventura and involved relocating a bike trail, parking long and other access amenities away from the shoreline and restoring the beach and sand dunes.

Pacifica State Beach Managed Retreat, Beach and Estuary Restoration

Coastal erosion at Linda Mar State Beach threatened critical infrastructure and oceanfront property; while at the same time flood hazards from nearby San Pedro Creek caused periodic flood damage to the City of Pacifica. A managed retreat strategy was developed and implemented through a partnership of agencies, including the California State Coastal Conservancy, City of Pacifica, community groups, scientists and engineers. The project aimed for a combination of managed retreat and estuary restoration goals to reduce the coastal flood hazards. It is one of the first beaches to utilize managed retreat as a method of shoreline protection. In addition to sand replenishment (also called "beach nourishment"), it has restored habitat for four threatened and endangered species and enhanced public access with expanded trails and parking lots.

San Francisco Bay Living Shoreline-Nearshore Linkages Project

Living shoreline projects utilize a variety of structural and organic materials to stabilize to reinforce the shoreline, minimize coastal erosion, and maintain coastal processes while protecting, restoring, enhancing, and creating natural habitat for fish and aquatic plants and wildlife.[412] An innovative pilot project was constructed in the San Francisco Bay in 2012 to test the implementation of living shorelines as an adaptive method to provide habitat functions and values, as well as cope with sea-level rise and other environmental changes related to climate change. The project includes a comparison of multiple techniques to restore critical eelgrass and native oyster habitat at two sites. The California State Coastal Conservancy is leading this project which was designed and implemented

through a multi-agency partnership.

ACTIONS NEEDED FOR SAFEGUARDING OCEAN AND COASTAL ECOSYSTEMS AND RESOURCES

Improve Management Practices for Coastal and Ocean Ecosystems and Resources and Increase Capacity to Withstand and Recover from Climate Impacts

(1) Hazard Avoidance for New Development

In order to minimize the adverse effects of sea-level rise and storms, it is important to carefully consider decisions regarding areas vulnerable to flooding, inundation and erosion. The state should not build or plan to build, lease, fund, or permit any significant new structures or infrastructure that will require new protection from sea-level rise, storm surges or coastal erosion during the expected life of the structure, beyond routine maintenance of existing levees or other protective measures, unless there is a compelling need (*e.g.* coastal-dependent marine terminals or marinas that must necessarily be sited in areas at risk). If the state is building or planning to build, lease, or permit structures that will require additional new expenditures for sea-level rise protection during the expected life of the new structures, the state should ensure that the project proponent:

a) Minimizes risks through siting, design and engineering;
b) Ensures viable funding sources for building, monitoring and maintaining the new sea-level rise protections;
c) Ensures that any new protections must consider how risk changes over time, ensures that actions to reduce risk in the short-term do not increase risk in the long-term; and ensures that any new protections are capable of being augmented over time;
d) Designs protection in a manner that maximizes conservation of natural resources and public access.

As discussed in the Emergency Management section of this document, it is important to note that actions to reduce risk in the near term (such as developing protections for near-term sea-level rise) may encourage development patterns that actually increase risk in the longer term. Development must be carefully considered in light of local vulnerabilities, principles laid out in this section, and any recommendations resulting from the State Coastal Leadership Group described below.

(2) Encourage Innovative Design of New Structures/Infrastructure in Areas Vulnerable to Sea-level Rise

Where there is a compelling need for structures and infrastructure in areas susceptible to sea- level rise, storm surge and erosion, best available material science and structural design should be utilized to minimize pooling water on roadways, ensure maximum durability and public safety, and otherwise incorporate expected impacts into building plans.[413] The State should propagate relevant design standards for engineering and construction in areas

susceptible to sea-level rise, storm surge and erosion and priority should be given to development of green or nature-based infrastructure when appropriate. Efforts in other states affected by hurricanes (Florida, Georgia, Louisiana, etc.) should be studied to illuminate the potential impacts of severe storms in California.

(3) Enhance Integration of Climate Risk Considerations, Including Extreme Weather Events and Sea-Level Rise, into Emergency Management Activities

For a discussion of the integration of climate risks considerations into emergency management activities, please see the Emergency Management section of this document.

(4) State Coastal Leadership Group

Although there is a lot of work in California to address sea-level rise, coastal storms and erosion, the urgency of the situation requires more active management and coordination to understand what is working on local, regional and state levels that can be expanded and to leverage resources and better integrate work in an on-going manner. The OPC will lead an inclusive, collaborative, science-based process to inventory existing actions to reduce risks from sea-level rise, storms and erosion and to collaborate with others to improve the capacity of entities at multiple scales to more effectively act to reduce these risks. OPC will work with the California Coastal Zone Management Agencies (Coastal Commission, BCDC and Coastal Conservancy), the state coastal land owners (State Lands Commission, Department of Parks and Recreation) and other state entities and with consultation with local land use planning authorities, tribes, federal partners, and other stakeholders.

This process will involve activities such as:

- Conducting a science needs assessment in partnership with the CA Ocean Science Trust and the OPC's Science Advisory Team to identify key information needs and the opportunities for existing and new science to inform management and reduce risks.
- Engaging state partners to assess progress and future plans and leverage resources.
- Engaging non-state entities working on many scales to learn what is working, what could be expanded and what else needs to be done.
- Collaborating with FEMA, NOAA, USGS and the Army Corps of Engineers and state agencies such as the Coastal Conservancy, Coastal Commission, BCDC and the Department of Water Resources on improving mapping of areas at risk of flooding due to sea-level rise, storms and shoreline change.
- Bring resources and expertise to assist the State Lands Commission, Coastal Commission and others address the issue of changing boundaries between public trust lands and private lands.
- Providing resources on funding sources and mechanisms for supporting actions to understand and reduce risks on many scales.
- Describing a range of tools that can be utilized to reduce risk while maximizing conservation of natural resources and public access, consistent with the public trust doctrine.
- Supporting state agencies to have the capacity to take effective action.

- Improving coordination and sharing of information needed to leverage resources and improve consistency and effectiveness.

The OPC will consider how to support innovative practices including managed retreat and use of natural processes and habitats to reduce risk from flooding, inundation and erosion; and will also address expected impacts to public access and use of beaches, trails and recreational areas along the coast.

(5) Support Pilot Projects for Innovative Shoreline Management Techniques

Particularly during the State Coastal Leadership Group described above, the state should continue to support local and regional governments and other entities implementing innovative shoreline management projects. Pilot project may provide valuable insights into best practices for managing shorelines in the era of rising sea levels and storm surges.

(6) Continue to Study and Support Investment in Cost-Effective Green Infrastructure to Reduce Flood Risk and Stormwater Runoff and to Maximize Associated Co-Benefits

As noted above, there can be significant cost savings and co-benefits associated with the use of green infrastructure, such as wetland restoration and urban forestry, to improve water quality and flood protection. Co-benefits may include greenhouse gas reductions that can reduce the pace and scale of climate impacts, habitat for wildlife, and improved air quality. For example, wetlands have the potential to reduce subsidence in the Delta, thus reducing pressure on levees which in turn reduces risk of levee failure and flooding. *See DWR's Twitchell Island Project in the* Biodiversity and Habitat *section for more information.*

(7) Addressing Climate Impacts in Local Coastal Programs and General Plan Guidelines

Under existing law, Local Coastal Programs (LCPs) and General Plans are key tools for addressing sea-level rise, storms and shoreline change. The Coastal Commission is in the process of developing more specific guidance for addressing sea-level rise and other climate change related land use and coastal resource protection issues into LCPs. Continued investments to update LCPs is necessary since most LCPs currently do not include plans for reducing risk from sea-level rise. In addition, the Governor's Office of Planning and Research (OPR) will also be providing a 2013 update to its General Plan Guidelines (GPG 2013). The GPG 2013 will be a resource for decision-makers, planners, and the public for the development and implementation of local general plans. The GPG 2013 will include advice on how general plans can address needed preparation for climate impacts.[414]

(8) Support and Continue Progress Toward a More Integrated Ecosystem Approach to Management of Ocean Resources

Ocean acidification, changing ocean temperatures, rising sea levels, changes in oxygen levels, changes in ocean circulation, more extreme weather events, and cumulative and synergistic impacts, are rapidly changing marine habitats. Species ranges, species interaction, reproductive success, and many other variables are shifting. There is need to move away from a focus of only looking to management approaches that focus on single-species management. A more integrated approach might include the tenets of ecosystem

management, a process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political and cultural needs of current and future generations. While recognizing the importance of a more integrated approach, it is important to recognize that managers will continue to work within the confines of existing regulatory requirements, laws, and responsibilities as they relate to single species.[415] A more integrated approach will be better suited to highly dynamic changing variables. For instance, the Pacific Fishery Management Council is developing an ecosystem-based approach to managing fish stocks in the offshore waters of Washington, Oregon, and California. Ecosystem-based management as defined by the Council "recognizes the physical, biological, economic, and social interactions among the affected components of the ecosystem and attempts to manage fisheries to achieve a stipulated spectrum of societal goals, some of which may be in competition."[416] The Pacific Fishery Management Council is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976.[417] In addition, the Delta Reform Act of 2009 adopted an ecosystem approach to restoring the Delta, along with the co- equal goal of improving statewide water supply reliability.[418]

(9) Continued Development of State Sediment Master Plan and Sediment Management Activities

The Coastal Sediment Management Working Group (CSMW) is a collaborative taskforce of state, federal, and local/regional entities, chaired by the U.S. Army Corp of Engineers South Pacific Division and the California Natural Resources Agency.[419] The CSMW is developing a comprehensive state Sediment Master Plan ("SMP") for the conservation, restoration, and preservation of valuable sediment resources along the coast of California. Sediment includes materials such as gravel, sand, silt and clay formed by natural erosion such as precipitation, wind, and stream flows. Humans have substantially altered natural sediment transport processes within California's coastal watersheds, reducing storm protection, habitat and recreation along the coast. The goal of the SMP is to reduce shoreline erosion and coastal storm damages, provide for environmental restoration and protection, increase natural sediment supply to the coast, restore and preserve beaches, maintain or improve coastal access, improve water quality along coastal beaches, and optimize the beneficial use of material dredged or excavated from ports, harbors, wetlands, and other sediment sources.[420] For instance, the types of hybrid levees discussed in Box 47: "Wetlands" - Nature's Flood Protection" would utilize dredged sediment from nearby flood control channels for marsh restoration. That dredged sediment is currently disposed of in landfills.[421] Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS) Program is implemented by state, federal and local partners, including the Bay Delta Conservation and Development Commission (BCDC). BCDC is working, in part with the CSMW, to prepare sediment management plans that integrate the successful Long Term Management Strategy for dredging with flood control planning, wetlands restoration and other aspects affecting sediment processes throughout the San Francisco Bay system.[422]

(10) Water Management Responsive to Saltwater Intrusion Issues

For information about saltwater intrusion and water management activities, please see the recommendations for continuing to mainstream climate considerations into water management in the Water section of this document.

Better Understanding of Evolving Trends that May Impact Ocean and Coastal Ecosystems and Resources

(1) Better understand the impacts and opportunities associated with offshore renewable energy development

Renewable energy development helps to reduce greenhouse gas emissions from fossil fuel use and can help reduce the pace and scale of climate impacts on ocean and coastal ecosystems and resources. M arine renewable energy has the potential to play a role in meeting California's renewable portfolio standards and energy demand; however, marine renewable energy development can also have some negative impacts on coast and ocean ecosystems and resources including noise and light pollution and impacts on avian and other flying species. In response, the California Marine Renewable Energy Working Group; is an interagency group chaired by the California Ocean Protection Council was formed with the following goals:

- Address uncertainties in regulatory processes for marine renewable energy projects in California;
- Address the information needs of state agencies and stakeholders to inform potential impacts and user conflicts with marine renewable energy projects; and
- Facilitate the development of agreements and joint state-federal committees to improve coordination of state and federal permitting processes.

As noted above, it will be important to understand the benefits and impacts of ocean renewable energy development in the larger context of other expected climate impacts and traditional stressors on ocean and coastal ecosystems and resources.

(2) Support Reform of Federal Flood Insurance Program

As noted above, there were $68 billion of California assets insured under the Federal Flood Insurance program as of August 2012. However, continuing issues with respect to the financial integrity of NFIP may pose serious threats to the economic well-being and health of Californians. The State should support appropriate continuing reform of NFIP and implementation of the 2012 Biggert-Waters Flood Insurance Reform Act[423] while engaging in risk communication efforts and other efforts described in this chapter.

Better Understanding of Climate Impacts on Ocean and Coastal Ecosystems and Resources

(1) Further Vulnerability Assessments and Cost Analyses

Additional vulnerability assessments and cost analyses are needed to fully assess California's risks to climate impacts and appropriate responses to reduce those risks. Every community potentially impacted by sea-level rise will need to prepare vulnerability and cost assessments

that include but are not limited to consideration of recreational and environmental losses to the evaluation of cumulative and synergistic impacts, the importance of hazard avoidance, and the importance of adequately accounting for the environmental and recreational costs and benefits of strategies. Appropriate resources are needed for local governments and communities to not only prepare vulnerability assessments and cost analyses but also for the training and tools to apply the results to adaptation planning and implementation. Specifically, local vulnerability assessments are needed at scales that enable and inform planning and project implementation. The State has already invested significant resources to conduct and support vulnerability and cost assessments across sectors and a sampling of additional needs are listed below. An Adaptation Planning Guide for local and regional governments has also been developed.[424]

a) Water Supply, Wastewater and Stormwater: An assessment of the state's wastewater and stormwater facilities is needed to identify vulnerabilities of aging infrastructure and system capacities in light of more extreme weather events and sea-level rise projections in the NRC report and as incorporated into the OPC's guidance to state agencies on planning for sea-level rise. Any such assessment should include cost analysis of system upgrades and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
b) Hazardous Waste Sites and Facilities: An assessment is needed for toxic release vulnerabilities from the state's hazardous waste facilities and hazardous waste sites in light of more extreme weather events and sea-level rise projections in the NRC report. The assessment should include recommendations for addressing vulnerabilities, including cost analysis of recommendations and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
c) Underground Storage Tanks (USTs): An assessment is also needed to address toxic release vulnerabilities from the state's USTs, not just in coastal areas, but also in inland areas susceptible to flooding. This need is further described in the Water section of this document.
d) Energy and Transportation Infrastructure: Additional needs with respect to vulnerability studies for energy and transportation infrastructure are described in the Energy and Transportation sections of this report.
e) Cumulative and Synergistic Impacts: As noted above, ocean acidification, changing ocean temperatures, rising sea levels, and changes in oxygen levels are compounding other stressors on ocean and coastal habitats and resources such as pollution and overfishing. Development of ocean renewable energy projects, and other offshore energy development, may also present new stressors on ocean and coastal habitats and resources. The cumulative impact, and any synergistic dynamics among the stressors, is not well understood, and the potential implications for commercial fish and shellfish species and human health are also not fully understood. A more robust scientific understanding of cumulative and synergistic impacts, accompanied by a science-informed trade-off analysis framework, is critical to supporting innovative management

techniques that are responsive to the new, and rapidly changing, marine conditions. Further, there is a need for OPC to continue supporting data layers within the California Geoportal to underpin decisions that will be made by permitting agencies. Funding support to enable studies of such cumulative and synergistic impacts is needed.

f) Economic Costs to Californians. As noted above, there have been some studies to date of the economic impacts of sea-level rise to some California communities, and there has been some study of potential impacts from more extreme weather events. However, more information about the cost of expected climate impacts is needed to inform and evaluate management options. Needed economic cost studies include resource economics studies that study the value of services provided by ocean and coastal investments (e.g. improved water quality, enhanced soil stability, recreation and tourism opportunities, benefits from intact ecosystems, etc.). Funding support to enable such studies is needed.

g) Marine Species and Ecosystems. See Biodiversity and Habitat section of this document for information regarding the need for a comprehensive, state-wide vulnerability assessment for marine species and ecosystems in California.

(2) Continued Modeling Scientific models are tools used to generate predictions and explanations. Models must be built, tested for accuracy, and revised.[425] Models add greatly to our understanding of the possible outcomes from and consequences of changes to a system.

Along the coast, the main drivers of change will be changing water conditions (water level, waves, storms, extreme events, acidification, or temperature), and changes to the shoreline (sediment supplies, addition or removal of structures, development patterns). Models may be used to predict changes in the California shoreline, expected storm surges, pollution inputs, estuarine and near shore impacts, and sediment movement in coastal areas in the era of climate change. Modeling is important to examining the full extent of consequences associated with various sea-level rise projections along with storm wave conditions and the dynamics at coastal inlets. Continued development and refinement of models for climate impacts on California's ocean and coastal ecosystems and resources will be important. Funding to support such work will be needed.

(3) Continued Support and Investment in Monitoring Efforts

Monitoring changes to biological, chemical and physical processes is critical to continue advancing knowledge of climate impacts on coastal and marine ecosystems and resources and to support informed management responses that incorporate the best-available science on changing ocean and coastal conditions. Partnerships to enable funding and staffing of these efforts will be important. The Ocean Protection Council (OPC), in partnership with the Ocean Science Trust and the OPC's Science Advisory Team, will lead a process to identify priority monitoring needs to improve management of ocean and coastal resources under a changing climate. This process will address topics such as:

a) Ongoing monitoring and assessment of coastal inundation damages, for purposes of

statewide flood planning;
b) Monitoring of offshore meteorological parameters and wave heights to obtain data for storm surge modeling and meteorological forecasting; and
c) Estuarine monitoring for changes to wetlands, sediment, changes in salinity, etc.

Information Sharing and Education

(1) Invest in Risk Communication Efforts, Emphasizing Disclosure of Risks that Have Not or Cannot Be Addressed in an Economically Feasible Manner[426]

The State should invest in efforts to raise public awareness and understanding of sea-level rise and accompanying risks of flooding, erosion, infrastructure and property damage, and permanent submersion of coastal lands, salt water intrusion, toxic releases and other public health impacts. The state should also invest in efforts to raise awareness of the limitations of flood insurance and disaster relief, and the costs associated with response and recovery efforts associated with various anticipated sea-level rise impacts. Finally, the state should invest in efforts to raise awareness regarding options to protect new and existing structures and infrastructure from sea-level rise; awareness raising efforts should include discussion of any relevant benefits from employing green infrastructure, cost estimates, awareness and support for protecting vulnerable communities, and funding sources for protective measures. For example, California State Parks are one important venue to communicate risk and disseminate information. There are 114 coastal units in the State Park System – encompassing some 340 miles of the coast, and including coastal portions of State Parks, State Recreation Areas, Natural Reserves, and State Beaches. In 2011, 34 million visitors attended coastal parks. Each of those visitors presents an opportunity to communicate about climate change.

(2) Improve Maps and Tools and Provide Training to Incorporate Best-Available Climate Science into Planning and Operation and Management Decisions for Assets at Risk from Sea-level Rise

As sea-level rise projections and storm surge projections continue to be refined, maps and tools reflecting those projections must be developed and updated to support flood management planning, hazard planning, capital investment and development decisions. Training in the use of these maps and tools must also be provided so that best available knowledge about expected impacts can be fully integrated into routine governmental decision making, for instance for land use planning, transportation planning and operation and management, and the siting and operation and management of energy infrastructure.[427]

(3) Sustainability Modeling Tools for Fishery Managers

Utilizing data collected from monitoring efforts, and best available understanding of cumulative and synergistic impacts from climate and other stressors, sustainability modeling tools should be developed to assist fishery managers. These tools should be consistent, to the extent it serves the State, with relevant ecosystem-based management approaches propagated by the Pacific Fisheries Management Council as described above. California's network of MPA's provide scientist with an unprecedented opportunity to utilize and create

tools to assess trends in oceanographic conditions that fishery scientists and managers may then use to determine the effects of these changing conditions on fisheries.

(4) Public Health Risk Communication Efforts

As noted above, climate impacts to ocean and coastal ecosystems and resources have numerous public health implications. Flooding, permanent inundation, and more extreme weather events may cause: toxic exposures from USTs and hazardous waste sites and facilities, increased pollution from stormwater and wastewater systems, contamination of fish and shellfish, and serious property damage including damage to transportation and energy systems and critical infrastructure including hospital facilities. In-situ instrumentation will help provide better data to inform needed beach closures to limit health risk exposures and consumption advisories. CDPH and SWRCB already have programs in place that could be used for these continuing public health risk communication efforts.

Box 52

California Ocean and Coastal Ecosystems and Resources

Given the myriad facets of California's ocean and coastal assets, many different state entities play an important role with respect to California's ocean and coastal ecosystems and resources. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate impacts.

California Coastal Commission (Coastal Commission) was established by voter initiative in 1972 (Proposition 20) and later made permanent by the Legislature through adoption of the California Coastal Act of 1976. The California Coastal Commission works in partnership with coastal cities and counties and is committed to protecting and enhancing California's coast and ocean for present and future generations. It does so through careful planning and regulation of environmentally-sustainable development, rigorous use of science, strong public participation, education, and effective intergovernmental coordination. The Coastal Commission works in partnership with local governments to develop local land use plans and implementing ordinances, or Local Coastal Programs. The plans are developed by local governments and certified by the Commission, and are a key mechanism for addressing sea-level rise and other climate change impacts at the local level throughout the state.

California Department of Fish and Wildlife (CDFW) established in 1927, is the state agency designated to protect, maintain, enhance, and restore California's marine and terrestrial ecosystems and species for their intrinsic and ecological values. CDFW is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific and educational uses. CDFW also prevents, prepares for, and responds to spills of oil and other deleterious materials, primarily in the marine and coastal environment.

California Department of Parks and Recreation (California State Parks or CSP) is a trustee agency responsible for managing 114 coastal parks that cover over 340 miles of the California coast. Those parks include state beaches with amenities such as campsites and

picnic areas, as well as coastal rivers, estuaries, and dune systems, many protected as natural preserves and state wilderness areas. State Parks also provide access to state marine parks and other marine protected areas. In 2011, 34 million people visited state beaches and other coastal parks. CSP's Division of Boating and Waterways (DBW), is responsible for planning, developing, and improving facilities on state-owned and state-managed properties, and funds applied research on coastal waves, beaches, sea level, and climate change. CSP's mission is to provide for the health, inspiration and education of the people of California by helping to preserve the state's extraordinary biological diversity and its most valued natural and cultural resources while also providing opportunities for high-quality outdoor recreation.

California Department of Public Health (CDPH) was established on July 1, 2007, through enactment of SB 162, which vested responsibility for public health programs in CDPH. CDPH assists local health agencies in addressing microbiological contamination of beaches and recreational waters.

California Department of Toxic Substances Control (DTSC) which began as a unit within the Department of Health Services in the early 1970s, protects California's people and environment from harmful effects of toxic substances through the restoration of contaminated resources, enforcement, regulation and pollution prevention.[428]

California Department of Transportation (Caltrans) with origins dating back to 1895, is the state agency responsible for transportation planning, construction, and maintenance of the State Highway system. Caltrans oversees significant transportation infrastructure located in coastal areas, including highways and bridges.

California Department of Water Resources (DWR) established in 1956, is responsible for managing and protecting California's water resources and supplies. DWR includes a Division of Flood Management, established in November 1977, and has been instrumental in working on Enhanced Flood Response and Emergency Preparedness.

California Energy Commission (CEC) established in 1974, is the state's primary energy policy and planning agency. As further discussed in the Transportation and Energy sections of this document, the CEC aids in planning and managing energy resources that may be vulnerable to climate impacts including sea-level rise.

California Fish and Game Commission (FGC) established in 1870, is a Commission comprised of five members, appointed by the Governor and confirmed by the Senate. The Commission formulates general policies for the conduct of CDFW, but also has general regulatory powers, including deciding seasons, limits and methods of take for sport fish. The Commission also has responsibilities for invasive species; establishing/regulating use of Marine Protected Areas (MPAs); listing/delisting threatened and endangered species under the California Endangered Species Act; prescribing terms and conditions for issuance of licenses/permits by CDFW; and revoking or suspending privileges of those that violate

California Fish and Game laws and regulations.

California Ocean Protection Council (OPC) was established in 2004 pursuant to the California Ocean Protection Act. OPC is tasked with the following responsibilities: coordinating activities of ocean-related state agencies to improve the effectiveness of state efforts to protect ocean resources within existing fiscal limitations; establishing policies to coordinate the collection and sharing of scientific data related to coast and ocean resources between agencies; identifying and recommending to the Legislature changes in law; and identifying and recommending changes in federal law and policy to the Governor and Legislature.

California Ocean Science Trust (OST) is a nonprofit 501(c)(3) public benefit corporation established pursuant to the California Ocean Resources Stewardship Act of 2000 (California Public Resources Code Sections 36970-36973. OST's mission is to advance a constructive role for science in decision-making by promoting collaboration and mutual understanding among scientists, citizens, managers, and policymakers working toward sustained, healthy, and productive coastal and ocean ecosystems.

California State Lands Commission (SLC) The California State Lands Commission was created in 1938 and serves the people of California by managing and protecting over 4 million acres of sovereign land, including the beds of California's navigable rivers, lakes and streams, and the State's tide and submerged lands. The Commission's jurisdiction extends along the State's over 1,100 miles of coastline and offshore islands from the ordinary high water mark, as measured by the mean high tide line, except where there is fill or artificial accretion, to three nautical miles offshore. The Commission also has oversight authority over legislatively granted public trust lands, which includes the lands and waterways underlying California's major ports. All lands under the Commission's jurisdiction, granted or ungranted, are state assets held in trust for the benefit of the people of California and subject to the protections of the common law Public Trust Doctrine. The Commission also manages energy and mineral resource development and use under approximately 130 oil, gas, geothermal and mineral leases covering more than 95,000 acres of State-owned lands. The Commission is responsible for preventing oil spills by providing the best achievable protection of the marine environment at the State's 58 marine oil terminals through ensuring compliance with the State's Marine Oil Terminal Engineering and Maintenance Standards. Further, the Commission administers the State's Marine Invasive Species Program[429] and in that capacity is responsible for preventing or minimizing the release of invasive species in California waters from vessels that are 300 gross registered tons and above.

California Technology Agency (formerly the Office of the State Chief Information Officer) was established in 2007 and is a cabinet-level agency responsible for the approval and oversight of all state information technology projects, including Geospatial Information Systems (GIS) and the State of California Geo-Portal.[430] The California Geo-Portal includes maps of Marine Protected Areas, nautical charts, OPC's coastal viewer, and links to MarineBios an interactive map for users to visually explore marine and coastal spatial

planning data held in the California Department of Fish and Wildlife, Marine Region, Geographic Information System.

Delta Protection Commission (DPC) The mission of the Delta Protection Commission is to adaptively protect, maintain, and where possible, enhance and restore the overall quality of the Delta environment consistent with the Delta Protection Act, and the Land Use and Resource Management Plan for the Primary Zone. This includes, but is not limited to, agriculture, wildlife habitat, and recreational activities. The goal of the Commission is to ensure orderly, balanced conservation and development of Delta land resources and improved flood protection.

Delta Stewardship Council (DSC) was created in legislation to achieve the state mandated coequal goals for the Delta. "'Coequal goals' means the two goals of providing more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place." Since the waterways in the Delta are at sea level and are tidally influenced, and since may Delta islands are at or below sea level, the coastal effects of climate change will also affect resources within the Delta.

San Francisco Bay Conservation and Development Commission (BDC) is a state agency that was created by the California Legislature in 1965 with the charge of minimizing future unnecessary filling of the Bay and promoting its wise use and improving public access along its shoreline. BCDC has developed an extensive climate change adaptation program. Recent projects include new policies to address sea-level rise; a collaborative scientific study to characterize ecosystem services provided by wetlands and develop strategies to improve wetland resilience; and a collaborative project with NOAA to work with several local governments and special districts to identify the potential Bay-related impacts of sea-level rise and storms adaptation approaches that address identified vulnerabilities. BCDC is also working with the Association of Bay Area Governments collaborative planning and implementation process to develop a comprehensive regional resilient shorelines strategy that addresses rising sea level and storms as well as earthquakes.

State of California Coastal Conservancy (SCC) SCC, established in 1976, is a state agency that purchases, protects, restores, and enhances coastal resources, and works to provide access to the shore. SCC works in partnership with local governments, other public agencies, nonprofit organizations, and private landowners to develop plans and implement projects that protect and enhance coastal and marine habitats. In 2012, the Legislature specifically authorized the SCC to address the impacts of climate change including but not limited to extreme weather events, sea-level rise, storm surge, beach and bluff erosion, salt water intrusion, and other coastal hazards that threaten coastal communities, infrastructure, and natural resources.

State Water Resource Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting

statewide policy and supporting the pollution control programs administered by the Water Boards. The Ocean Unit of the SWRCB is responsible for the development of the California Ocean Plan and other significant regulatory documents for bays and estuaries. The Water Boards administer programs related to ensuring that beaches are safe to swim by regulating the discharge of waste and supporting the monitoring of coastal watershed and beach health. As further described in the Transportation section of this document, SWRCB's Underground Storage Tank (UST) Program protects public health and safety and the environment from releases of petroleum and other hazardous substances from tanks.

Governor's Office of Emergency Services (OES) OES is responsible for the coordination of overall state agency response to major disasters in support of local government. The Agency is responsible for assuring the state's readiness to respond to and recover from all hazards and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts. OES includes the Public Safety Communications Office.

Coastal assets and infrastructure are under the purview of various federal, state, regional and local agencies, and there are significant coastal assets under private ownership and management. As discussed in this chapter, management and planning for climate impacts on such assets and infrastructure requires a high degree of coordination.

The National Oceanic and Atmospheric Administration (NOAA) is a federal agency with origins dating back to 1807. NOAA's mission focuses on scientific work to understand and predict changes in climate, weather, oceans, and coasts; dissemination of scientific information; and conservation and management of coastal and marine ecosystems and resources. The NOAA Coastal Services Center is dedicated to working with state and local coastal programs to determine data needs and deliver not only the data, but also the tools and training needed to turn these data into useful information.[431]

The Federal Emergency Management Agency (FEMA) also plays an important role in flood disaster planning and preparation and response and recovery. Both NOAA and FEMA are important partners for the State of California with respect to ocean and coastal ecosystem and resource management.[432]

As discussed in this chapter, local and regional governments play an important role with respect to California's ocean and coastal ecosystems and resources.[433]

PUBLIC HEALTH

INTRODUCTION

Climate change creates significant and evolving challenges to the health and well-being of California's diverse population of nearly 38 million people, leaving some Californians particularly vulnerable.[434] Even in our large urban areas, our health is closely linked to a healthy and stable natural environment - clean air and water, green spaces, healthy fresh food, and a balance in the use of natural resources.

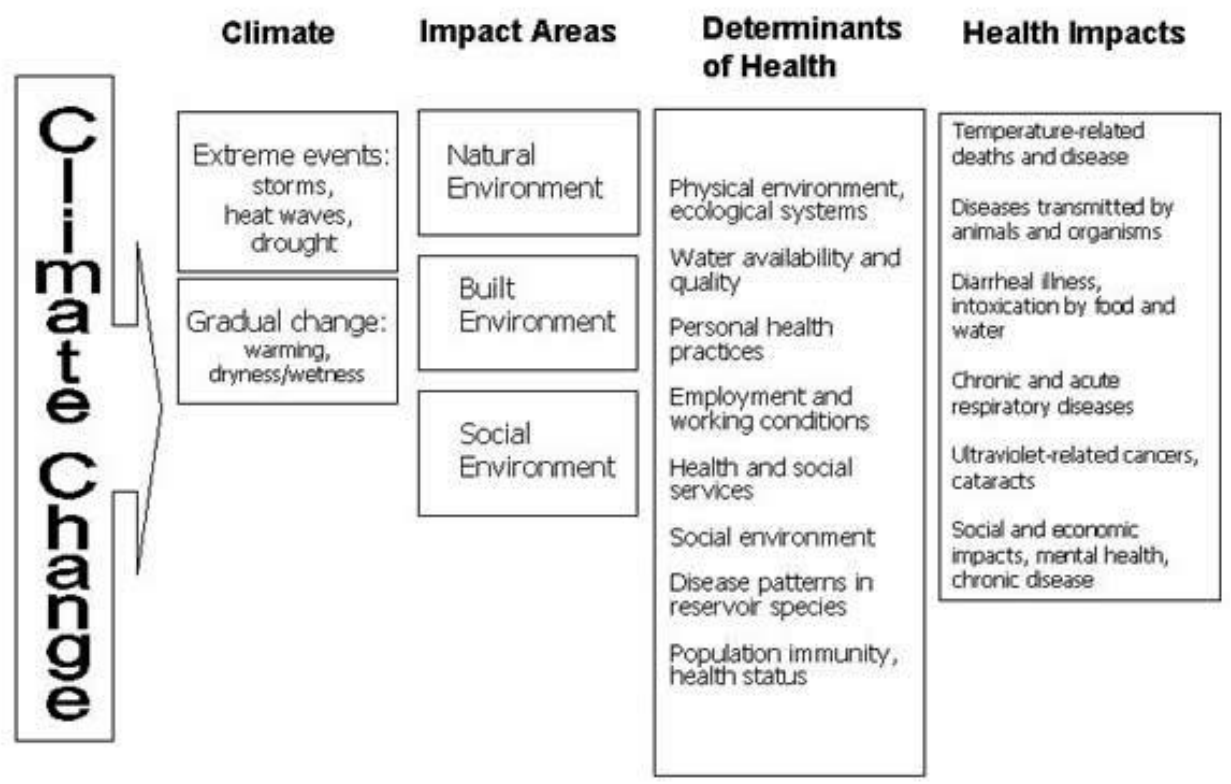
Climate change poses a variety of public health risks, including risks related to heat, outdoor and indoor air quality, water quality and availability, toxics, extreme weather events, flooding, workplace safety, mobility, infectious diseases, limitations on health services, and food safety and food security. Some of these risks are interrelated and interact with the underlying health status of different segments of our population. It is therefore important that climate adaptation planning efforts be integrated with ongoing health protection and health promotion efforts. California has begun to take significant steps toward addressing one of the leading effects of climate change, increasing temperatures and extreme heat, but much more remains to be done to protect and prepare our population. There are still actions needed to enhance our understanding of climate impacts on public health; to improve the capacity of communities to prepare, respond and recover from climate-related health risks; to better understand evolving trends – such as the increased use of energy efficient buildings or urban greening - that may impact public health in the era of climate change, and to continue information sharing and educational outreach on climate risks to public health.

Many different state entities play an important role with respect to public health in California. Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. Short descriptions of these entities are provided below in Box 53: California Public Health.

Climate Change Risks to Public Health

As shown below in Box 53 there are a number of determinants of health that include the natural and built environment, health and social services, and socioeconomic conditions. Climate change will result in new, progressively changing, average conditions as well as more extreme weather events, and these changes create significant new public health risks including risks associated with heat-related illness and mortality, respiratory impacts, infectious diseases, and changes in socioeconomic conditions that may impact well-being. These pathways are shown below.

Box 53



from Public Health Agency of Canada - Sustainable Health Development Strategy 2007-2010: Dynamics of Climate Change and Public Health
http://www.phac-aspc.gc.ca/publicat/sds-sdd/sds-sdd2-b-eng.php

Box 54

Health Equity & Climate Change

Section 152 of the California Health and Safety Code charges CDPH's Office of Health Equity with strategic planning and implementation of activities to address health equity.[435] Health equity is based on the principle that all people have the same opportunities for health. Some people have experienced socioeconomic disadvantage or historical injustice or may be culturally, linguistically or geographically isolated which can lead to a lower quality of life and increased risk of disease, injury and death. Public health programs such as the Health in All Policies Task Force[436] as well as private initiatives are working to address health inequities and create more opportunities to enhance productivity and health for all of the state's residents.

Climate change poses immense challenges for achieving health equity because, while all people are impacted by climate, populations that are socially and economically vulnerable will bear a disproportionate burden. These communities already experience higher rates of chronic

disease and lower life expectancy, and have fewer resources to plan and prepare for the additional impacts of climate change, presenting them with additional challenges for readiness, response and recovery. Health equity and environmental justice are therefore important goals in the state's climate adaptation and resilience planning efforts.

Increasing Temperatures and Extreme Heat

Increased heat in many parts of California will bring a greater risk from both higher ambient temperatures and extreme heat events. Higher ambient temperatures in California are already associated with increased mortality due to cardiovascular disease.[437] Extreme heat brings greater risk of death from dehydration, heat stroke, heart attack, and other heat related illnesses. In an extended California heat wave in 2006, over 650 deaths occurred.[438] By mid-century, extreme heat events in urban centers such as Sacramento, Los Angeles, and San Bernardino could cause two to three times more heat-related deaths than occurred in 2006.[439] Urban areas are more likely to experience "heat island" effects. Heat islands occur in urban areas where materials such as grass, trees, and soil are replaced by materials such as roads, buildings and other surfaces that increase absorption of sunlight and decrease the dissipation of heat.[440] Populations in cooler areas in California may also be at greater risk because individuals are less acclimatized to heat, people are less aware of behaviors that can reduce exposure (e.g. reduce activity level or go to an air conditioned location) or reduce physiologic stress (e.g. appropriate hydration), the built environment is not designed for warmer conditions (e.g. buildings lack adequate air conditioning), and such communities may not have plans for emergency heat mitigation measures.[441] In addition, the elderly and persons with chronic health conditions or who are on certain medications are at additional risk for heat illness.[442]

Box 55



Pictured: Community Cooling Center
http://www.epa.gov/climatechange/images/impacts-adaptation/WisconsinCoolingCenter.jpg

Air Quality Impacts

Higher temperatures are expected to increase the frequency, duration, and intensity of conditions conducive to air pollution formation. For example, temperature increases in the mid-range of what climate modeling suggests might be possible – would produce 75 to 85 percent more days with weather conducive to ozone formation in Los Angeles and the San Joaquin Valley. Air quality can be further compromised by increases in wildfires, which emit particulate matter, as well as any increased air pollution that results from any increased energy demands due to the changing climate.[443]

Changes in temperature, precipitation and extreme weather events, may also change the production, distribution, and dispersion of air-borne allergens ("aeroallergens") such as pollen, mold, and indoor allergens. While there are still no definitive conclusions on how climate will impact air-borne allergens, particularly at the regional level, models indicate that pollen will likely increase in many parts of the United States, there may be shifts in the seasonal timing of allergen production, while some allergen producing species may become extinct – new allergens may be introduced, and there may be increases in allergen content and potency. Allergies are the sixth most costly chronic disease category in the United States, collectively costing the health care system approximately $21 billion annually.[444] Pollutants and allergens can cause or aggravate a wide range of health problems including asthma and other debilitating and costly respiratory and cardiovascular diseases, which fall disproportionately on low income and persons of color.

Recent studies indicate that climate change may also negatively impact indoor air quality.[445] Outdoor air quality may worsen and intrude into buildings. Emissions from indoor sources, such as paints, pesticides, or building materials containing formaldehyde, may also be exacerbated by changing climate conditions such as increased heat. There may be more exposure to damp indoor spaces and exposure to mold, bacteria, and other biological contaminants as a result of increased extreme precipitation and flood events. Changing human behavior in response to climate change, such as increased air conditioning use, can also lead to poor indoor air quality, especially if heating and cooling systems are not properly maintained or if ventilation is poor.

Wildfire

As further described in the Forestry section of this document, more frequent and severe wildfires are projected to occur. This will not only impact air quality and create adverse effects on respiratory and cardiovascular health, as noted above, but may also cause property loss, displacement, injury and loss of life. Wildfire smoke affects not only the region in which a fire occurs but also creates hazards in adjacent areas through the transport of smoke.

Flooding

As further described in the Water and Oceans and Coastal Ecosystems and Resources sections of this document, both inland and coastal flooding are expected to increase as a result of climate change. This can lead to loss of life, injury, an increased mental health burden, loss of property and employment, displacement, economic disruptions, interruption of health services and mobility, and toxic or infectious exposures.

Changing Water Availability and Water Quality

As further discussed in the Water section of this document, the quality and quantity of water supplies available for drinking water, agriculture and other uses are threatened by various climate impacts including declining Sierra Nevada snowpack, salt water intrusion, changing precipitation patterns and flood risks.

Significant capital improvements are needed to continue to provide safe drinking water to the public. According to a national assessment of public water system infrastructure by U.S. EPA, California will require over $10 billion in capital improvements over the next twenty years for water systems to continue to provide safe drinking water to the public (including treatment and other infrastructure needs).[446] In the absence of climate change, California would still have significant need for infrastructure investments to continue to provide safe drinking water[447]; however, climate change is likely to make that need more acute. For instance, lower summer and fall flows may result in greater concentration of contaminants. These changes will challenge water treatment plant operations to produce safe drinking water.[448] In addition, any climate-related disruptions to electricity can also threaten the operation of electricity-dependent treatment plants and pumps.[449] U.S. EPA's national assessment is beginning to capture voluntary information regarding efforts to proactively address the potential effects of climate change at the water utility level, and has found relatively few projects are being undertaken to anticipate and prepare for climate risks.[450] U.S. EPA repeats the assessment

every four years, continues to refine its methodologies, and will be undertaking a new assessment in 2014.

Also as discussed in the Water section of this document, climate impacts may lead to intensified groundwater usage – particularly in the absence of improvements to water management systems; intensified groundwater usage may, in turn, result in land subsidence (land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to movement of materials below the Earth's surface, such as the withdrawal of underground water[451]). The effects of subsidence may include strain on houses and other structures, increased exposure to flooding in lowland coastal areas, water well casing failures, and changes to the elevation and gradient of stream channels, drains, and other water transport structures.[452] Subsidence can also permanently reduce the capacity of aquifers to store water.[453]

As further discussed in the Water section of this document, flood waters can be expected to contain excessive turbidities, especially in watersheds that have experienced fires, and that will challenge many of the existing surface water treatment facilities. Improvements to chemical feed and solids handling facilities may be required to ensure that proper treatment is provided to meet drinking water standards during flood flow conditions. These flows will likely occur throughout the winter and spring precipitation periods.

Food Security - Impacts to Nutrition and Food Safety

As further discussed in the Agriculture section of this document, climate change may impact food production and that may impact food prices and nutrition. Food cost increases disproportionately affect low income households and may impact nutrition as consumers chose low-nutrition, low cost food options in place of more expensive fresh fruits and vegetables.

Ironically, food insecurity is linked to obesity, which increases vulnerability to heat events. Potential impacts to food safety from climate change are discussed in relationship to infectious diseases below.

Infectious Diseases

Infectious disease (or *communicable disease*) is defined as an illness caused by a specific *infectious agent* or its toxic product that results from transmission of that agent or its products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector or inanimate environment.[454] Climate change impacts public health and infectious disease morbidity and mortality, primarily in illnesses caused by vector-, water-, and food-borne diseases.[455]

Vector-borne Infectious Diseases

Some infectious diseases are transmitted to humans by insects or other animals (transmitting insects or animals are called "vectors"); and these types of diseases are called "vector-borne" diseases.[456] Vector-borne diseases are among the most complex of all infectious diseases to prevent and control.[457] This complexity is attributable to the many factors that can contribute to the transmission, rate of transmission and evolution

of such vector-borne diseases, including, but not limited to, the vector populations, the disease pathogens carried by the vectors, ecological and climate patterns, and human interaction with the vector population.[458]
As noted in the 2009 California Climate Adaptation Strategy, three vector-borne diseases are of particularly concern in California: human hantavirus cardiopulmonary syndrome, Lyme disease, and West Nile Virus.

Changes in temperature and precipitation associated with climate change may lead to changes in the spread of vector-borne diseases. Climate change may alter the number of disease-carrying vectors. For instance, in places where there is increased rainfall, there may be more standing water where mosquitoes can lay eggs.[459] Similarly in places where winters are becoming milder, tick season may be extended.[460] Climate change may also change the way a pathogen spreads. For instance, West Nile Virus may be both positively and negatively impacted by increased temperatures; warmer temperatures allow the West Nile Virus to move faster through the transmission cycle[461], but may shorten mosquito life-spans.[462] In addition to increased disease risk, there is a risk of introduced vectors becoming established, along with the diseases they carry such as dengue. For instance, invasive *Aedes* species mosquitoes have been detected and may become established in some regions of California.[463]

Hantaviruses are principally rodent-borne diseases. Climate change may impact rodent populations through influencing food availability. Increased intensity and frequency of extreme climatic events may interact with other factors contributing to the spread of hantavirus (like changes in human behavior leading to higher risk of exposure).[464]

Water-borne Infectious Diseases
In the United States and other developed countries, we enjoy a quality of life in which waterborne infectious diseases are no longer a constant threat as a result of high-quality water treatment and other measures, however waterborne diseases have not been completely eradicated.[465] In the United States from 1948 to 1994, heavy rainfall correlated with more than half of the outbreaks of waterborne diseases.[466] Changes in the severity or frequency of precipitation events may lead to an increase in waterborne diseases.[467] Climate driven increases in ocean surface temperatures may also be associated with an increase in harmful algal blooms (HAB) and proliferation of the *Vibrio* bacteria that can contaminate shellfish.[468] In addition to water-borne gastrointestinal infections, waterborne respiratory infections may also be affected by climate change. For instance, proliferation of *Legionella* bacteria, which is dispersed by cooling systems and potable water outlets (such as shower heads), may be linked to an increase in wet-humid and warm weather.[469]

Food-borne Infectious Diseases
Everyone, from the farmer to the consumer, has a role in keeping food safe. The U.S. food safety system is complex, being composed of many federal, state and local stakeholders, including agriculture, health and environmental agencies. It is not

uncommon for several agencies to play roles in assuring the safety of a single food commodity from farm to fork. Regulations governing the safety of animal and plant products at the production level are enforced by the U.S. Food and Drug Administration (FDA), CDPH's Food and Drug Branch, and CDFA's Milk and Dairy Food Safety Branch, Regulations governing food processing are enforced by the FDA, the USDA Food Safety Inspection Service, CDPH's Food and Drug Branch and CDFA programs including the CDFA Meat, Poultry Inspection Branch and CDFA Milk and Dairy Food Safety Branch. CDFA also works with egg producers, processors, academia and other agencies to proactively assure the safety of eggs, poultry and dairy products through voluntary quality assurance programs. FDA and CDFA also enforce regulations governing the use of animal health products in food animals and the safety of animal feed. And USDA Center for Veterinary Biologic has regulatory authority over veterinary biologics production, distribution and use in animals. The use of pesticides is regulated by U.S. EPA and the California Department of Pesticide Regulation.[470]

Because of the numerous factors governing food safety, a causal link between climate change and increased risk of food-borne diseases has not yet been well-established. However, Salmonella and Camplyobacter display a distinct seasonal pattern that has been associated with climate variability (increased temperatures, heat waves, and flooding) and may thus be exacerbated by climate change.[471]

Climate Impacts on Health Services

As noted in the Oceans and Coastal Ecosystems and Resources section of this document, hospitals and critical energy and transportation infrastructure are threatened by sea level rise and coastal erosion. Extreme events, such as wildfire and storms, may also threaten critical infrastructure important to the delivery of health and other vital services. State efforts to promote and coordinate hospital and healthcare preparedness and resilience are coordinated through the **Hospital Preparedness Program**, funded by CDC and administered by CDPH's Emergency Preparedness Office in collaboration with the California Hospital Association, California Primary Care Association, local public health departments and other partners. In recognition of these growing risks, the President's June 2013 Climate Action Plan, notes that the U.S. Department of Health and Human Services will "launch an effort to create sustainable and resilient hospitals in the face of climate change. Through a public-private partnership with the healthcare industry, it will identify best practices and provide guidance on affordable measures to ensure that our medical system is resilient to climate impacts. It will also collaborate with partner agencies to share best practices among federal health facilities."[472] California's emergency health services are further discussed in the Emergency Management section of this document.

Mental Health and Stress-Related Disorders

Growing evidence of global climate change and increases in extreme weather disasters due to climate change can lead to mental health disorders associated with social disruption, death or injury, economic losses, and geographic displacement, as well as cumulative effects from repeated exposures to extreme events. The effects of climate change impact the social,

economic and environmental determinants of mental health, with the most severe consequences being felt by communities who were already disadvantaged prior to the event.[473] Common mental health conditions associated with extreme events may include, among other things, acute traumatic stress, post-traumatic stress disorder, grief, depression, anxiety disorders, somatic complaints, and drug or alcohol abuse. Those individuals already vulnerable to mental health disease and stress-related disorders are likely to be at increased risk. Furthermore, barriers to the utilization and delivery of mental health services may arise following extreme weather events.[474] In addition, children are at disproportionate risk of health impacts of climate change; a more thorough quantification of child-specific risk is needed.[475] These issues need much more attention including involving social scientists and mental health practitioners in understanding climate impacts on the mental health of different groups and their engagement in efforts to prepare for climate risks.

Vulnerable Populations

As discussed in the Emergency Management section of this document, not all communities and not all members of a community are equally vulnerable to climate events. Underlying health status ("sensitivity") and socio-economic conditions may vary and access to information, services and resources affects how impacts are experienced. Initial efforts to map population vulnerabilities in California are further described below and in the Emergency Management section of this document.

Box 56

First Person Narrative on Climate Change and Health
By Elizabeth Baca, MD, MPA (used with permission)

I remember reading about climate change and its potential effects when I was in graduate and medical school. Today those effects are coming to bear, and nowhere is this more evident than in human health.

According to the World Health Organization, health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. We know that social, economic, and environmental factors affect health.[476] There has been a great deal of research on how the social and physical environment "gets under the skin" to make one sick. Everyone is affected by these factors that influence life expectancy and health, but certain populations are more significantly impacted.[477] As a practicing pediatrician in a community health center in the Bay Area where ninety-three percent of our patients live below 200% of the federal poverty level, the children I see in clinic bring all the research to life. The young patients I care for are more susceptible to all the environmental health exposures. Many of these children have very difficult-to-control asthma and allergies, which has the potential to be exacerbated due to the current changes in our climate.

The anticipated health effects from climate change vary from disruptions to our food and water

supply to disease pattern change. Yet impacts to public health are already being experienced. This is not surprising considering that the 12 warmest years on record have occurred in just the last 15 years.[478]

Extreme warm weather can have serious health effects. Not only does heat worsen pre-existing diseases such as heart disease, diabetes, and kidney disease, it also causes heat stroke and dehydration in healthy populations. Asthma, a common childhood illness, is worsened by diminished air quality resulting from increased temperatures. Although we have treatments that control asthma, when environmental factors like poor air quality persist, the condition becomes difficult to control.

Clinically, I am seeing more children with difficult to control allergies. In addition to more allergy symptoms, I would expect to see an increase in asthma exacerbations, since pollen is a major trigger. Any climate driven changes to air-borne allergens, such as increases in pollen counts or change in the seasonal timing of allergen production, will undoubtedly make allergies and asthma more difficult to control in the future.

In the long term, if we do not take action, we will see major disruptions to human health and well-being. Although the challenges before us seem daunting, we still have time to act. Solutions for a healthy planet, by promoting more forms of active transportation, using less and cleaner sources of energy, and taking steps to reduce our carbon foot print, are also solutions that improve health now and promote healthy and more resilient populations in the future.

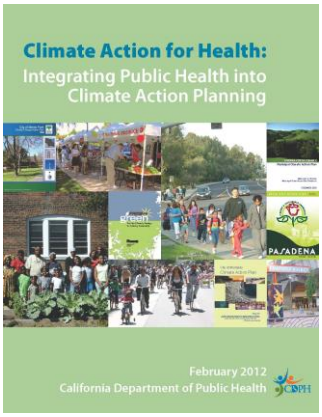
As a physician, I believe climate change is one of the biggest public health challenges we must address. Although all of us are affected by a changing climate, certain groups—such as children, the elderly, and socially or economically disadvantaged populations—are disproportionately at risk of its health impacts. It will take a multi-sector, innovative approach to confront climate change, but it is imperative that we do so now to secure the future of California and ensure a healthy environment for our children going forward.

Elizabeth Baca, MD, MPA received her medical degree from Harvard Medical School and her graduate degree from the Kennedy School of Government. In addition to teaching medical students, residents, and caring for patients, she works on state-level policy to create healthy, sustainable communities.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

CDPH and others have worked to create linkages and find ways to integrate climate mitigation and climate adaptation into today's health protection and health promotion programs at the state and local level in California.

Box 57



Climate Action for Health: Integrating Public Health in Climate Action Planning – In February 2012, CDPH developed this guide to assist local planners and public health agencies in incorporating targeted health elements into climate action plans and achieve health co-benefits while reducing greenhouse gas emissions.[479]

State of California: Preparing California for Extreme Heat: Guidance and Recommendations
In the wake of the hottest July ever recorded in the United States, California released a plan to deal with extreme heat caused by climate change. This broad Guidance document was developed by the Heat Committee of the Public Health Workgroup in the Climate Action Team, and provides recommendations for incorporating extreme heat projections into planning and decision making in California.[480]

CDPH Climate Education and Training
CDPH works to expand awareness and knowledge of the health impacts of climate change and how climate mitigation and adaptation strategies can be integrated with efforts to promote healthy and sustainable communities and protect vulnerable populations. CDPH has collaborated with the California Conference of Local Health Officials, the Public Health Institute (PHI), the Local Government Commission, UCLA Fielding School of Public Health, regional adaptation planning collaboratives, and others to offer a variety of climate and health educational activities. These efforts include:

> ***Statewide Webinar series*** - CDPH created a climate webinar series "***Climate Change and Public Health: Building Healthy Communities and a Healthy Planet"*** for public health professionals and community health advocates on how climate change is impacting health across California, especially within vulnerable communities. These and ongoing webinars are communicating the need for action at the local level, providing tools and identifying opportunities for improving health and addressing climate change.[481]
>
> ***Climate Change as a Public Health Issue: Communication Lessons and Strategies for Local Health Departments*** - In November 2010, CDPH and the California Conference of Local Health Officers co-sponsored two workshops in Los Angeles and Oakland on climate change and public health. The workshops featured Dr. Edward Maibach, a leading US researcher on public attitudes on

climate change, public health communication and social marketing.[482] In order to better understand public knowledge, attitudes on climate change as an important health issue CDPH conducted focus groups in English and Spanish with community health leaders in the Summer, 2013.[483]

Online Climate Change Health Data - CDPH's California Environmental Health Tracking Program provides a wealth of online climate and health data including maps of climate change vulnerabilities and surveillance data on heat-related illness and death. That climate change data may be found at: http://www.ehib.org/page.jsp?page_key=863

Be Prepared California - As further described in the Emergency Management section of this document, the CDPH Emergency Preparedness Office has developed the Be Prepared California online tool to help Californian's prepare for public health emergencies.[484]

Research on Climate Exposure and Socio-Economic Vulnerability of California Communities

The Third California Climate Change Assessment featured a number of studies on the exposure and vulnerabilities of California communities to climate impacts. These studies included studies of particular communities, like Fresno and San Luis Obispo, and the development of a climate vulnerability index to identify the areas of the State most vulnerable to climate impacts.[485] The climate vulnerability index combined 19 indicators into one overall climate vulnerability score and includes factors specifically related to climate impacts, such as air conditioner ownership, percentage of tree cover, and workers in outdoor occupations. [See Box 24 and Box 25 in the Emergency Management section of this document for State Climate Vulnerability Maps]

CDC Building Resilience Against Climate Effects (BRACE) Collaboration

In 2012, CDPH was awarded a four-year CDC climate change and health grant which will allow California to utilize the five-step CDC BRACE model (Building Resilience Against Climate Effects) to develop a comprehensive climate and health adaptation plan.[486]

Research on Mosquito Borne Viruses and Tools for their Surveillance and Control

The UC Davis Center for Vector Borne Diseases, Arborvirus Research Program conducts research on mosquito borne viruses and tools for their surveillance and control. Study areas have been established at multiple habitats within Riverside, Los Angeles, Kern and Sacramento Counties. UC Davis is collaborating with local agencies of the Mosquito and Vector Control Association of California as well as the CDPH Vector-Borne Diseases Section and Viral and Rickettsial Diseases Laboratory.[487]

California Mosquito-Borne Virus Surveillance and Response Plan

In April 2013, CDPH, the Mosquito and Vector Control Association of California, and the University of California released a revised enhanced surveillance and response plan for mosquito-borne viruses in the State of California.[488]

Box 58

Developing Climate and Health Initiatives at the Local Level

In California's largest county, the Los Angeles County Department of Public Health (LA Co DPH) has adopted an innovative "Five-Point Plan to Reduce the Health Impacts of Climate Change". Working with academic, governmental and community partners, the Department is striving to reduce health impacts of climate change while building healthy, sustainable and resilient communities, ensuring the climate change efforts are linked with ongoing health protection and health promotion in the county's diverse population.

The initiative includes five specific actions:

- Inform general public about the nature of climate change and the health co-benefits associated with taking action to reduce carbon emissions;
- Ensure that climate mitigation and health are incorporated into local planning and policies;
- Provide guidance on climate preparedness to local government and communities that can reduce risks and create more resilient communities;
- Build the capacity of LA Co DPH staff and programs to monitor impacts to improve climate preparedness and response; and
- Adopt practices within LA Co DPH demonstrating leadership in sustainable operations and facilities for department itself.

"Local public health officials have seized on an unprecedented opportunity to protect and improve population health. They are now playing a vital role in communicating the human health implications of climate change. But beyond the messages of protecting health, we must explain how actions to reduce carbon emissions and prepare for climate change also promote the development of healthy, sustainable and resilient communities."

-Angelo J. Bellomo, Director of Environmental Health, Los Angeles County Dept. of Public Health

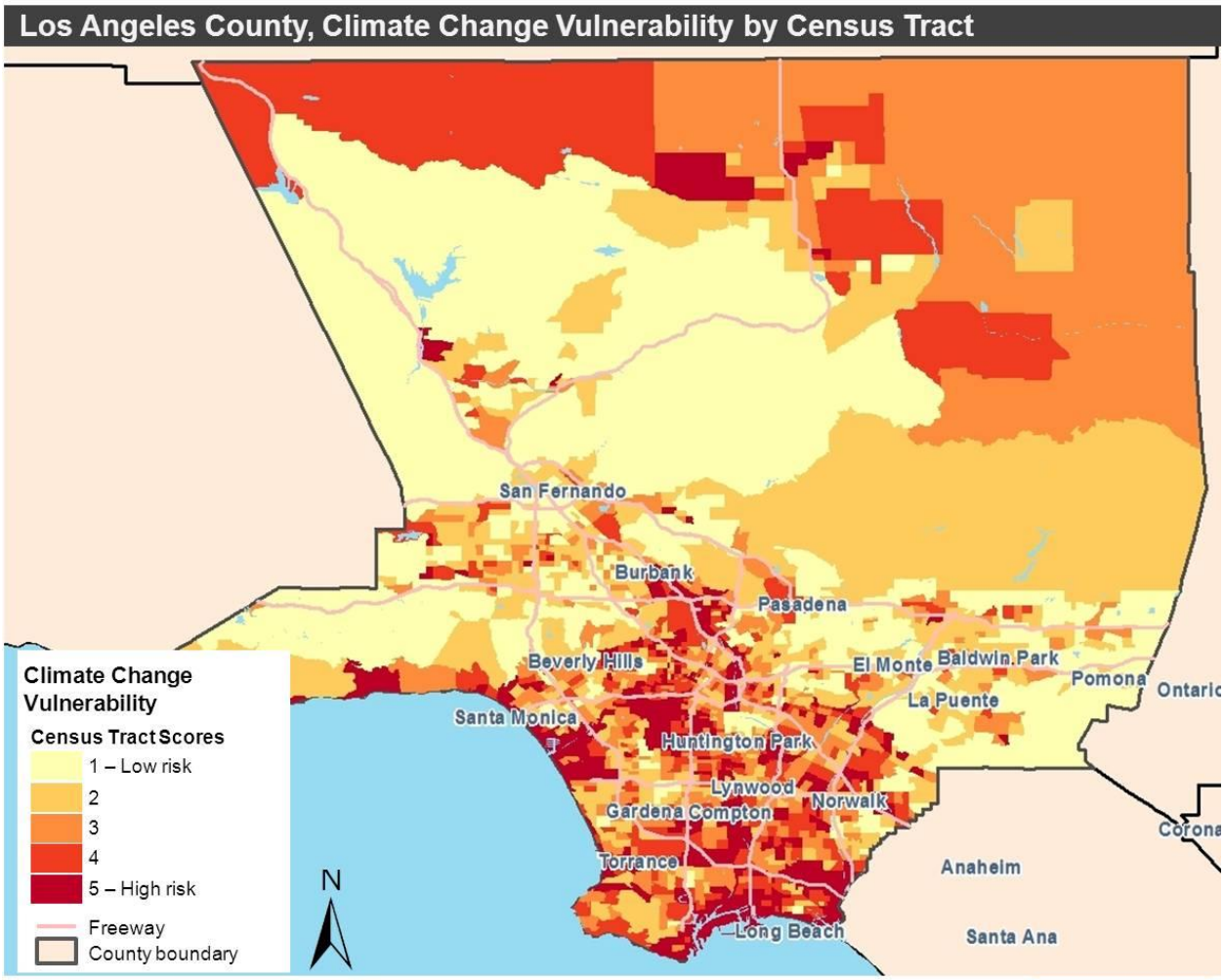
Association of State and Territorial Health Officials (ASTHO) Climate Change Population Vulnerability Screening Tool

CDPH's Environmental Health Tracking Program developed vulnerability assessment screening methods with the support of a grant from the Association of State and Territorial Health Officials (ASTHO).[489] The tool supplemented an existing environmental justice screening method[490] with metrics associated with climate change impacts and adaptive capacity, such as population sensitivities (e.g. elderly living alone; car access), air conditioning ownership, green space, and ecological risks (e.g. flood risk or fire risk).[491] Implementation of the screening tool was piloted in Fresno County and Los Angeles County and produced the maps in Box 59 and Box 60 below. Racial disparities were found in each county for climate change vulnerability. In Los Angeles, 46% of African Americans and 36% of Latinos reside in the two highest risk categories, as compared to 30% of whites; and in Fresno County, 49% of African Americans and 45% of

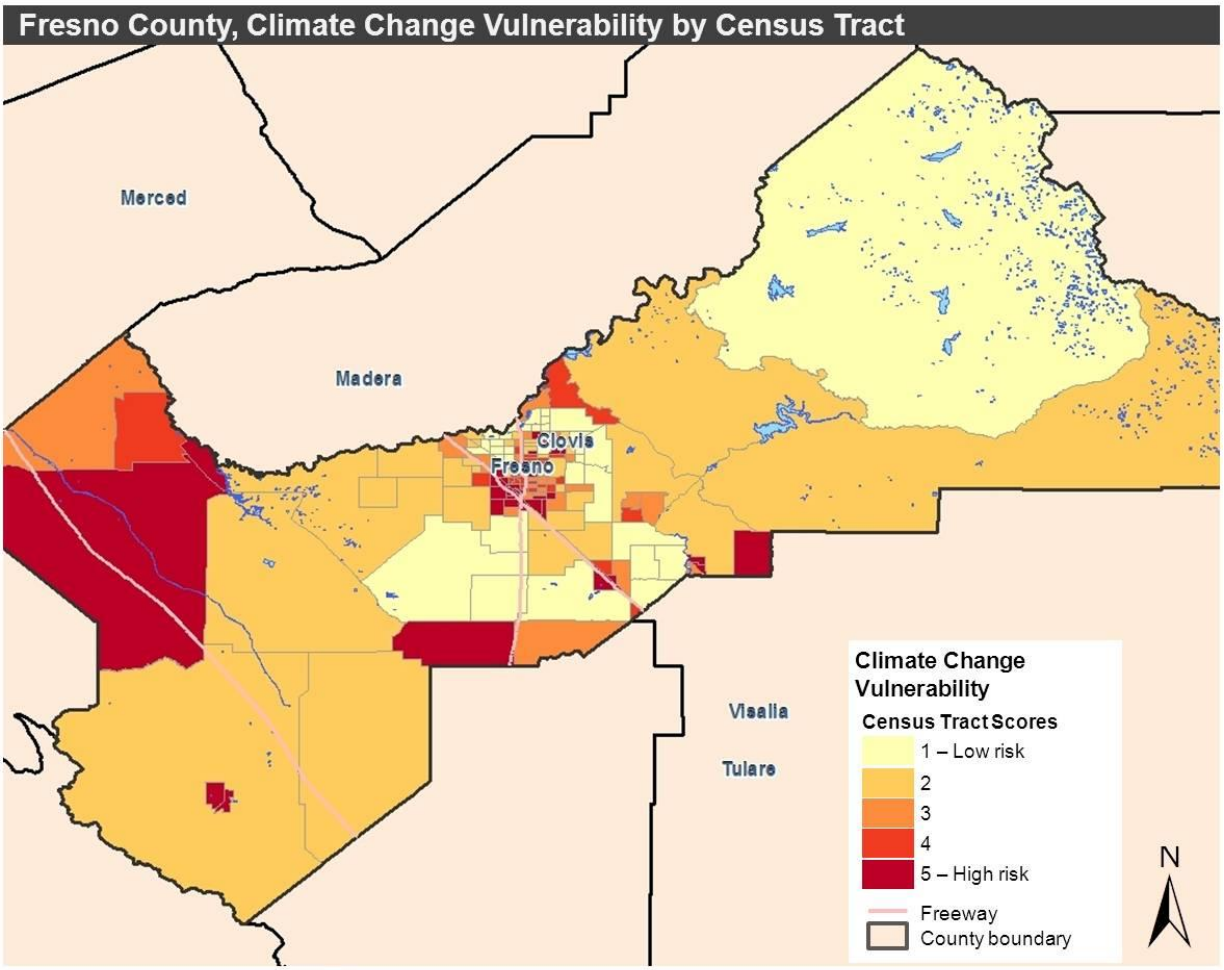
Latinos reside in the two highest risk categories, compared to 26% of Fresno's white population.

Final climate change population vulnerability scores, including cumulative impact polygons, Los Angeles County

Box 59



Box 60



Final climate change population vulnerability risk scores at the census tract level, Fresno County

California Communities Environmental Health Screening Tool, Version 2.0

In 2014, CalEPA and OEHHA announced the availability of the California Communities Environmental Health Screening Tool, Version 2.0 (CalEnviroScreen 2.0).[492] This tool presents the nation's first comprehensive screening methodology to identify California communities that are disproportionately burdened by multiple sources of pollution and presents the statewide results of the analysis using the screening tool. A report describing the methodology and results along with an online mapping application are available. Continued refinement of the tool over time is expected. Among other things, CalEnvirosScreen 2.0 will be used by the California Environmental Protection Agency to identify disadvantaged communities pursuant to Senate Bill 535 (2012) for the allocation of funds in the Greenhouse Gas Reduction Fund.[493]

Protecting Public Health During Drought Conditions

In 2010, CDC's National Center for Environmental Health (NCEH) released "When Every Drop Counts: Protecting Public Health During Drought Conditions – A Guide for Public Health Professionals"[494] to assist public health officials, practitioners, and other stakeholders in their efforts first to understand and then to prepare for drought in their communities. It provides information about how drought affects public health, recommends steps to help mitigate the health effects of drought, identifies future needs for research and other drought related activities, and provides a list of helpful resources and tools.

Transportation-related Progress Benefiting Public Health

The California Department of Public Health has made significant progress developing tools to quantify the health co-benefits of different transportation strategies to reduce greenhouse gas emissions. Models developed by CDPH demonstrate that physically active transportation – bicycling and walking – not only has the potential to significantly decrease GHG emissions, but also increases community resilience by reducing chronic diseases that create vulnerability to heat, pollution and other climate impacts. Per mile traveled, the health co-benefits of active transport appear to be many-fold greater than any other transportation strategy, including electrification of the automobile fleet.[495] As further described in the Transportation section of this document, progress has been made on cool pavements legislation to begin the work of addressing urban heat island effect. The Transportation section of this document also describes progress on smart growth, advanced clean car standards, low carbon fuels, and high speed rail that will help lower emissions from transportation and provide related health benefits that will be important in the face of climate risks such as more extreme heat events and worsening air quality.

Energy-related Progress Benefiting Public Health

As further described in the Energy section of this document, progress has been made on a variety of measures that will help prepare communities for enhanced energy resilience in the face of climate impacts including energy efficiency measures and Local Energy Assurance Planning[496].

Box 61

California Medical Association and American Medical Association Efforts on Climate Change

Health professionals are well positioned to help inform others in the health sector, the general public and policy makers about the relationship between human health and climate change. They have both the necessary scientific background and the communication skills to get the message across in an understandable way. [497]

In October 2012, the California Medical Association (CMA) House of Delegates adopted a resolution (Resolution 117-12) to support the ongoing implementation of California's landmark the California Global Warming Solutions Act of 2006 (AB 32) aimed at reducing the emissions

that cause climate change. CMA noted that the California Air Resources Board and health professionals around the country have identified a number of health concerns related to air pollution and climate change, including increased heat-related illness and death, exacerbation of respiratory disease and a rise in cardiopulmonary mortality.[498]

The American Medical Association (AMA) has also supported the Environmental Protection Agency's authority to regulate and control greenhouse gas emissions in the United States.[499]

Emergency Management Climate Progress Benefiting Public Health

As further described in the Emergency Management section of this document, there has been progress toward integrating climate considerations into Emergency Management in California. The progress includes the development of tools like the California Adaptation Planning Guide (APG), to help local and regional governments with climate adaptation planning efforts. CDPH collaborated in the development of the health and social vulnerability sections of the APG, and provided examples of how this work intersects with Local Health Department public health preparedness and health equity efforts. Other efforts to integrate climate into emergency management efforts include the incorporation of climate change into the State Hazard Mitigation Plan.

Natural Resource Investments that Help Communities Prepare for Climate Risks

As further described in the Forestry, Biodiversity and Habitat, Oceans and Coastal Ecosystems and Resources, and Water sections of this document, there has been some progress on managing natural resources to reduce and prepare for climate risks. Fire hazard reduction, raising awareness about wildfire risks and safety precautions, and post-fire recovery actions have been helping to reduce public health risks from wildfire. Urban forests and urban greening help to provide shading, reduce energy demand, and reduce water contamination from stormwater runoff. Integrated regional watershed management has been helping to enhance water quality and availability in the face of climate impacts. Wetlands restoration and creation and enhanced flood monitoring have been helping to reduce public health risks associated with sea level rise and extreme weather. As further described in the Forestry, Biodiversity and Habitat, Oceans and Coastal Ecosystems and Resources, and Water sections of this document, opportunities exist for additional cost-effective investments in natural resources that promote resilient, healthy communities.

Preparing for Climate Risks to Agriculture

As further described in the Agriculture section of this document, some important progress has been made with respect to preparing for impacts to the agricultural sector in California. For instance, CDFA established a climate consortium to assist specialty crop growers prepare for the impacts of climate change. Opportunities for further work to ensure food security and food safety in the face of climate risks are discussed in the Agriculture section of this document.

ACTIONS NEEDED FOR IMPROVED READINESS FOR CLIMATE-RELATED PUBLIC HEALTH RISKS

While the activities highlighted above depict early efforts and progress made, further action is still needed to help California prepare for climate risks to public health.

Improve Capacity of Communities to Prepare, Respond and Recover from Climate-Related Health Risks

Planning for Climate Change and Water-Related Public Health Risks

Climate change will present new challenges to providing safe drinking water. Any new state plans for drinking water or infrastructure investments to provide safe drinking water should consider climate risk implications.

The state's Drinking Water Program, which was transferred from CDPH to the State Water Resources Control Board on July 1, 2014, has participated with US EPA, other states and representatives of several of California's water utilities on the USEPA National Drinking Water Advisory Council Climate Ready Utility Workgroup. The workgroup developed findings and recommendations relating to the development of a program enabling water and wastewater utilities to prepare long-range plans that account for climate change impacts. The findings and recommendations were published (Climate Ready Water Utilities, December 2010) and placed on the US EPA website.[500]

The state's Drinking Water Program will continue to work with public water systems in the State to evaluate and permit innovative new sources of drinking water such as desalinization plants.

California should also begin to examine and identify the vulnerability of its public water systems to climate risks such as salt water intrusion, sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses will be needed. These analyses should be coordinated with other state agencies, water agencies and local agencies. Other priorities include advancing the science and policy needed to expand the role of recycled water as a drinking water supply. This work involves developing regulations to guide the use of recycled water for recharging groundwater and surface water reservoirs subsequently used as drinking water sources ("indirect potable reuse") and, and eventually directly as a water source for drinking water systems ("direct potable reuse"). Emergency regulations regarding the use of recycled water for groundwater recharge were completed and became effective June 18, 2014. [501]

Evaluate Health Care Infrastructure Resilience

The Public Health workgroup of the Climate Action should convene a discussion with state agencies (including CDPH's Emergency Preparedness Office, the Office of Statewide Health Planning and Development and Emergency Medical Services Authority), healthcare industry partners and other stakeholders to discuss measures to improve resilience of the health care sector to climate impacts, and how such efforts can be coordinated with related federal efforts. Any assessment should also consider health care "surge capacity"—the ability to provide care

to large numbers of patients in the immediate aftermath of an extreme event (heat wave, flood, storm, etc.) and the resilience of the health care workforce.

California should also begin to examine the vulnerability study of its health care infrastructure to climate risks such as sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses, and the implementation of any recommendations for reducing vulnerabilities, will be needed. A 2009 study funded by the Public Interest Energy Program at the California Energy Commission, indicated that a 55-inch sea level rise increase (which is within the range of sea level rise projections for San Francisco in 2100), would increase the number of health care facilities along San Francisco Bay that are at risk of a 100-year flood from 15 to 42.[502] (For more information on risks associated with sea level rise in California, please see the Oceans and Coastal Ecosystems and Resources section of this document.)

Support Implementation of Recommendations in the 2013 State of California Extreme Heat Guidance Document

As noted above, the State of California has developed *Preparing California for Extreme Heat: Guidance and Recommendations*. The State should support implementation of its recommendations. As the document notes, the implementation of some recommendations will require additional resources.

Support Development of Public Health Planning Tools for Local Communities

Enhanced climate and health-sensitive warning systems are needed. For instance, the California Environmental Health Tracking Program, which is a collaboration of the California Department of Public Health and the Public Health Institute, funded by the CDC, has conducted a study to determine if heat alerts accurately predicted times when people suffered the most heat illness[503] The methodologies that the National Weather Service (NWS) uses to issue heat alerts and warnings for local areas do not incorporate explicit health criteria. Working with the CDC, NOAA and the NWS, state and local health scientists can provide their expertise to enhance the sensitivity of NWS heat products so that California's population and health systems can be better warned and prepared to take countermeasures during heat emergencies.

Public health surveillance is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice.[504] Such surveillance can serve as an early warning system for impending public health emergencies; can document the impact of an intervention, or track progress towards specified goals; and can monitor and clarify the epidemiology of health problems, to allow priorities to be set and to inform public health policy and strategies.

Surveillance depends on the most accurate and latest data available. California's local health jurisdictions, CDPH, and the CDC employ a variety of public domain and commercial surveillance systems to capture syndromic and ongoing surveillance data. These systems vary from a simple system collecting data from a single source, to electronic systems that receive data from many sources in multiple formats, to complex surveys. When considering or employing a health surveillance system, jurisdictions should use the CDC's *Guidelines for*

Evaluating Surveillance Systems to address the need for a) the integration of surveillance and health information systems, b) the establishment of data standards, c) the electronic exchange of health data, and d) changes in the objectives of public health surveillance to facilitate the response of public health to emerging health threats (e.g., new diseases).[505]

Tools that provide public health data and information to public health officials will be an important part of efforts to detect, track, prepare, and respond to climate-related health risks. California should collaborate with federal and local partners to support development and enhancement of such tools.[506]

Better Understanding of Evolving Trends that May Impact Public Health in the Era of Climate Change

Healthy Energy Efficient Buildings

Constructing and upgrading buildings to be more energy efficient can provide tremendous benefits including lower utility costs, greater energy security, improved air quality, reducing emissions that cause climate change, and the creation of green jobs. However, if construction or upgrades are performed improperly, health risks may arise. For instance, if proper ventilation is not part of design, then indoor air quality may be compromised and can be exacerbated by changing climate conditions. US EPA released a 2011 document entitled "Guidelines to Ensure Healthy Indoor Air during Home Energy Upgrades".[507] The Guidelines provide a step-by-step process for conducting assessments to evaluate indoor air conditions and the potential for risks that may arise during residential energy upgrades.

California includes in its 2008 and newly adopted 2013 Energy Efficiency Standards for New Residential and Nonresidential Buildings[508] ventilation requirements that meet or exceed current minimum state and national ventilation requirements. These requirements are consistent with best practices for the design of ventilation systems for newly constructed buildings, as well as, the additions and alterations of existing buildings. In June of 2013, the California Energy Commission (CEC) also published the draft Action Plan for the Comprehensive Energy Efficiency Program for Existing Buildings (the "Action Plan") in order to meet the intent and requirements of legislation[509] that requires the CEC develop a comprehensive program to achieve greater energy efficiency in the state's existing buildings. The programs and standards that are developed according to the final Action Plan may include strategies to meet or exceed national and state requirements for whole house and multi-family ventilation including: heating, ventilation and air conditioning (HVAC) systems and equipment; combustion safety; contaminant distribution and source ventilation that are identified in the EPA Protocols for Home Energy Upgrades. The Action Plan also establishes building industry outreach and education goals for job training that includes health and safety considerations. Support for implementation and compliance with the state's energy efficiency standards and the Action Plan will be important to realizing all the benefits of energy efficient buildings. CDPH's Division of Environmental and Occupational Disease Control (DEODC) includes the California Breathing Asthma Program, Childhood Lead Poisoning Prevention Program, Healthy Homes Program and Environmental Health Laboratories. The CEC and DEODC will work together during the implementation of the Action Plan.

Low Allergen or Nonallergenic Urban Greening to the Extent Feasible

As noted above, there are still no definitive conclusions on how climate will impact air-borne allergens, particularly at the regional level, but models indicated that pollen will likely increase in many parts of the United States and there may be shifts in the seasonal timing of allergen production and other changes to air-borne allergens. In order not to exacerbate public health issues associated with air-borne allergens, urban greening programs should consider low allergen or nonallergenic species to the extent that such species are otherwise regionally suitable.

Better Understanding of Climate Impacts on Public Health

Further Development and Support of Local Vulnerability Assessments

As noted above, some initial local vulnerability assessments, for communities, have been developed for selected communities, like Fresno, Los Angeles and San Francisco. However, all California communities face climate risks to public health, and there is still a need for further development and support of local vulnerability assessments for climate-change health risks (such as risks relating to heat, air quality, fire, flooding, and water availability and quality). Conducting geographically-specific vulnerability assessments and the identification of vulnerable populations can help guide efforts to design and implement strategies to address local risks and needs of high risk groups. The February 2012 ASTHO Climate Change Population Vulnerability Screening Tool discussed above should be revised to include improved data and additional stakeholder input; and vulnerability analyses for additional communities should be undertaken. CDPH's four year CDC BRACE grant will expand this planning for ten additional counties; however, funding to expand and support these efforts so that local public health partners can be actively involved may be necessary.

Increase Capacity to Monitor Climate-Related Deaths and Illnesses

Continued actions to improve disease reporting and surveillance will aid efforts to understand and respond to emerging climate risks to public health. These actions may include: coordinating with federal and regional rapid surveillance efforts; upgrading the California Death Registration System[510] to provide for continuous monitoring of abnormal death patterns, including heat-related death; and improving surveillance programs for infectious diseases including vector-borne, water-borne and food-borne diseases.

Social Vulnerability Mapping for Climate Change

Multiple screening tools for social vulnerability now exist, such tools reflect a variety of conceptual frameworks, methodologies, and data. These tools have varying strengths, weaknesses, assumptions and limitations. CDPH should convene a meeting with various state entities and other partners who have developed such social vulnerability tools in order to identify gaps that may be filled by collaborative research and to examine best practices for developing social vulnerability assessments for Cal-Adapt.

Regional Studies of Aeroallergens

Significant gaps still exist with respect to California's ability to monitor potential shifts in air-borne allergens. Funding to enhance allergen monitoring, identification and forecasting would support efforts to better understand how allergens are shifting in response to climate change, and would help support the development of policies to help reduce these health risks for Californians in light of these changing conditions.

Information Sharing and Education

Capacity Building to Raise Awareness and Foster Action to Address Climate Risks to Public Health

Outreach efforts are important to ensure that public health and medical professionals are prepared and educated on climate risks. Health professionals are uniquely positioned to help raise community awareness about risks to public health from a changing climate[511] and a health framing may help more members of the public to consider climate risks and actions.[512] In addition to capacity building efforts described in the Introduction to this document, a grant program for local health departments and professional medical and nursing associations could be established to support the development of courses on climate and California health risks for the staff and constituents of such organizations. Funding and adequate staffing to support such a grant program would be required. Any such capacity building courses for local public health, medical and nursing professionals should include information about the health impacts of climate change, as well as information related to the prevention and management of climate-related illnesses (e.g., heat illness) and promoting resilience.

Public Education on How to Reduce and Prepare for Climate Health Risks

The Public Health workgroup of the Climate Action Team together with other relevant state entities, should develop culturally and linguistically relevant educational materials for diverse populations (e.g., vulnerable communities, school-age children, businesses, and labor) using best practices in climate change education.[513] Materials should promote an understanding of various health risks associated with California's changing climate, including, but not limited to, risks associated with extreme weather, heat waves, heat and outdoor labor, air quality, aeroallergens, wildfire, floods and sea level rise, and drinking water, and describe strategies and actions that foster preparedness.

Public education campaigns should be designed to disseminate this information. The campaign should not only utilize existing resources to disseminate information (e.g., the bepreparedcalifornia.ca.gov website and public health advisories), but should also involve collaboration with partners and innovative modes for disseminating information. Additional funding and staffing will be needed for this effort.

Box 62

California Public Health

Many different state entities play an important role with respect to public health in California.

Understanding the jurisdictional scope of these entities is important for a robust discussion of continued steps needed to adequately prepare for climate risks. Short descriptions of these entities are provided below:

California Department of Public Health (CDPH) is dedicated to optimizing the health and well-being of the people in California. CDPH includes an Emergency Preparedness Office which is further described in the Emergency Management section of this document. The Office of Health Equity is also within CDPH, and includes the Climate and Health Team. For more on health equity, please Box 54.

California Health and Human Services Agency (CHHS) oversees thirteen departments and one board that provide or coordinate a range of services, including medical care for low-income Californians (MediCal), emergency medical services, social and mental health services , food support programs (Snap Ed, Cal Fresh), alcohol and drug treatment services, income assistance and public health services to Californians from all walks of life. CDPH is a department within CHHS.

Many other state entities also play important roles with respect to health issues in California. These entities include:

California Air Resources Board (CARB) is dedicated to promoting and protecting public health, welfare and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state. CARB's major goals include providing safe, clean air to all Californians, protecting the public from exposure to toxic air contaminants, and reducing emissions that cause climate change.

California Department of Food and Agriculture (CDFA) works to serve the citizens of California by promoting and protecting a safe, healthy food supply, and enhancing local and global agricultural trade, through efficient management, innovation and sound science, with a commitment to environmental stewardship.

California Department of Forestry and Fire Protection (CAL FIRE) and **State of California's Office of the State Fire Marshall (SFM)** is CAL FIRE is dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. In addition, the Department provides varied emergency services in 36 of the State's 58 counties via contracts with local governments. CAL FIRE also supports "urban forestry", increasing the number and health of trees planted in cities. The mission of the State Fire Marshal is to protect life and property through the development and application of fire prevention engineering, education and enforcement.

California Department of Industrial Relations (DIR) enforces the state's labor laws to improve the workplaces of over 18 million wage earners and their employers; DIR includes the Division of Occupational Safety and Health, better known as Cal/OSHA, which protects workers and the public from safety hazards and the Division of Workers' Compensation which oversees the delivery of benefits and adjudication for work injuries, illness and death.

California Department of Insurance (CDI) works to foster an insurance market that is fair, competitive and accessible to all Californians.

California Department of Pesticide Regulation (CDPR) works to protect human health and the environment by regulating pesticide sale and use, and by fostering reduced-risk pest management.

California Department of Toxic Substances Control (DTSC) The mission of DTSC is to protect California's people and environment from harmful effects of toxic substances through the restoration of contaminated resources, enforcement, regulation, and pollution prevention.

Governor's Office of Emergency Services (OES) is responsible for the coordination of overall state agency response to major disasters in support of local government. The Agency is responsible for assuring the state's readiness to respond to and recover from all hazards – natural, manmade, war-caused emergencies and disasters – and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts. The work of OES is further described in the Emergency Management section of this document.

California Environmental Protection Agency (Cal/EPA) is dedicated to the protection of human health and the environment, and oversees six boards and departments, including CARB and the **Office of Health Hazard Assessment (OEHAA)**.

Department of Water Resources (DWR) is responsible for managing and protecting California's water. DWR works with other agencies to benefit the state's people, and to protect, restore and enhance the natural and human environments.

Labor and Workforce Development Agency oversees the six major departments, boards and panels that serve California businesses and workers, including the California Department of Industrial Relations' Division of Occupational Safety and Health.

State Water Resources Control Board (SWRCB) and nine **Regional Water Quality Control Boards (Water Boards)** were created in 1949. SWCRCB protects water quality by setting statewide policy and supporting the pollution control programs administered by the Water Boards. SWRCB's mission is to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.

Strategic Growth Council (SGC) is a cabinet level council which ensures the consideration of health and health equity as part of the state's planning for sustainable growth. The Health-in-All-Policies Task Force, Health Community Indicators Project and grant programs for Sustainable Community Planning and Urban Greening all address health elements critical to the state's planning and policies for Strategic Growth.

The State of California also has a number of important federal partners with respect to public health issues. These federal partners include: **Centers for Disease Control and Prevention** (CDC) which collaborates to create the expertise, information, and tools that people and

communities need to protect their health – through health promotion, prevention of disease, injury and disability, and preparedness for new health threats[514]; **the U.S. Environmental Protection Agency (US EPA)** which works to protect human health and the environment across a range of issues include air, water, waste and climate change[515]; **Federal Emergency Management Agency (FEMA)** which supports citizens and first responders to build, sustain and improve capability to prepare for, protect against, respond to, recover from and mitigate all hazards[516]; **U.S. Department of Health and Human Services (HHS)** which is the United States government's principal agency for protecting the health of all Americans and providing essential human services, especially for those who are least able to help themselves[517]; the **National Institutes of Health (NIH)** which is an agency within HHS and is the nation's medical research agency[518]; **National Institute of Environmental Health Services (NIEHS)** which is part of NIH and has a Climate Change and Human Health Program engaged in research and capacity building on human health impacts related to climate change and adaptation[519]; **U.S. Department of Food and Drug Administration** and the **U.S. Department of Agriculture** which help to regulate food safety as further discussed below;[520]and the **U.S. Department of Labor Occupational Health and Safety Administration** which works to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.[521] CDPH serves on or advises a number of national committees to develop knowledge, guidance and indicators to help the public health sector prepare for climate change including the National Drinking Water Advisory Council's Climate Ready Utility Workgroup[522]and the National Climate Assessment[523].

Local governments and sixty-one local public health departments also play a critical role in ensuring the public health of Californians.[524] Individuals and private sector actors, including employers, insurance companies, health care providers, educational institutions, and non-profit organizations, also play an important role in creating healthy and sustainable communities. For an example of collaborative efforts supporting public health initiatives at the local level, see Box 58: **Developing Climate and Health Initiatives at the Local Level** and Box 61**: California Medical Association and American Medical Association Efforts on Climate Change** above.

TRANSPORTATION

INTRODUCTION

Climate Risks to California Transportation

California's economy and its residents rely on a robust, multi-modal transportation system. California's transportation infrastructure includes extensive roads and highways, railways, ports, airports, transit systems, and a variety of supporting fueling and energy systems.

Billions of dollars of goods are transported through California on the State's diverse transportation system. California is a major global gateway for products entering and leaving the United States. Ports, railways, airports, and the State Highway System provide critical goods movement routes for the State and Nation. In addition to goods movement, the transportation system is also critical for the movement of people and delivery of services.

While the transportation sector is a source of greenhouse gas emissions, it is also vulnerable to a variety of climate impacts. Sea level rise and coastal erosion threaten ports and low lying airports, coastal roads and highways, bridge supports, transit systems, and energy and fueling infrastructure. [For more information on how the Port of San Diego is preparing for climate risks, please see Box 65**:** First Person Narrative: Ports by Cody Hooven below.] Climate change is expected to cause both coastal flooding and inland flooding which may compromise underground storage tanks for fuel, causing fuel delivery interruption, pipe ruptures, and toxic releases. Floods and landslides can also cause road closures, transportation hazards, and millions of dollars in transportation infrastructure damage. [See images below of flooding and infrastructure damage.] Extreme heat associated with climate change also threatens highways and railways. High temperatures cause road surfaces to expand, creating pressure that can cause pavement to buckle. Rail lines are also vulnerable to heat. Similar to roadway buckling, metal rail lines kink under extreme heat conditions which can lead to rail breakage and train derailment. Extreme storm events may damage energy and fuel distribution systems as well as transportation infrastructure; this can impair goods movement, including supplies for affected communities, and mobility for residents, including impacting evacuation routes for communities. [For more information about extreme events and impacts to transportation systems, please see Box 64: Transportation and Hurricane Sandy] If groundwater utilization intensifies in response to climate-induced changes in water availability, there may also be an increase in land subsidence events that threaten roads, railways, and bridges. [Please see the Water section of this document for more information on subsidence.]

Box 63



I-5, Sacramento, Oct. 13, 2009
Photo: California Department of Transportation



State Route 330, San Bernardino County, Dec. 27, 2010
Photo: California Department of Transportation

As further discussed below, California has already made significant progress with respect to addressing emissions from the transportation sector which cause climate change, as well as assessing vulnerabilities of the sector. California has adopted innovative smart growth measures (to contain sprawl), clean car standards, and a low carbon fuel standard. It has also begun the important work of assessing vulnerabilities of the transportation sector and addressing climate impacts.

More work is still needed to prepare California's transportation sector for anticipated climate impacts. Impending climate impacts not only have implications for decisions regarding the siting of new transportation infrastructure, climate impacts also have implications for maintenance and operation plans, and for design features of transportation systems, including system design for emergency planning and extreme weather events.

Box 64

Transportation and Hurricane Sandy

According to the August 2013 report issued by the Hurricane Sandy Task Force, the states impacted by Hurricane Sandy lost between $30 billion and $50 billion in economic activity due to extensive power outages, liquid fuel shortages, and near-total shutdown of the region's transportation system. Access to gasoline and diesel fuel in New York City and northern New Jersey was severely impaired following Hurricane Sandy. This was largely caused by flooding damage to major terminals and docks in the Arthur Kill area of New Jersey. These fuel shortages delayed first responders and other response and recovery officials. As a result, portable generators sat unused and lines at fueling stations were long and problematic while consumers

struggled to identify which gas stations had power and were operational.[525]

Hurricane Sandy was the worst disaster for public transit systems (e.g., bus, subway, commuter rail) in the nation's history. On October 30, 2012, the morning after the storm made landfall, more than half of the nation's daily transit riders were without service. New York City's subway system was shut down on October 28, in advance of the storm, and remained closed through November 1. During that time, the City experienced traffic gridlock, and those who were able to get to work experienced commutes of up to several hours. Seawater breached many critical infrastructure systems, flowing into the Hugh L. Carey (Brooklyn-Battery) Tunnel, flooding eight of the New York City Subway tunnels, and damaging a variety of other transportation systems in the region.[526]

Response and recovery actions for the transportation sector required coordination between many entities. The Federal Emergency Management Agency is funding, under its Public Assistance program, repairs to airports, port and harbor facilities, and other publicly owned transportation systems not covered by the Federal Transit Administration or the Federal Highway Administration (FHWA) emergency relief programs. Other transportation systems, such as the intercity rail lines operated by Amtrak, and Federal assets at airports such as air traffic control towers and navigation systems, were funded or repaired by the Federal Railroad Administration or the Federal Aviation Administration, respectively. In a unique partnership with the National Park Service, the piers and docks on Liberty Island, which allow ferry access to the Statue of Liberty, were repaired by the Eastern Federal Lands division of FHWA.[527] The Hurricane Sandy Task Force has proposed recommendations to promote resilient infrastructure investments and to improve coordination between federal, state and local officials, as well as with members of the public, businesses, non-profits, and other community groups.[528]

Although the risk of a hurricane making landfall in California is very low, many California counties are at risk for storm damage caused by severe high winds and flooding.[529] Climate change and California storm risks are further described in the Emergency Management, Water, and Oceans and Coastal Ecosystems and Resources sections of this document.

Several state entities play an important role with respect to transportation in California. The state also has important federal, local and private sector partners with respect to transportation. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks. For more information, see Box 66 *at the end of this chapter titled California Transportation.*

Box 65

FIRST PERSON NARRATIVE: Ports
By Cody Hooven, Senior Environmental Specialist
Port of San Diego

As a senior environmental specialist for the Port of San Diego, I have one of the best jobs at the Port. I work in an exciting field at the intersection of science and policy on environmental

issues, and I am helping to pave the way for the Port to grow as an economic engine for the San Diego region.

The Port of San Diego encompasses almost 6,000 acres of state tidelands in and around San Diego Bay that have been entrusted to the Port since 1962. These lands span five cities, including San Diego, Coronado, National City, Chula Vista, and Imperial Beach. The Port's mission is to protect Tidelands Trust resources by providing economic vitality and community benefit through a balanced approach to maritime industry, tourism, water and land recreation, environmental stewardship, and public safety.

The Port's maritime industry is supported by four terminals, two dedicated to cargo, and two for cruise ships. There are also a number of maritime industrial businesses on our tidelands that build and repair ships and operate in other ways to keep goods moving in and out of the region. Many of these businesses also support the military, including Naval Base San Diego, one of only two major fleet support installations in the United States.

The Port plays a large role in the important tourism industry as well, managing hundreds of commercial leases, including visitor-serving hotels, marinas, restaurants and attractions. Our various roles influence our regional partnerships and the ways we engage with regional stakeholders.

In our role as an environmental steward, the Port has emerged as a regional and state leader in climate change planning. With support and direction from our executive leadership and Board of Port Commissioners, my colleagues and I have made substantial progress in "greening" the Port's activities – both our own operations and those of our waterfront businesses. Examples include installing a shore power system for cruise ships to reduce their emissions while at berth, building the world's first LEED Gold-certified cruise ship terminal, and implementing an innovative Green Business Network for waterfront businesses to increase their environmental sustainability. For these and other efforts, the Port was awarded the 2013 Climate Leadership award from the U.S. EPA.

Recently, in collaboration with regional colleagues and stakeholders, we began long-term climate adaptation planning for San Diego Bay. Of the many impacts predicted from a changing climate, sea level rise poses the most urgent need for action for the Port and its stakeholders. Some actions we're taking are studying sea level rise as a region with the *Sea Level Rise Adaptation Strategy for San Diego Bay* and developing adaptation strategies that can be incorporated into a long-term plan. Some of these strategies are beginning to be incorporated into development planning (e.g., elevating building pads or establishing habitat buffer zones). We're working to protect the valuable jobs, regional infrastructure and natural resources, and economic contributions that continue to make San Diego Bay a vital asset to California.

Considering these long-term impacts now will ensure that we are prepared for and resilient to future conditions and will help ensure our long-term success.

The Port of San Diego and our fellow California ports represent some of the largest port facilities in the nation, providing tremendous economic benefit to our local, regional, state and

national economies. Over the last decade in particular, California ports have been fundamentally focused on improving environmental conditions in and around our port facilities. We've implemented innovative and exciting operational changes and environmental improvement programs that significantly exceed state and national standards.

Even with these efforts, much remains to be done. The Port of San Diego has taken the lead on planning for a changing climate and looking for ways to adapt, but we have a long way to go and can't do it alone. With ports playing such a vital role in goods movement and economic activity for the state and the nation, we need to continue working with our neighboring agencies, our regions, and our state leaders to protect these valuable assets.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

As noted above, the transportation sector is both a source of emissions that cause climate change, and vulnerable to expected climate impacts. As described here, the State of California has made progress on both fronts. This Highlights section is not a complete or exhaustive catalogue of all climate progress in the transportation sector in California. Many portions of the transportation sector are primarily under the jurisdiction of entities other than the State (e.g. local streets and roads, private freight rail lines, and ports and airports owned and operated by local entities); these parts of the transportation sector are largely beyond the scope of this report. However, it is anticipated that future, periodic updates to this Plan may include additional information on ports, airports, rail, and transit systems - as such information is generated by the type of inter-agency collaboration recommended at the end of this section (*See* the "Information Sharing and Education" recommendation below)

Progress on addressing vulnerabilities and climate impacts:

<u>Caltrans Progress:</u>
Following up on the 2009 California Climate Strategy, and in response to the current and anticipated effects of a changing climate, Caltrans has initiated both efforts to reduce the department's greenhouse gas emissions and various readiness measures. Caltrans is collaborating with partners and stakeholders. Measures to support readiness implemented by Caltrans to date include support of needed climate research, preparation of guidance to incorporate climate considerations into the planning and design of projects, and in the ongoing maintenance and operations of State Highway facilities. Below is a list of actions Caltrans has already implemented, and success stories to date:

- Published an April 2013 document titled: *Caltrans Activities to Address Climate Change* that quantifies the amount of greenhouse gas emissions reduced resulting from Caltrans' operations such as new pavement technology and the use of energy efficient roadway lighting systems.
- Participated in a multi-state agency contract with the National Academies of Sciences to conduct a Sea Level Rise Assessment for the West Coast. The study produced sea level rise projections for California, Oregon, and Washington for 2030, 2050 and 2100.

- Developed "*Guidance on Incorporating Sea Level Rise – For Use in the Planning and Development of Project Initiation Documents*", and "*Estimating Sea Level for Project Initiation Documents*" based on the results of the National Academies of Sciences sea level rise report. These documents ensure that Caltrans staff use consistent methodologies when analyzing potential impacts from sea level rise to existing infrastructure and for future projects.
- Formed the internal Caltrans Climate Change Workgroup to foster communications and coordination on various climate change and readiness efforts within the various Caltrans Divisions and District Offices.
- Collaborated with partners, including the Governor's Office of Planning and Research, the California Emergency Management Agency, and the California Natural Resources Agency, to develop the July 2012 California Adaptation Planning Guide to assist local and regional governments in preparing for climate impacts.
- The Caltrans' Office of Highway Drainage Design is developing new design criteria for bridges and culverts in tidally influenced areas. The intent is to update drainage design criteria to consider potential sea level rise in conjunction with flooding events and high tides to ensure bridge and culvert infrastructure (in coastal areas) can adequately facilitate the movement of water under the highway without flooding the roadway.
- Collaborated with the California Department of Fish and Game on the 2010 California Essential Habitat Connectivity Project: A Strategy for Preserving a Connected California. The project was focused on promoting a functional network of connected wild lands essential to survival of California's diverse natural plant and animal communities in the face of climate change and continued human development pressures. The fragmenting effects of roads on habitat are mitigated, while transportation and land-use planning are made more efficient and less costly, and dangerous wildlife-vehicle collisions are reduced. The Project was produced by a highly collaborative, transparent, and repeatable process that can be emulated by other states.
- Working with local municipalities to use recycled and reclaimed water to irrigate landscaped portions of the State Highway System when available. Old watering systems are being upgraded to new efficient Remote Irrigation Control Systems. These systems ensure plants are watered the appropriate amount at the most efficient times. These efforts promote both water and energy efficiency and greater water and energy security supports transportation readiness.
- Participating in an interagency working group developing an Extreme Heat Adaptation Guidance document and working on research and standards for "cool pavement" technologies. "Cool pavements" are paving materials that reflect more solar energy, enhance water evaporation, or have otherwise been modified to remain cooler than conventional pavements in order to reduce temperatures in urban settings.[530] This work is further described below.
- 2013 release of "Addressing Climate Change Adaptation in Regional Transportation Plans - A Guide for California MPOs and RTPAs". This document is intended to provide information to Metropolitan Planning Organizations (MPOs) and state designated Regional Transportation Planning Agencies (RTPAs) on possible steps to incorporate

climate change impacts into their long-range transportation plans, or regional transportation plans. This document helps distill down climate planning issues to assist small MPOs and rural RTPAs, given their small staffing levels. Whenever the opportunity arises, Caltrans staff will encourage smaller MPOs and rural RTPAs to consider incorporating climate change impacts into their long-range planning process.[531]

Characterizing Uncertain Sea Level Rise to Support Investment Decisions – Port of LA (PoLA) study

This report was issued in July 2012 as part of the State's Third Climate Change Assessment. The study examined the cost effectiveness of incorporating investments to address sea level rise during capital upgrades. The edge of PoLA's terminals currently lies about 12 feet above mean sea level, however for one of the four PoLA facilities, sea level rise investments during the next capital upgrade appears cost justified.[532]

Impacts of Predicted Sea Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region

This report was issued in July 2012 as part of the State's Third Climate Change Assessment.[533] The population of the Bay Area is almost 7.2 million, and residents take over 21 million trips per day on average weekdays; with 82% of all trips made by automobile, 12% by walking or biking, and 5% by public transit. The nine county Bay Area also has an economy of almost $300 billion, and that economy is highly dependent on goods movement and mobility. The Bay Area has important port, airport, and freight infrastructure in addition to transit and road infrastructure.

Among other things, the 2012 report updated prior analyses with improved data, and also examined how sea level rise, coupled with an extreme storm event, may impair the ability of first responder fire stations to reach communities.

Cool Pavements Bill (Assembly Bill 296 or "AB 296")

In October 2012, the Cool Pavements Bill was signed into law. The bill requires that the California Environmental Protection Agency develop a definition for the term "urban heat island effect"[534], and requires that Caltrans collaborate on research regarding cool pavement technologies and develop a standard specification for sustainable or cool pavements that can be used to reduce the urban heat island effect.

Progress on reducing emissions from transportation:

Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375 or "SB 375")

The Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375 or "SB 375") requires ARB to develop regional greenhouse gas emission reduction targets for passenger vehicles. ARB is to establish targets for 2020 and 2035 for each region covered by one of the State's 18 Metropolitan Planning Organizations. Each of California's MPOs then prepare a "sustainable communities strategy (SCS)" that demonstrates how the region will meet its greenhouse gas reduction target through integrated land use, housing and transportation

planning. Once adopted by the MPO, the SCS will be incorporated into that region's federally enforceable regional transportation plan (RTP).

ARB staff released its methodology for reviewing greenhouse gas reductions for an SCS in July 2011, and has already reviewed and issued executive orders accepting Final SCSs from Sacramento Area Council of Governments (SACOG), Southern California Association of Governments (SCAG), and the San Diego Association of Governments (SANDAG).

Advanced Clean Cars

California has a long and successful history of adopting technology-advancing vehicle emission standards to protect public health. In January 2012, the California Air Resources Board approved a new emissions-control program for model years 2017 through 2025. The program combines the control of smog, soot and global warming gases and requirements for greater numbers of zero-emission vehicles into a single package of standards called Advanced Clean Cars.

Low Carbon Fuel Standard

Executive Order S-1-07, the Low Carbon Fuel Standard (LCFS) (issued on January 18, 2007), called for a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020.[535] In 2009, the California Air Resources Board adopted a regulation to implement the LCFS. The first-of-its-kind regulation is aimed at diversifying the variety of fuels used for transportation. It boosts the market for alternative-fuel vehicles and will achieve 16 million metric tons of greenhouse gas emission reductions by 2020.[536] In December 2008, eleven states, citing California's LCFS, signed a letter of intent to begin work on a northeast/mid-Atlantic regional low carbon fuel standard.[537]

Alternative and Renewable Fuel and Vehicle Technology Program and Air Quality Improvement Program (Assembly Bill 118 or "AB 118")

Through passage of AB 118 in 2007, the State Legislature created the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) and the California Air Resources Board's Air Quality Improvement Program (AQIP). The ARFVTP and AQIP programs were reauthorized in September 2013, pursuant to Assembly Bill 8.[538]

The Energy Commission's ARFVTP has an annual program budget of approximately $100 million to support projects relating to the development and deployment of alternative and renewable fuels and advanced transportation technologies. ARFVTP provides funding for Zero Emission Vehicle technology fueling infrastructure, such as electric chargers and hydrogen fueling stations, ZEV technology trucks, and advanced technology low carbon biofuels produced from waste-based resources. The program helps spur innovation, attract green investments and business to California, create jobs, and create a safer California by helping the State achieve its climate goals. The California Air Resources Board's AQIP has an annual program budget of approximately $40 million per year, and provides incentive funding for commercially available electric and hydrogen fuel cell electric cars, and ZEV and hybrid trucks.

High Speed Rail

The California High-Speed Rail Authority (Authority) is responsible for planning, designing, building and operating the first high-speed rail system in the nation. By 2029, the system will run from San Francisco to the Los Angeles basin in under three hours. The high speed rail system is expected to relieve congestion related to other transportation modes and reduce greenhouse gas emissions that cause climate change.

The Authority has released a Call to Industry: Sourcing Renewable Power Supplies to solicit guidance and insight about purchasing renewable power sources. To meet the Authority's 100 percent renewable energy goal, the Authority will procure or produce enough renewable energy to offset the amount of energy it takes from the state's power grid to operate trains and facilities. This net-zero approach will increase the environmental benefits and reinforce California's commitment to the renewable energy economy.

The Authority is also working with regional partners to implement a statewide rail modernization plan that will invest billions of dollars in local and regional rail lines to meet the state's 21st century transportation needs.[539] Among the projects in the rail modernization program, is the electrification of Caltrain in the San Francisco Bay Area.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO THE TRANSPORTATION SECTOR

Further collaborative work is needed to continue to enhance transportation readiness in California.

Better understanding of evolving trends that may impact transportation systems

In addition to changing climate conditions, transportation continues to evolve in California. Preparing for climate impacts on California's transportation system must be considered in conjunction with the evolving landscape of California's transportation sector. For instance, there might be a need to:

(1)Better understand the impact and opportunities associated with vehicle electrification and other advanced clean cars on timing and demand for energy supplies (at the same time that climate impacts are occurring and causing changes to energy demand) and better understand the reliability of energy supplies for all vehicles in the face of expected climate impacts. The California Energy Commission already does some of this type of work, for instance in its Energy Demand Forecast, and could further this type of analysis in collaboration with other agencies.

(2) Better understanding of likelihood of land subsidence events that may compromise transportation systems and steps that can be taken to avoid such subsidence if possible. This type of enhanced knowledge will likely take collaboration between a number of entities including the California Department of Water Resources (DWR), Caltrans, SWRCBS, and local and regional governments. Subsidence and more specific recommendations regarding avoiding subsidence are included in the Water section of this document.

Improve the reliability of California's transportation system in the face of expected climate impacts

Action is needed to translate the findings of vulnerability studies described above into actions that improve the reliability of California's transportation system in the face of expected climate impacts. This might include:

(1) Continued integration of climate impact considerations and best available climate science in transportation planning, design, programming, construction, operations and maintenance and updating such efforts as the state of climate science evolves; and

(2) Implementing actions needed to ensure transportation fuel availability and functioning of fuel distribution infrastructure in light of expected climate impacts;

(3) Prioritizing improvements to address climate vulnerabilities in transportation systems, including prioritizing those projects that protect key evacuation routes and modes first; and

(4) For new construction and repairs, using state-of-art materials/infrastructure design to optimize transportation system resilience (against extreme heat, challenges of standing and moving water during extreme weather events including storms and floods) with continued research on materials and design to enhance resiliency of transportation systems.

Further enable incorporation of anticipated climate impacts into transportation plans

As noted above, pursuant to SB375 MPOs have been developing sustainable community strategies for incorporating regional greenhouse gas emission reduction targets in regional transportation plans. As also noted above, the 2013 document "Addressing Climate Change Adaptation in Regional Transportation Plans - A Guide for California MPOs and RTPAs" provides guidance to MPOs and RTPAs on possible steps to incorporate climate impacts into long-range transportation planning. As the 2013 guidance document notes, there is currently no requirement to incorporate climate impacts into regional transportation planning, and MPOs and RTPAs have varying capacity and resources to do so. The Strategic Growth Council currently administers a grant program for cities, counties, MPOs, regional transportation planning agencies, joint power authorities and councils of governments to assist with implementation of SB375; a certain amount of that grant funding is prioritized for projects in disadvantaged communities.[540] A similar grant program might help enable incorporation of climate impacts into sustainable community strategies and/or regional transportation plans.

Better understanding of expected climate impacts to inform transportation planning

(1) There is a continued need for regional climate model downscaling, particularly near major population centers, to provide more detailed information regarding anticipated, California-

specific climate impacts - so that such information can inform transportation planning. This type of work will be further described in the forthcoming California Climate Research Plan.

(2) There is also a need for better understanding of the specific vulnerabilities of transportation infrastructure (ports, roads, airports, transit systems) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As noted above, transportation infrastructure in California is managed by a variety of federal, state, local/regional, and private entities. These types of infrastructure vulnerabilities would likely need to be conducted by the entities most directly responsible for the particular infrastructure in question; enabling funding, staffing and/or other technical assistance for the vulnerability assessments might be necessary. For instance, for Caltrans to do a complete vulnerability assessment of the 50,000 lane miles, bridges and culverts under its jurisdiction would require approximately $5 million. The most appropriate form of assistance for a vulnerability assessment would be dependent on what type of entity is conducting the assessment (for instance, grant assistance might be appropriate for local/regional entities).

(3) There is a need for better understanding of specific vulnerabilities of fueling infrastructure: (refineries, pipelines, marine terminals, underground storage tanks, and fueling stations) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with transportation infrastructure, the entities most directly responsible for the fueling infrastructure in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary; and the appropriate form of assistance would vary according to the assessment.

(4) Better understanding of the specific vulnerabilities of energy systems supporting refineries, fueling stations, transit systems, and other important parts of California's transportation system to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with the above, the entities most directly responsible for the particular energy systems in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary. The CEC, ISO, and PUC would likely be the entities involved in this type of assessment. The work of these entities is further described in the Energy section of this document.

(5) In order to aid prioritization of needed changes in transportation planning and operations, the vulnerability assessments referenced above should include consideration of both the probability of impacts and the magnitude of potential damages, transportation disruptions, injuries and loss of life.

Information Sharing and Education

(1) While many agencies are beginning to incorporate climate impacts and considerations into planning and operations, information sharing and collaboration between agencies could expedite the learning process regarding best practices for transportation management in the era of climate change. The state could help convene an interagency task force on reducing risks to California transportation; such a task force should include federal, state, local/regional agencies and appropriate transportation, water, energy planning professionals. Caltrans might be an intuitive choice for leading such a convening effort.

(2) An interagency task force on reducing risks to California transportation might assist in the development of training tools and guidance for transportation professionals regarding incorporating climate impacts and considerations into transportation planning, design, programming, construction and operation and maintenance. The development of such tools and guidance may require funding and staff support.

Box 66

California Transportation

Several state entities play an important role with respect to transportation in California. The state also has important federal, local and private sector partners with respect to transportation. Understanding the role of these various entities is important for a robust discussion of efforts to prepare for climate risks.

California Department of Transportation (Caltrans) is responsible for improving the mobility, safety, and environmental quality of the state's multi-modal transportation system. Caltrans operates, maintains, and develops the State Highway System; supports aviation activities by promoting safe and effective use of existing airports and heliports; provides leadership in the implementation of safe, effective public transportation; and implements statewide transportation policy through coordination at the local and regional levels and the development of transportation plans and projects.

California Energy Commission helps plan for and direct responses to energy emergencies.

California High-Speed Rail Authority (Authority) has a mission to plan, design, build, and operate a high-speed train system for California.

California Independent System Operator Corporation (CAISO) is a nonprofit public benefit corporation that manages the flow of electricity across the high-voltage, long-distance power lines that make up 80 percent of California's power grid.

California Public Utilities Commission (CPUC) has regulatory and safety oversight over railroads, light rail transit agencies, and rail crossings.

California State Water Resources Control Board (SWRCB) regulates petroleum underground storage tanks, water quality issues that result from use of the CalTrans road system, and water quality issues at ports and airports.

State of California Office of State Fire Marshal (SFM) regulates the safety of approximately 5,500 miles of intrastate hazardous liquid transportation pipelines and acts as an agent of the federal Office of Pipeline Safety with respect to the inspection of more than 2,000 miles of interstate pipelines. This office also has operational oversight regarding restoration of petroleum product pipeline service following temporary closures associated with pipeline failures or leaks.

California State Lands Commission (SLC) develops and oversees compliance with Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS). These standards apply to all existing and new marine oil terminals in California, and include criteria for inspection, structural analysis and design, mooring and berthing, geotechnical considerations, fire, piping, mechanical and electrical systems. The purpose of these standards is to increases the integrity of existing facilities to better withstand earthquakes and tsunamis, thus reducing the risk of petroleum spills and temporary loss of the ability to receive and export transportation fuels at marine terminals.

Several federal agencies are important partners for California on transportation issues. The **Federal Transit Administration (FTA)** has primary federal responsibility for public transit systems. The **U.S. Department of Transportation Federal Aviation Administration (FAA)** has primarily regulatory authority over airports. The **U.S. Department of Transportation Federal Highway Administration (FHWA)** supports the State and local governments in the design, construction, and maintenance of the national highway system. The **U.S. Department of Transportation Maritime Administration** assists major ports in redevelopment plans, provides expertise on port financing and port infrastructure, and is the licensing agency for deep water LNG ports. The **Federal Energy Regulatory Commission (FERC)** has authority for oil pipelines as well as the operation and reliability of proposed and operating liquefied natural gas (LNG) terminals. The **Federal Maritime Commission (FMC)** is the federal agency responsible for regulating the U.S. international ocean transportation system.

Various local government agencies and private entities manage other transportation facilities. Local streets and roads are operated and maintained by cities and counties and many rail lines are privately owned. Ports may be operated by a state, a county, a municipality, a private corporation, or a combination. California has eleven publicly-owned, commercial ports.[541] Local authorities may also own and operate airports – for instance, the aviation unit of the Port of Oakland, which is an autonomous division of the City of Oakland, owns and operates the Oakland International Airport.[542]

WATER

INTRODUCTION

California's water resources support nearly 40 million people, many more millions of aquatic and terrestrial plants and animals including salmon and steelhead and California Redwoods and Sequoias, trillions of dollars of economic activity, millions of acres of the most productive farmland in the world, and a bountiful array of landscapes and ecosystems. But California's water supplies and water demands are not equally distributed throughout the state, and management and stewardship of water has been a constant source of tension throughout the history of California. Climate change adds new vulnerabilities and exacerbates historical challenges to California water management. Adapting California's water sector to the impacts of climate change will require a coordinated effort between federal, state, and local governments, businesses, and California's residents.

The water sector in California is influenced by a Mediterranean climate where water systems are designed to store water for dry months, provide winter and spring flood protection, and to address considerable year to year hydrologic variability. It is this very Mediterranean climate that enables the bountiful resources, diversity and economic vitality that is California. The major impacts of climate change on California's water sector may be changes in the timing, form, and amount of precipitation, changed runoff patterns, increases in the frequency and severity of extreme precipitation events (floods and droughts), and sea level rise.

Since the release of the 2009 California Climate Adaptation Strategy, significant progress has been made on improving water use efficiency, flood protection, developing scientific knowledge about climate risks to California's water supplies; however, more opportunities exist to enhance the resilience of the state's water supplies. These accomplishments and further needs are discussed in more detail below.

Management of California's water resources is complex and occurs at federal, state, regional and local levels. Some of the federal and state agencies involved in the management of water resources are listed at the end of this chapter in the Box 73*: California Water Management.*

Climate Risks to California's Water Resources

The major impacts of climate change on California's water sector may be changes in the timing, form, and amount of precipitation, changed runoff patterns, increases in the frequency and severity of extreme precipitation events (floods and droughts), and sea level rise. These impacts can negatively affect both water supplies and water quality.
Climate changes may also change water demand and alter other conditions (such as increasing wildfire risks) that impact the water sector as well. (For more information about climate and wildfire risks, please see the Forestry section of this document.)

Furthermore, climate changes that impact water supply, demand and quality occur against the background of other stressors on the California water system including continued population

growth and urbanization. The "Climate Change: Stressing Our Water Systems" graphic below summarizes expected climate impacts on California's water (see Box 69).

Changes in Precipitation and Runoff

Changes to precipitation and the timing and volume of runoff will challenge the operational flexibility of California's multi-purpose water management systems

Higher temperatures will mean that more precipitation falls as rain instead of snow, and the remaining snowpack melts and runs off earlier in the year.[543] Delays in snow accumulation and earlier snowmelt will have many related impacts including impacts on water supplies, natural ecosystems, and winter recreation.[544] (See **Box 70 Opinion: California's vanishing snowpack is another victim of climate change** By Forrest Shearer) While flows may be higher in winter, water levels in waterways and reservoirs may be lower in spring and summer; water supply for a variety of uses including hydropower and energy generation,[545] agriculture, recreation, and environmental uses will likely be reduced during the times of year when it is most needed.[546] For instance, hydropower generation may decline during summer months, at the same time that climate changes, such as increased temperatures and extreme heat waves, increase summer energy demand for air conditioning.[547] (For more information on climate impacts on the energy system, please see the Energy section of this document.)

California's snowpack has historically stored about 15 million acre-feet of water and this amount of naturally occurring water storage has been an integral part of California's water-supply systems. Snow has traditionally added about 35 percent to the reservoir capacity available to water managers in the state, carrying water over from California's winter wet season to the summer dry season.[548] The water management community has invested in, and depends upon, a system based on historical conditions; modifying management, operations (see information below on system reoperation), and infrastructure will be necessary to attune the system to a changing climate.[549] By 2050, scientists project a loss of at least 25 percent of the Sierra snowpack.[550] Other forms of storage, whether surface storage or groundwater storage, can help save water when flows are high for use at times when flows are low. Above ground, or surface storage, can be in the form of large on-stream dams and reservoirs, large off-stream dams, or smaller on-stream and off-stream reservoirs. Groundwater storage consists of replenishing groundwater basins either directly through injection, or by allowing water to percolate into the ground naturally or from constructed spreading basins.[551] New storage capacity will be needed as Sierra snowpack declines.

California precipitation is variable not only between seasons (wet in winter and dry in summer), but also over the geographic range of the state. Many climate models predict that the disparity in precipitation between various parts of the state will be even greater in the future, with the southern part of California becoming drier.[552]

System reoperation means changing existing operation and management procedures for existing reservoirs and conveyance facilities to increase water related benefits from these

facilities or to adapt to changing climate and hydrologic conditions. System reoperation may improve the efficiency of existing water uses (e.g., irrigation) or it may increase the emphasis of one use over another. Although reoperation is generally regarded as an alternative to construction of major new water facilities, physical modifications to existing facilities may be needed in some cases to expand the reoperation capability. Legal changes also may be needed. DWR has a System Reoperation Program.[553]

Box 67



California Department of Water Resources
Shasta Reservoir; March 13, 2009; showing low water levels

Increased Hydrologic Variability and Extreme Events

California has always experienced wide year-to-year and seasonal variability in precipitation. However, climate change is expected to increase that variability.

Flood

More than seven million Californians are currently exposed to flooding hazards within 500-year floodplains.[554] With climate change, extreme rainfall events are expected to increase in frequency and magnitude. A warmer atmosphere contains more water vapor and more moisture is available to form precipitation in extreme events and to provide additional energy to further intensify such events.[555] More frequent and more severe floods in California are projected.[556]

Flooding can lead to a variety of public health concerns, including water quality impacts, safety issues, property damage, mold in damp buildings, displacement and post-disaster mental health issues.[557]

Box 68



California Department of Water Resources
Flooding - Levee damage

Drought

Droughts are also expected to increase in frequency, duration, and intensity; and drought affects all sectors - impacting public health, biodiversity, agriculture, and the economy.[558] (See the Public Health, Biodiversity and Habitat, Agriculture, and Emergency Management sections of this document for more information.)

During droughts, groundwater use will likely intensify, potentially resulting in increased overdraft and subsidence (which can result in permanent loss of storage and damage to overlying infrastructure, including flood management and transportation facilities), and further stressing groundwater-dependent ecosystems. Agriculture relies extensively on the state's aquifers; groundwater is the only source of water for much of our most productive farmland, and agricultural water needs are likely to be heightened during prolonged hot and dry periods. Groundwater is also often the only source of water for small, rural water systems and households, which may lack the technical, managerial, and financial capacity to respond to drought conditions.

Drought can also impact water quality. Shrinking amounts of water can concentrate contaminants such as heavy metals, industrial chemicals and pesticides, and sediments and salts.[559]

Many of California's groundwater basins have been contaminated from industrial discharges, municipal wastes, and agriculture. Once contaminated, groundwater is difficult to clean up and may no longer be suitable for its intended use. To meet future demand, which is expected to increase, effective groundwater management will need to ensure that groundwater quality and quantity is maintained at sustainable levels that support the beneficial uses of water over the long-term.

To mitigate potential shortages during drought, a variety of measures may be utilized. State, regional and local agencies have increasingly been pursuing a strategy of making regions more self-reliant by developing new or underused water resources locally; improving water storage capacity may be another important strategy for preparing for drought risks. For instance, new or underused water resources may come from including: improved water conservation and water use efficiency, expanded water recycling, improved stormwater management, conjunctive use (coordinated management of local surface and groundwater), desalination, and groundwater remediation. Temporary shortages during drought may also be addressed by firming up existing water transfer agreements, and entering into spot transfer or short-term water transfer agreements.[560]

Sea Level Rise

Sea level rise also poses a critical threat to the California water sector, particularly for water supplies exported from the Sacramento-San Joaquin Delta. Increased salinity intrusion into the Delta threatens these water supplies.[561] In addition, coastal groundwater aquifers are already vulnerable to salinization, which will be exacerbated by rising seas; new and innovative management techniques for protecting aquifers from salinity intrusion may be needed.[562]

As further discussed in the Oceans and Coastal Ecosystems and Resources chapter, wastewater treatment systems may also be threatened by sea level rise.

Changing Water Demand & Other Climate Stressors on California's Water Systems

Changing water demand

As climate is expected to impact precipitation and runoff, it is also anticipated to impact water demand. For example, as further discussed in the Agriculture section of this document, warmer temperatures are anticipated to cause a demand for more water for irrigation.[563]

Potential for subsidence and reduced flows from intensified groundwater use

Climate change may increase water demand and lead to intensified groundwater use. In California, water use already shifts drastically from surface water to groundwater during dry years, and as climate change is likely to increase the severity and duration of dry years,

groundwater use is expected to intensify, potentially resulting in increased overdraft and subsidence (as further described below).

Many of California's groundwater basins are already in overdraft, with groundwater being used faster than it is being replenished and groundwater levels declining.[564] Overdraft can cause land subsidence (land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to movement of materials below the Earth's surface, such as the withdrawal of underground water[565]). The effects of subsidence may include strain on houses and other structures such as transportation infrastructure, increased exposure to flooding in lowland coastal areas, water well casing failures, and changes to the elevation and gradient of stream channels, drains, and other water transport structures.[566] Subsidence can also permanently reduce the capacity of aquifers to store water.[567]

Where groundwater withdrawals are hydraulically linked to such surface flows, intensified groundwater use can also lead to reduced surface flows, which may already be low due to climate-related changes in precipitation and runoff.[568]

Wildfire and erosion impacting watersheds

As discussed in the Forestry section of this document, climate change is also expected to cause more frequent and severe fires. Burned watersheds are prone to increased flooding and erosion, which can impair water-supply reservoirs (e.g. with high sediment loads reducing the storage capacity of reservoirs), water quality, and drinking-water treatment processes (greatly increasing water treatment costs).[569]

Thermal changes affecting aquatic habitat

Slow and low flows in waterways can lead to increased water temperatures that can negatively impact aquatic species; increased air temperatures can also increase water temperatures in the same area. Many aquatic species depend on certain temperature ranges for suitable habitat, and increases in water temperature can negatively impact such species.[570] For instance, the September 2002 Klamath fish kill was an unprecedented adult salmonid mortality event; the Klamath fish kill was caused by a number of factors including unusually warm water temperatures and low flows.[571] (For information regarding climate impacts to marine waters, please see the Oceans and Coast Ecosystems and Resources section of this document.) Climate impacts to aquatic species can have negative impacts on subsistence, recreational and commercial fishing. (See, for example, Box 7 Declining snowpack and the loss of a fly fishing dream in the Biodiversity and Habitat section of this document.)

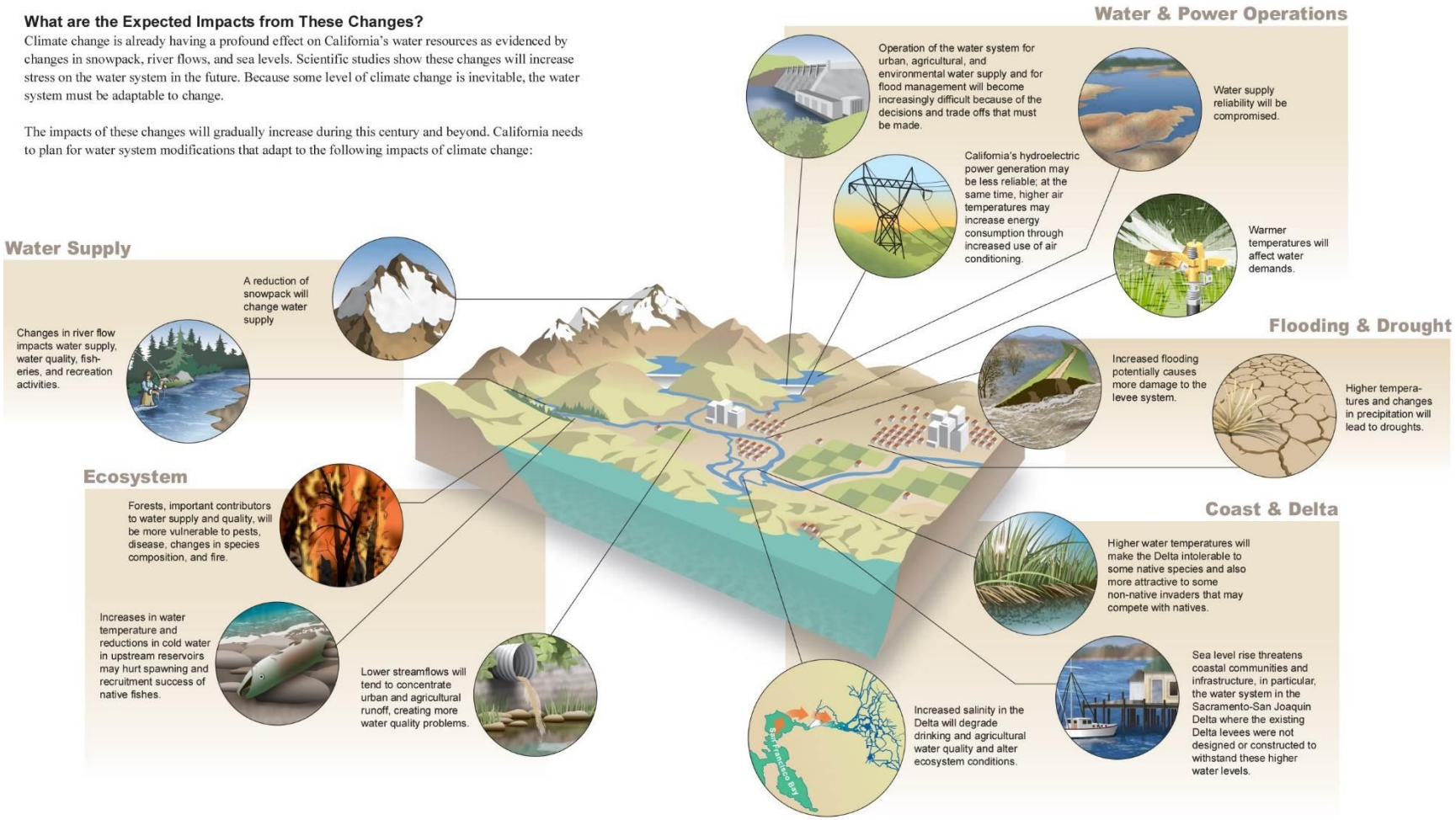
Climate Change: Stressing Our Water Systems

Box 69

What are the Expected Impacts from These Changes?

Climate change is already having a profound effect on California's water resources as evidenced by changes in snowpack, river flows, and sea levels. Scientific studies show these changes will increase stress on the water system in the future. Because some level of climate change is inevitable, the water system must be adaptable to change.

The impacts of these changes will gradually increase during this century and beyond. California needs to plan for water system modifications that adapt to the following impacts of climate change:



Box 70

Opinion: California's vanishing snowpack is another victim of climate change
By Forrest Shearer (October 2012) [Used with permission]

As a professional snowboarder lucky enough to ride mountains around the world, I have seen the impacts of climate change first-hand. I've seen once-famous slopes now with zero snow, ski resorts that have shut down, and glaciers that are disappearing.

In my native state of California, boarders and skiers are bracing for the effects of a warmer world. Scientists are predicting the Sierra snowpack will decline by 25 percent by 2050. We caught a preview this past ski season, when Lake Tahoe and Squaw Valley had to make their own snow well into February. It's no wonder the California Ski Industry Association is a big supporter of AB 32, the state's landmark clean energy and climate law.

But whether or not you've ever strapped on a board or some skis, all Californians should get behind the state's groundbreaking efforts to save energy and tackle climate change. Because sooner or later, our changing climate will affect all Californians.

Consider that declining mountain snowpack I mentioned. It's not just important for skiers and boarders and the businesses that rely on them. It also provides about one third of California's drinking water.

Or look at the record heat that's been roasting parts of California, along with much of the rest of the country. It's been epic; in fact, July was the hottest month on record for the continental United States, with drought covering almost two-thirds of the lower 48 and wildfires burning up two million acres.

Scientists tell us that extreme heat will become more and more common as the world warms. And we can expect more severe droughts, heavy rainfall events, and other extreme weather, as well as more wildfires.

Communities in vulnerable areas across the country are already feeling the burn of global warming. Through a program with the environmental nonprofit, Protect Our Winters, called "Hot Planet/Cool Athletes," I go to schools in mountain communities throughout the U.S. to talk

about climate change.

Through these visits, I've seen that young people get it. Their future depends on a healthy environment, and they are committed to doing their part. At one school, a teacher talked about the school's recycling efforts, and said anyone who wanted to get involved should see a student who was in charge of the whole program. I was very impressed with that kid and it's my hope that today's young students become tomorrow's environmental leaders.

But we shouldn't put the burden on kids to protect the environment.

Adults have to take responsibility for the mess we've made and not leave it for future generations to clean up.

So far, California is doing pretty well. The first step in tackling climate change is burning less fossil fuel, and California leads the nation in energy efficiency. Then you develop alternative energy sources that are cleaner or that don't pollute at all. California leads the country in solar power, wind power, and electric vehicle deployment. And now with AB 32, we will show the nation how to create a successful market-based system for reducing emissions.

What Californians do is especially important, because what happens here will be imitated elsewhere. Californians are trendsetters, especially when it comes to influencing younger people. Surfing, skateboarding, and snowboarding started here, movies and television shows are made here, and environmental trends get started here - the rest of the country, and much of the world, ends up following our lead. Through AB 32 and other smart energy policies, California is blazing a trail to a sustainable clean energy future.

For some people, it's too much. They want us to slow down. But we can't stop now.

When you're tackling gnarly terrain on a snowboard, you can't hesitate. You have to know that you've trained, trust your instincts, and commit yourself fully. California has made a great start on a rad run. Let's stay committed.

Forrest Shearer grew up as a Southern California surfer and is now a professional snowboarder. His California-based sponsors include Patagonia, Clif Bar, Sanuk, and Jones Snowboards. He works with Protect our Winters, the Alliance for Climate Education, and the Action Sports Environmental Coalition.

HIGHLIGHTS OF STEPS TAKEN TO DATE AND SUCCESS STORIES

These activities highlight that climate change planning and preparedness have been areas of focus for the State's water managers for decades and have only grown in importance and urgency in recent years.

Since as early as 1987, the California Department of Water Resources (DWR) has been conducting research on changing climate conditions and alerting the public to potential changes that could affect water supplies. The 2005 Update to the California Water Plan included a substantial discussion of potential impacts of climate change on the water sector, a first for a major state planning process.

Since the *2009 California Climate Adaptation Strategy* was released, significant progress has been made with respect to improving understanding of the climate risks to the state's water sector and preparing for those risks.

California Water Action Plan

In January 2014, the California Natural Resources Agency, the California Environmental Protection Agency, and the California Department of Food and Agriculture released the final California Water Action Plan, laying out California's water-related goals and vision for the next five years.[572] The plan will guide state efforts to enhance water supply reliability, restore damaged and destroyed ecosystems, and improve the resilience of our infrastructure.

Key actions identified in the Plan include:

- Make conservation a California way of life.
- Increase regional self-reliance and integrated water management across all levels of government.
- Achieve the co-equal goals for the Delta.
- Protect and restore important ecosystems.
- Manage and prepare for dry periods.
- Expand water storage capacity and improve groundwater management.
- Provide safe water for all communities.
- Increase flood protection.
- Increase operational and regulatory efficiency.
- Identify sustainable and integrated financing opportunities.

Water use efficiency, groundwater reporting, and recycled water

In November 2009, Governor Schwarzenegger signed SB7x7, or the Water Conservation Act of 2009, into law. SB7x7 requires a statewide 20 percent reduction in urban per capita water use by the year 2020 ("20x2020").[573] SB7x7 also directed DWR, in consultation with the California Agricultural Water Management Council, academic experts, and other stakeholders to develop and report to the Legislature a proposed methodology for agricultural irrigators, farmers and ranchers to use in quantifying the efficiency of agricultural water use and a plan of implementation that includes estimated implementation costs, roles and responsibilities, and types of data that would be needed to support the methodology. "A Proposed Method for Quantifying the Efficiency of Agricultural Water Use: A Report to the Legislature" was released in May 2012.[574]

In 2009, the Governor and Legislature also enacted SB 7x6, which requires the reporting of groundwater levels to DWR.[575]

In 2009, the Water Boards also approved the Recycled Water Policy, which promotes sustainable local water supplies that help adapt to climate change.[576] In 2010, the California

Public Utilities Commission (CPUC) instituted a rulemaking for development of a comprehensive policy framework for recycled water use by the larger investor owned utilities.[577]

In 2009, the Governor and the Legislature enacted SB 918 to amend the Water Code, and require, among other things, the adoption of uniform water recycling criteria for indirect potable water reuse for groundwater recharge and an investigation of the feasibility of developing uniform water recycling criteria for direct potable reuse.[578]

Preparing for climate change in the Delta

The Delta is an extremely important part of the state's water system, serving two-thirds of our state's populations and providing irrigation water for millions of acres of farmland. The region supports wetland and riparian habitats, as well as numerous fish and wildlife species. In recent years, important fish populations have declined dramatically, leading to historic restrictions on water supply deliveries. The current system also relies on water flowing through a network of fragile levees that are vulnerable to a variety of climate risks including floods and sea level rise, as well as other stressors such as seismic events.

There are currently three major planning activities underway to address the problems in the Delta: the State Water Resources Control Board's Bay-Delta Water Quality Control Plan update (Water Quality Control Plan), the Delta Stewardship Council's Delta Plan (Delta Plan), and the Bay-Delta Conservation Plan (BDCP).

The Water Quality Control Plan update will eventually determine the amount and timing of water entering, moving through, and exported from the Delta watershed. Many interests representing federal, state and local agencies, water users, non-governmental organizations, the scientific community and the public are participating in the current Water Quality Control Plan update, which is scheduled for completion in 2014.

The Delta Plan became effective with legally-enforceable regulations on September 1, 2013. The Delta Plan's provisions further the state's coequal goals for the Delta: improve statewide water supply reliability, and protect and restore a vibrant and healthy Delta ecosystem, all in a manner that preserves, protects and enhances the unique agricultural, cultural, natural resource and recreational characteristics of the Delta.[579]

BDCP is being developed as a 50-year habitat conservation plan with the goals of restoring the Sacramento-San Joaquin Delta ecosystem and securing California water supplies. The BDCP would secure California's water supply by building new water delivery infrastructure and operating the system to improve the ecological health of the Delta. The BDCP also would restore or protect approximately 145,000 acres of habitat to address the Delta's environmental challenges. The BDCP is made up of specific actions, referred to as Conservation Measures, to improve the Delta ecosystem. The BDCP includes 22 conservation measures aimed at improving water operations, protecting water supplies and water quality, and restoring the Delta ecosystem within a stable regulatory framework. As the Delta ecosystem improves in response to the implementation of the conservation measures, water operations would become more

reliable, offering secure water supplies for 25 million Californians, an agricultural industry that feeds millions, and a thriving economy.[580] (Additional information on BDCP can be found in the Biodiversity and Habitat section of this document, in the Box 11 "Innovative land-use planning to balance multiple objectives".)

Supporting Local Water Management

For the last 11 years, DWR and the Water Boards have funded local and regional water planning through the Integrated Regional Water Management (IRWM) Program. In 2008, the Legislature formally added climate change adaptation as a required element of eligible plans. DWR updated the IRWM Guidelines to meet this requirement in 2010 and further refined the guidelines in 2012. In order to assist regional planners with meeting this new requirement, DWR placed full-time climate change specialists in each of its four regional offices to provide technical assistance and outreach to IRWM planning groups, water agencies, and local governments working on incorporating climate change mitigation and adaptation into their planning activities. DWR requires a climate change vulnerability assessment for every regional water management plan.[581]

In a related effort to provide additional technical guidance to IRWM groups, DWR partnered with the US Environmental Protection Agency, the US Army Corps of Engineers (USACE), and the Resources Legacy Fund to develop the *Climate Change Handbook for Regional Water Planning,* a comprehensive guide to assessing vulnerabilities and incorporating climate change into water management plans.[582]

Reducing Flood Risk

The state has taken several recent steps to improve land use decision-making and public safety in flood-prone areas:

- Assembly Bill 162, passed in 2007, requires cities and counties in the State to annually review the general plan land use element within "those areas covered by the plan that are subject to flooding identified by floodplain mapping prepared by the Federal Emergency Management Agency (FEMA) or the Department of Water Resources."[583]
- In 2010, DWR published "Implementing California Flood Legislation Into Local Land Use Planning: A Handbook for Local Communities", an award-winning guidance document to aid cities and counties in implementing the 2007 flood risk management legislation, specifically including considerations of climate change in land use planning decisions in floodplains.[584]
- In 2013, DWR and the U.S. Army Corps of Engineers (USACE) released *California's Flood Future: Recommendations for Managing California's Flood Risk*, a report that shows $580 billion in assets are exposed to flood risk throughout the state and 7 million Californians live in a floodplain. The report provides a comprehensive look at flooding, along with challenges and recommendations for improving flood management.[585]

- The Water Boards adopted some of the first permits in the nation to emphasize land use as a key provision in its stormwater permits that also provides flood management protection.[586]
- The California Building Code was updated to incorporate voluntary regulations to help flood-proof residential construction.[587]
- DWR updated the Urban Levee Design Criteria to incorporate advanced engineering approaches, including climate change considerations.[588]
- The 2012 Central Valley Flood Protection Plan provides a framework for modernizing flood management and investment in the Central Valley.[589]
- As further described in the Ocean and Coastal Ecosystems and Resources section of this document, construction of four coastal observatories in 2013 – in Eureka, Bodega Bay, Big Sur, and Santa Barbara – that will improve flood watch and flood warning information that can be provided to local emergency responders.

Mainstreaming Climate Considerations in Water Management

The state continues to improve the incorporation of climate change information in its water planning and management activities. For instance, in the *California Water Plan Update 2009,* the State's strategic plan for water resources, DWR included a robust analysis of 12 future climate change scenarios and outlined myriad Resource Management Strategies that can be used by State and regional water managers to improve water supply reliability and quality.[590] The *California Water Plan Update 2013* will include additional scenarios, tools, and analysis that provide state leaders and local decision makers with additional information about future changes in California's water resources.[591]

Education and outreach are important components of the DWR Climate Change Program. DWR convenes the Climate Change Technical Advisory Group (CCTAG) to advise agencies on the scientific aspects of climate change, its impacts on water resources, the use and creation of planning approaches and analytical tools, to inform the development of adaptation responses for California's water sector.[592] The DWR Climate Change Program offers two classes to DWR staff. They include Climate Literacy 101 for all staff and Climate Literacy 201 geared toward project managers and others who need to understand climate modeling and environmental documentation. The classes are so well-attended that six such classes were offered within the first year.[593] DWR has also established climate change exhibits at local science centers as well as online educational climate videos.[594]

Continued Research

Several major research initiatives were also initiated or completed since 2009. DWR served on the steering committee for the Third California Climate Change Assessment which was completed in 2012; and a significant portion of the Third California Climate Change Assessment was dedicated to water-focused research.[595] DWR also serves on the Steering Committee for the California Landscape Conservation Cooperative.[596]

As discussed in the Oceans and Coastal Ecosystems and Resources chapter, the National Research Council (NRC) completed a comprehensive study of sea level rise along the West Coast in 2012. The States of California, Oregon, Washington, and three federal agencies co-sponsored the NRC study, with DWR as the project manager.[597]

DWR has also initiated a study to develop tree-ring reconstructions of paleo-stream flows in the Sacramento, San Joaquin, and Klamath River Basins. This study will extend the hydrologic record beyond the relatively short modern observational period and will thus provide an improved picture of climate variability.

Box 71

Local Actions to Prepare for Climate Risks to Water – Los Angeles

Los Angeles is implementing a number of actions to prepare for climate risks to its water supply, including water conservation measures and locally-developed water supplies to reduce its dependence on imported water.

Under the City of Los Angeles Water Conservation Ordinance (Ordinance) restrictions on certain water uses apply at all times, to all customers.[598] Some of these prohibited uses include:

- Watering landscape between the hours of 9:00 a.m. and 4:00 p.m.
- Watering of any hard surfaces such as sidewalks, walkways, driveways or parking areas;
- Outdoor watering during periods of rain;
- Allowing runoff onto streets and gutters from excessive watering;
- Allowing leaks from any pipe or fixture to go unrepaired;
- Washing vehicles without using a hose with a self-closing water shut-off nozzle;
- Serving water to customers in restaurants unless specifically requested.

The Ordinance contains five water conservation "phases" which correspond to severity of water shortage, with each increase in phase containing more stringent conservation measures. Awareness and enforcement efforts are conducted by the LADWP Water Conservation Response Unit whose mission is to stop wasteful water practices. During times of severe drought, the Response Unit actively patrol Los Angeles communities to help inform customers of water waste they observe in progress and learn about through tips from neighbors and concerned citizens. First offenses are given verbal "warning" in the form of water conservation tips, water saving devices where possible and printed educational materials in order to raise customer awareness. Subsequent violations, however, can result in fines. Monetary citations, when given, range from $100 to $600 and are listed as specific charges on the LADWP utility bill. No monetary citation is given without prior warning.[599]

The Los Angeles Department of Water & Power (LADWP) has also embarked on a sustainability plan to increase its local water supply and decrease its reliance on imported water by making

significant investments in conservation, stormwater capture, water recycling, and the remediation and cleanup of groundwater contamination in the San Fernando Basin (SFB)[600] As laid out in the 2010 Urban Water Management Plan (UWMP), ambitious long term goals for these local water supplies are projected through 2035.

On October 4, 2012, the Board of Water and Power Commissioners (Board) adopted the Board Resolution "LADWP Guiding Principles for the Development and Implementation of the Local Water Supply Program" which called for LADWP to generate a plan to accelerate local water supply development and remediate contamination in SFB beyond the goals set in the 2010 UWMP. As a result of this Board Resolution, LADWP began developing an initiative entitled "LA's Water Reliability 2025."

Preliminary findings of LA's Water Reliability 2025 show that LADWP can potentially meet its 2010 UWMP goals for local water resource development about a decade early by accelerating plans to implement specific stormwater capture, water conservation, recycled water projects and programs, and remediation of contamination in the SFB.

LADWP completed a study in June 2011 to analyze the operational and water supply impacts of potential shifts in the timing and quantity of runoff along the Los Angeles Aqueduct (LAA) system due to 21st Century climate change. Projected changes in climate expected to alter hydrologic patterns in the LAA's eastern Sierra Nevada Watershed include decreased precipitation, earlier snowmelt, increased ratios of rain to snow, increased variability of winter storm patterns, and increased evapotranspiration.

Changes in climate are also projected to increase the amount of rainfall and decrease the amount of snow that would occur in the Sacramento and San Joaquin rivers watersheds, thereby affecting State Water Project supplies from the Sacramento/San Joaquin River Delta. Local groundwater water supplies also expect considerable changes in recharge from precipitation as well. In addition to these water supply impacts, changes in local temperature and precipitation are anticipated to alter in-city water demand patterns.

LADWP is continuing to monitor developments in climate change science to better understand potential implications for the City's local and imported water supplies and in-city demands.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA WATER RESOURCES

Vigorously prepare California for flooding

Flooding currently presents a clear and present danger to public health and safety that will only worsen with climate change. As noted above, more than seven million Californians are currently exposed to flooding hazards within 500-year floodplains.[601] California remains underprepared for this current and growing threat, and the following actions are recommended:

- Protect taxpayer investments by requiring that DWR and SWRCB formally consider and account for climate risk in all water infrastructure planning, design, permitting, and funding, including loans and grants to local agencies;

- Expand the Western Observing and Forecasting System to allow for offshore observations that will provide greater forecast lead times for coastal communities;

- Conduct a vulnerability assessment of critical State-owned infrastructure located in the state's floodplains;

- Expand piloting and begin implementation of forecast-based operations to allow more flexibility to operate existing reservoirs for changing climate conditions;

- Given the concentration of State government facilities and functions in Sacramento, prepare a catastrophic disaster response and recovery plan for the Sacramento metropolitan area, in collaboration with local and regional governments and other partners;

- Continue work to implement critically needed repairs to California's levee system; and

- Reconnect rivers to their floodplains, rehabilitate upper watershed source areas, and provide more natural floodplain features and functions that slow, spread, capture, and infiltrate floodwaters throughout a watershed. Specifically,

    - improve stewardship of forests and headwaters to reduce the risks of catastrophic wildfire and downstream flooding impacts; and

    - expand existing and establish new flood bypasses.

Support regional groundwater management for drought resiliency

While California's largely decentralized regime for groundwater management presents significant challenges to adapting to climate change, it presents significant opportunities as well. For example, regionally managed groundwater recharge, storage, and conjunctive use (the coordinated management of surface and groundwater) can play a key role in compensating for the loss of natural water storage as the Sierra Nevada snowpack diminishes. Many local and regional groundwater management agencies also have the authority and capacity to: 1) establish thresholds for groundwater drawdown, quality, and subsidence; 2) monitor groundwater conditions; and 3) take actions to manage demand when needed to avert problems. State level support and oversight should be provided where needed to ensure the success of local and regional management efforts.

California must take steps now to ensure that its aquifers will help make its water systems climate resilient. Below are some recommended actions. Funding and staffing will be needed to implement many of these actions.

- Promote better understanding about California's groundwater, conjunctive use, and the potential risks associated with changing climatic conditions, including examples of groundwater crises already occurring in the state and projections on the condition of California's groundwater basins in 20 years, based on current groundwater management practices and climate projections.

- Strengthen and expand the California Statewide Groundwater Elevation Monitoring (CASGEM) Program established by SB 7x-6, to ensure continued groundwater level monitoring in areas where voluntary monitoring is not occurring, statewide prioritization of basins, and identifying basins subject to critical overdraft. Support a statewide evaluation of current groundwater conditions and management efforts, by analyzing CASGEM data and reviewing the content and implementation of groundwater management plans; from this assessment, develop guidelines to promote best practices for regional groundwater management.

- Develop and fund a state program for monitoring drought impacts on groundwater resources, including for remote sensing-based monitoring of land subsidence associated with groundwater extraction, as drought conditions cause water users whose surface supplies are curtailed to increase their groundwater use, depleting basin storage and sometimes creating impacts to others by inducing migration of poor-quality groundwater into pumping zones or accelerating land subsidence.

- Improve the State-level integration of existing groundwater data (quality and quantity) and information with surface water data and information.

- Promote groundwater recharge and storage by:

    - streamlining and aligning regulatory programs, as appropriate, to support increased conjunctive use and groundwater banking;

    - developing tools to help characterize and delineate groundwater recharge areas;

    - evaluating economic and water security benefits from more sustainable management practices;

    - developing estimates of storm water capture and groundwater recharge potential, and a tracking database to inform water resource planning and permitting decisions;

    - developing guidelines for coordinating land use planning and protection of groundwater recharge areas;

- incentivizing local and regional efforts to use low impact development techniques in new development and retrofits through State loans and grants;

- incentivizing reduced pumping in overdrafted groundwater basins and increasing groundwater recharge through State loans and grants;

- modernize the state's storm water regulatory program to incentivize storm water capture and infiltration, and protect the infiltrative capacity of hydrogeologically vulnerable areas;

- complete rulemaking for groundwater recharge with recycled water (indirect potable reuse);

- identify obstacles to increasing most efficient use of water by agriculture and develop programs, policies and practices to overcome these obstacles; and

- develop and adopt salt and nutrient management plans consistent with the State Water Boards recycled water policy.

- As part of IRWM plans, provide multi-agency support for local pilot projects that could become part of a system of regionally-based, strategic groundwater drought reserves; such pilot projects should be prioritized for high-use basins.

- Work with local and regional groundwater management agencies in impacted, vulnerable, and high-use basins to develop and refine groundwater thresholds for quality, level, and subsidence, conduct monitoring needed to determine if thresholds are being met, and take actions needed to sustainably manage groundwater.

Diversify Local Supplies and Increase Water Use Efficiency

Climate change is adding to other stressors to make water supplies from major sources like the Colorado River and the Sacramento-San Joaquin Delta less reliable. Increasing regional self-reliance and diversification of local water supplies will enable Californians to better respond to changing economic and climactic conditions while ensuring a reliable water supply for the diversity of the state's water needs. California's water agencies utilize a variety of water management measures to improve local water supply reliability. These measures include agricultural and urban water use efficiency, local storage, conjunctive use, increasing stormwater capture and infiltration, recycled water, and ocean and brackish water desalination. Since the early 2000s with the start of the Integrated Regional Water Management (IRWM) there has been increasing emphasis on regional collaboration in the implementation of water management measures. With the passage of SB7x7 in 2009, urban water suppliers are required to set and meet 2015 and 2020 water use targets and agricultural suppliers are required to adopt agricultural water management plans and report on the implementation of efficient

water management practices. The Delta Stewardship Council's Delta Plan requires water suppliers to reduce reliance on water from the Delta.

- The State should continue to support regional water management planning and project implementation through additional funding for the IRWM. The IRWM Grant Program funds a wide variety of regional water management actions. The IRWM Program is intended to support flexible implementation of actions needed to address regional objectives and needs. As such, the IRWM funds water supply, water quality, flood management, and environmental protection and restoration.

- The State should develop a 2030 Statewide Urban Water Use Efficiency Plan with the goal of requiring urban water suppliers to continue the improvements in water use efficiency from the 20x2020 program. Accounting for population growth, continuing the current 20x2020 program will keep the total volume of urban water use in 2020 at the same volume as in the year 2000. The goal of the 2030 program is to replicate the 20x2020 success and keep the volume of 2030 urban water use the same as the 2020 level.

- Agricultural water suppliers with irrigated acreage equal or greater than 25,000 acres should begin utilizing the methodologies for quantifying agricultural water use efficiency in the "Proposed Methodology for Quantifying the Efficiency of Agricultural Water Use" by 2020.[602] Quantifying water use efficiencies can provide valuable information to water suppliers and highlight efficiency improvements, and climate risks to California water will be increasing over time.

- Provide targeted funding for:
    - agricultural and urban water suppliers for projects that plan and implement sustainable water solutions serving disadvantaged communities
    - urban and agricultural water use efficiency research and development programs for development, testing and implementation of new technologies
    - the "Save Our Water" media campaign so it can achieve the same visibility and outreach as the California Public Utilities Commission's energy reduction campaigns.

- Set a statewide target of 1 million acre-feet (MAF) of recycled water use annually by 2020. DWR, with SWRCB, should prepare a comprehensive report of regional recycled water conditions to guide expanded use of recycled water including assessment of a 'fit for purpose' concept for urban, agricultural and environmental applications and a cost benefit analysis.

- State should promote the SWRCB's stormwater use target of 500,000 AF per year.

- Develop a coordinated streamlined permitting process for desalination projects that provides strong environmental protection.

- State entities, including SWRCB, DWR, CDPH, and CDFA, together with stakeholders should work to develop comprehensive data collection on water diversion, delivery, and use. This will assist in measuring program performance for this and other strategies.

Reduce Sacramento-San Joaquin Delta climate change vulnerability

As noted above, the Sacramento-San Joaquin Delta is vulnerable to climate risks such as flooding, sea level rise, and stress on aquatic habitat. Several planning efforts are underway to further the co-equal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem.

Reducing climate change vulnerability in the Delta will depend on completion and implementation of the Water Quality Control Plan, the Delta Plan and the BDCP. At the same time, as discussed elsewhere in this chapter, regions that depend upon water from the Delta will need to develop far more regional self-reliance, through a variety of measures, to ensure long-term water supply reliability.

Prepare California for hotter and dryer conditions and improve water storage capacity

While drought is a normal part of the water cycle in California, drought conditions are becoming more common and more severe. California's water infrastructure provides the ability to manage some degree of hydrologic uncertainty and variability through operational tools such as water transfers, reservoirs, and conjunctive surface water and groundwater use. However, it is not sufficient to address extreme or prolonged drought conditions.

As noted above, a variety of measures may be utilized to mitigate potential shortages during drought, including minimizing reliance on imported water, improved water conservation and water use efficiency, expanded water recycling, improved stormwater management, desalination, groundwater remediation, conjunctive use, firming up existing water transfer agreements, and entering into spot transfer or short-term water transfer agreements. The state has made substantial investments, through grant programs, in helping local water agencies improve their water supply reliability and take other actions that reduce their vulnerability to droughts.

The state can further improve California's ability to deal with the risks of more frequent and severe drought conditions by:

Box 72



California Department of Water Resources
San Luis Reservoir; July 11, 2007

- Improving drought prediction at the one-month to two-year timescales critical for making operational decisions in managed water systems, and for helping those relying on unmanaged water supplies assess their risks, through investing in research and related hydroclimate monitoring to improve prediction. From an operational perspective, improving drought predictive capability is probably the single most important action the state could pursue.

- Reducing the drought vulnerability of small water systems, especially those in at-risk rural areas dependent on unreliable groundwater sources, through state financial assistance programs and through lowering the threshold for requiring public water systems to prepare Urban Water Management Plans (UWMPs) from 3,000 or more connections to 2,000 or more connections.

- Improving the understanding of wildfire risks to water infrastructure, and support actions to reduce those risks. The hotter, dryer climate conditions that result in drought, also create risks of more frequent and severe wildfires that can further impact water supplies that are already otherwise stressed by increased water demand and decreased flows. Wildfire is already a significant cause of system damage for small water systems in rural areas. The damages experienced by Denver Water facilities following Colorado's 2002 fire season[603] illustrate potential risks to large water system infrastructure in the Sierra Nevada. Wildfire risk planning should be included in large water agencies UWMPs.

- Improving flexibility in our water transfer systems. Streamlined water transfers in times of extreme drought will strengthen California's resilience to climate change.

- Improving water storage capacity, including supporting regional groundwater management as further discussed above.

Address water-related impacts of climate change on vulnerable and disadvantaged populations and cultural resources

Just as different regions of California will experience the impacts of climate change differently, so will the diverse populations of California. Indeed, some people—including those who are ill or unemployed, the very old and the very young—may be more sensitive or vulnerable than others, making them less capable of coping with climate change. For instance, the increased flood risk due to climate change may disproportionally impact poor communities, due to their location as well as their lack of mobility. Disadvantaged communities already grappling with drinking water quality and supply problems are unlikely to have the capacity to deal with the additional challenges—deeper and longer droughts, deteriorating water quality—that climate change may bring to their water resources. Climate change may also negatively impact water resources that are important for tribal subsistence and cultural purposes.

Climate impacts are experienced locally, in communities. Targeted assistance in the form of outreach, information, funding, investments and community engagement will improve the likelihood that communities will support, implement, and benefit from adaptation strategies that can improve community resilience.[604] For these reasons, water planners and their partners must ensure equitable access to information and resources and explicitly recognize, target, and prioritize efforts to ensure that the most vulnerable Californians are prepared for climate risks to water; for instance, by establishing stable long-term funding sources for the provision of safe drinking water to small disadvantaged communities. A Tribal Advisory Committee helped to develop the content in the California Water Plan 2013 Update, and continued engagement with tribal nations will continue to be important when managing water resources in the era of climate change.

Continue to mainstream climate considerations into water management

As noted above, DWR has made great progress in mainstreaming climate considerations into its many operations. It began climate research as early as 1987, has integrated climate considerations into the California Water Plan since 2005, convenes a Climate Change Technical Advisory Group, and offers climate literacy classes for its staff.

Further actions can help mainstream climate considerations in all the state's water management activities. For instance, in order to reduce institutional barriers to preparing for climate risks, the Water Boards will use relevant, peer-reviewed climate science to identify climate adaptation criteria and processes for incorporating climate change considerations into all Water Boards' programs, such as water quality permits or guidelines for infrastructure loans and grants. The State Water Board and DWR should develop funding criteria to discourage construction of new water infrastructure in high-risk areas. In coastal groundwater basins, which are vulnerable to increased salt water intrusion as a result of sea level rise, the Water

Boards will support and encourage measures such as recycled water injection and groundwater storage during wet years to make coastal aquifers more resilient to climate change impacts.

Utilize low impact development and other methods in State and regional stormwater permits to restore the natural hydrograph

The Water Boards are encouraging permitees to use a watershed approach to "slow the flow" of water, using urban runoff best management practices to achieve multiple benefits, such as reduced pollution, water supply augmentation, flood protection and habitat enhancement. Municipal stormwater permitees are required to exercise their land use authority to implement development programs that require installation of stormwater controls at new developments and significant redevelopment projects. The permits adopted require the use of Low Impact Development techniques but also recognize that alternative or regional projects can be beneficial. These techniques range from onsite tree planting to installation of porous pavement to designing recharge wetlands and must be monitored to measure their effect on water quality. In collaboration with other State, regional and local agencies, the Water Boards will identify data needs to enhance planning decisions associated with preparing for climate risks and incorporate that data gathering in their permitting authority.

Urban trees can help filter and remove pollutants from stormwater, and also reduce stormwater runoff. Continued and expanded support for urban forestry and urban greening will be important not only for water-related benefits, but to reduce heat island impacts and reduce energy demand as California experiences climate impacts. For more information on urban forestry and heat island effects, please see the Forestry and Public Health sections of this document.

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

Despite state laws requiring demonstration of "adequate water supplies" for development and extensive requirements for both land use and water resource planning, these processes continue to lack integration allowing land use decisions to be made that may conflict with water resource plans or imperil sustainable management of water resources. Currently, General Plan Guidelines lack the specificity to ensure that water supply and water quality issues created by new development are adequately analyzed and addressed; in an era when climate risks present escalating challenges to water resources, new development must be carefully integrated with sustainable water management efforts. The Governor's Office of Planning and Research will engage local land use authorities and water agencies and amend the General Plan Guidelines to promote local land use decisions that are consistent with local sustainable water management.

Closer integration of Urban and Agriculture Water Management Plans and Integrated Regional Water Management Plans into General Plans and local climate action plans and/or resilience plans, through better coordination and harmonized planning requirements, will help establish

consistent sustainability goals across these planning processes. Water sustainability should also be given consideration for addition to the requirements of Sustainable Communities Strategies that are required for each of the state's Metropolitan Planning Organizations (MPOs). Increased coordination between land use and water planners may also reveal opportunities for improvements in stormwater management and the use of recycled water, both important strategies for improving resilience.

Protect and restore water resources for important ecosystems

As noted above and in the Biodiversity and Habitat section of this document, climate change presents a variety of escalating risks to important ecosystems in California. In order to reduce these risks, the state should continue its efforts to restore key wetlands and to ensure adequate water quality and supply for important ecosystems. Collaboration between state entities working on water issues and ecosystem management issues will also continue to be important.

Better understand climate risks to California water and develop tools to support efforts to prepare for climate risks

Additional information and tools are needed to adequately prepare for climate risks to the California water sector.

For instance, more research is needed regarding:

- the relationship between snow pack, rainfall, and groundwater recharge and quality;
- land-cover and ecosystem responses to changing precipitation and runoff conditions;
- how water quality in rivers, lakes and aquifers will be affected by changes in precipitation, timing of flow, and temperature;
- how water flow management can help support climate-stressed aquatic species; and
- the role of extreme precipitation events and implications for within-year variability on our water supply.

It will also be important to continue and enhance monitoring of changing water conditions. Monitoring allows tracking of changes in snow-covered and rain-dominated portions of key watersheds, and direct observation of climate changes can help refine climate projections and models.

It will no longer be adequate to manage California water resources based on historical trends, and decisions support tools for water managers that reflect climate projections are needed to help guide water management and planning decisions.

Box 73

California Water Management

Management of California's water resources are complex and occur at federal, state, regional and local levels. Some of the entities involved in the management of California water resources are listed below. At the local level, cities, counties, local and regional water utilities, wastewater agencies, irrigation districts, reclamation and levee maintenance districts and flood control agencies along with others too numerous to list here provide water quality, water supply, flood control, and ecosystem management.

California Department of Water Resources (DWR) Protects, conserves, develops, and manages much of California's water supply including the State Water Project which provides water for 25 million residents, farms, and businesses. DWR also develops strategic goals, and near-term and long-term actions to conserve, manage, develop, and sustain California's watersheds, water resources, and management systems. DWR works to prevent and respond to floods, droughts, and catastrophic events that would threaten public safety, water resources and management systems, the environment, and property. DWR prepares the California Water Plan, which is updated every five years through a collaborative process, to present the status and trends of California's water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios. DWR also provides local assistance, in the form of technical advice and grants, to regional water management groups.

State Water Resources Control Board and Regional Water Quality Control Boards (Water Boards) Regulates the quality of both surface and groundwater, allocates surface waters to support beneficial uses and provides low-interest loans and grants for wastewater and drinking water treatment as well as stormwater and recycled water management.

California Water Commission Advises the Director of the Department of Water Resources on matters within the Department's jurisdiction, approves rules and regulations, and monitors and reports on the construction of the State Water Project.

Central Valley Flood Protection Board Plans flood controls along the Sacramento and San Joaquin rivers and their tributaries in cooperation with the US Army Corps of Engineers.

Colorado River Board Protects California's rights and interests in the resources provided by the Colorado River.

Delta Conservancy Leads efforts that advance environmental protection in the Delta and the economic well-being of Delta residents. The Conservancy's goal is to implement projects that will result in integrated environmental, economic and social benefits.

Delta Stewardship Council The Delta Stewardship Council was created by the Sacramento-San Joaquin Delta Reform Act of 2009 to develop a comprehensive management plan for the Delta

(Delta Plan) that furthers the co-equal goals of providing a more reliable water supply and restoring the Delta ecosystem.

California Department of Public Health (CDPH) Regulates public water systems; oversees water recycling projects; permits water treatment devices; certifies drinking water treatment and distribution operators; supports and promotes water system security; provides support for small water systems and for improving technical, managerial, and financial capacity; oversees the Drinking Water Treatment and Research Fund for MTBE and other oxygenates; and provides funding opportunities for water system improvements, including funding under Proposition 84, Proposition 50, and the Safe Drinking Water State Revolving Fund.

California Public Utilities Commission (CPUC) Regulates privately owned water and other utility companies.

California Department of Fish and Wildlife (DFW) Regulates and conserves the state's wildlife and is a trustee for fish and wildlife resources (FGC § 1802). It is the State's primary department for managing the native fish, wildlife, plant species, and natural communities for their intrinsic and ecological value. It serves a regulatory role by enforcing the California Endangered Species Act and Fish and Game Code 1600, Streambed Alteration Agreements.

Governor's Office of Emergency Services (OES) OES is responsible for overseeing and coordinating emergency preparedness, response, recovery, and homeland security activities in the state including those related to flooding and other water related disasters.

California Department of Conservation (DOC) Provides services and information that promote environmental health, economic vitality, informed land-use decisions, and sound management of California's natural resources. This department also manages a state watershed program.

California Department of Food and Agriculture (CDFA) Serves the citizens of California by promoting and protecting a safe, healthy food supply, and enhancing local and global agricultural trade, through efficient management, innovation and sound science, with a commitment to environmental stewardship.

California Department of Forestry and Fire Protection (CAL FIRE) Manages and protects California's natural resources. Provides fire protection and stewardship of more than 31 million acres of California's privately owned wildlands which provide important watershed source areas.

California Department of Parks and Recreation (State Parks) Manages more than 270 park units, which protect and preserve culturally and environmentally sensitive structures and habitats, threatened plant and animal species, ancient Native American sites, and historic structures and artifacts. Responsible for almost one-third of California's scenic coastline and manages many of the state's coastal wetlands, estuaries, beaches, and dune systems.

California Department of Pesticide Regulation Regulates pesticide sales and use and plays a significant role in monitoring for the presence of pesticides and in preventing further contamination of the water resource.

California Department of Toxic Substances Control (DTSC) Provides technical oversight for the characterization and remediation of soil and water contamination.

Delta Protection Commission Responsible for preparation of a regional plan for the "heart" of the Delta. The DPC ensures orderly, balanced conservation and development of Delta land resources and improved flood protection by adaptively protecting, maintaining, and where possible, enhancing and restoring the overall quality of the Delta environment including agriculture, wildlife habitat, and recreational activities.

Sierra Nevada Conservancy (SNC) Initiates, encourages, and supports efforts that improve the environmental, economic, and social well-being of the Sierra Nevada region, its communities, and the citizens of California. The region, which comprises all or part of 22 counties and more than 25 million acres, is California's principal watershed, supplying 65 percent of the developed water supply.

State Lands Commission (SLC) Manages public trust lands of the State (the beds of all naturally navigable rivers, lakes, and streams, as well as the State's tide and submerged lands along California's more than 1,100 miles of coastline). The public trust doctrine is applied to ensure that the public trust lands are used for water-related purposes, including the protection of the environment, public recreation, and economic benefit to the citizens of California.

Federal Agencies

US Army Corps of Engineers (USACE) Oversees management of flood protection infrastructure and facilities throughout the state and provides dredging services for waterways that serve as transportation and shipping routes. The USACE also regulates any construction or dredging within "navigable waterways of the United States" through Section 10 of the Rivers and Harbors Act.

US Bureau of Reclamation (USBR) Operates the Central Valley Project (CVP), the largest water project in California; and regulates diversions from the Colorado River.

US Department of Agriculture (USDA) Manages forests, watersheds, and other natural resources though the US Forest Service and US Natural Resource Conservation Service.

US Environmental Protection Agency (US EPA) Protects human health, safeguarding the natural environment.

US Fish and Wildlife Service (USFS) Conserves, protects, and enhances fish, wildlife, and plants and their habitats.

US Geological Survey (USGS) Provides water measurement and water quality research.

APPENDIX A: COMPENDIUM OF RECOMMENDED ACTIONS

The Safeguarding California Plan is not meant to replace the 2009 CAS, but to add new recommendations and replace portions of the prior document where new information allows for updating and revision. Except where revisions and new recommendations supersede, the strategies in the 2009 CAS continue to be relevant and are carried forward.

The 2009 CAS was built on several guiding principles. Many of these principles are still relevant and are carried forward as updated here:

- Use the best available science to identify risks and adaptation strategies;
- Understand that an effective strategy for preparing for climate risks should evolve as new information is available;
- Involve all relevant stakeholders;
- Establish and maintain strong partnerships across all levels of government, tribes, businesses, landowners, and non-governmental organizations;
- Give priority to strategies that also achieve benefits other than climate risk reduction benefits, including additional benefits to public health, the economy, environmental justice, and conservation of natural resources; and
- Ensure that strategies to reduce climate risk are coordinated, to the extent possible, with the state's efforts to reduce GHG emissions and other local, national and international efforts.

The Safeguarding California Plan is designed as policy guidance for state decision makers. Climate risks often present cross-sectoral challenges, and may require cross-sectoral solutions. As a result, the Safeguarding California Plan identifies cross-sectoral linkages throughout. Each sector chapter features its own recommendations; cross-sectoral strategies are presented in the Introduction.

The various actions recommended in this Safeguarding California Plan are compiled here for ease of reference. Full text and citations supporting these recommendations may be found in the Introduction and respective sector chapters of this document; any discrepancies between the text in this Appendix A and the text in the body of this Safeguarding California Plan should be resolved by referring to the text in the body of the Safeguarding California plan.

- **CROSS-SECTOR STRATEGIES**

Establish a mandate and guidelines for all state agencies to consider climate risks in their policies, planning efforts, and investments

● Require that climate risk considerations be incorporated into state infrastructure planning; and

● Provide guidelines for state agencies to incorporate climate risk considerations into all policies, plans, and investments:

- Encourage Iterative Approaches
- Protect California's Most Vulnerable Populations
- Achieve Multiple Benefits from Efforts to Reduce Climate Risks and Prioritize Green Infrastructure Solutions
- Integrate Efforts to Reduce Climate Risk with Efforts to Reduce the Emissions that Cause Climate Change to the Fullest Extent Possible
- Develop Metrics and Indicators to Track Progress on Efforts to Reduce Climate Risk

Provide data, tools, and guidance to support efforts to reduce climate risks

- Additional research to fill informational gaps about California's climate vulnerabilities and additional research on the scope, timing, cost and feasibility of management options to address climate change;
- Tools and guidance to support efforts to plan for climate risks at the state, local, and regional level; and
- Supporting monitoring to gather direct observations of the changing climate.

Build the capacity to plan for and implement actions to reduce climate risk through collaboration, education, outreach and funding.

●Foster collaboration and innovation across state agencies and across levels of government

●Develop a comprehensive climate education and outreach strategy

●Provide significant and sustainable funding for investments that reduce climate risks, human loss and disaster spending

ACTIONS NEEDED TO SAFEGUARD AGRICULTURE

Developing and promoting adoption of management strategies that reduce climate risks to agriculture

Actions to develop and promote adoption of management strategies with multiple benefits that reduce climate risks to agriculture will be important, these may include:

- Developing new and adapting existing best management practices that reduce climate risks, including, for example, soil conservation practices and practices that support pollinator health;
- Developing incentive programs for sustainable, science-based practices that create resilience to climate impacts, including pilot-projects to demonstrate proof-of-concept;
- As further discussed in the Water section of this document, management strategies that reduce climate risks to water are needed including, but not limited to, enhanced flood management, water use efficiency, and regional groundwater management for drought resiliency;

- Reducing the rate of farmland conversion to buffer against climate risks to food production by supporting smart growth and reducing urban sprawl, and supporting farmland conservation;
- While continuing breeding research as discussed above, also supporting efforts to systematically collect and preserve agricultural genetic material in recognition of the risk of agricultural biodiversity loss from climate change;
- Investing in and improving agricultural equipment to be adaptable between crops to facilitate shifting crop patterns and to optimize capital investments in the face of changing climate conditions; and
- Working with industry to develop new technologies for field-level monitoring of climate impacts, including, for example pests.

Understanding and responding to evolving trends that relate to agriculture

Changing climate risks and emergency management

CDFA is the lead agency on emergency management related to food and feed safety and agricultural diseases and pests. As noted in the Emergency Management section of this document, climate change is likely to require improvements emergency preparedness and response capacity. As discussed above, climate change has implications for infectious diseases and food and animal safety. It will be important to ensure that CDFA has adequate support and capacity to respond quickly to emergencies related to food and feed safety and agricultural diseases and pests.

Supporting new revenue streams for agriculture that support positive climate action

Climate change threatens the California agricultural sector with economic losses, and the ability to develop new revenue streams may help provide added fiscal resilience for California farmers and ranchers. Activities that generate new revenue streams may themselves help foster positive action on reducing the emissions that cause climate change, and help to build resilience against climate risks. For instance, as discussed above, the development of anaerobic digesters and co-digestion of agricultural by-products can provide flexible, renewable energy and help with waste diversion goals. Developing incentives for agricultural ecosystem services, such as beneficial soil practices (for example, cover crops, tillage practices, and the use of compost), can provide greenhouse gas and water quality benefits, and such practices can also foster greater resilience in the face of climate impacts (for instance by improving soil moisture during hotter, drier conditions).

Cross-sectoral climate impacts

Climate risks to other sectors are important to agriculture. Climate risks to water and management strategies to address those risks are obviously important to agriculture. Impacts in other sectors are also important, for instance, impacts to the energy system can disrupt agricultural production, impacts in the transportation sector can have critical implications for agricultural goods movement, and climate impacts to biodiversity and habitat may have impacts on species that are beneficial to agricultural production.

Furthermore, impacts to the agricultural sector can have important implications for other sectors. For instance, increasing temperatures, may require increased energy or water consumption for agriculture (for instance, to enhance or provide livestock cooling systems). As discussed in this chapter, declining agriculture productivity or price increases related to climate impacts may also have impacts on public health. Cross-sectoral collaboration and engagement will be increasingly important in the era of climate change.

Support risk sharing mechanisms that protect food security and California's agricultural sector

As discussed in the Emergency Management section of this document, insurance and disaster relief are important risk sharing mechanisms that can help foster resilience, especially when combined with other efforts to reduce climate risks. However, federal program spending on the types of crops grown in California remains a small fraction of that spent on crops, like corn, wheat, soy, and cotton, which are predominantly grown in other parts of the nation. Climate risks to California's crops and livestock not only threaten California's agricultural sector and economy, climate impacts may cause price increases in healthy foods, like fruits, nuts, and vegetables, that are important for food security in California, the nation, and the world.

California should continue to support national policy reforms that would provide crop insurance and disaster assistance safety net programs to all commodities, and ensure that California farmers and ranchers have access to these types of important risk sharing mechanisms.

Improving Understanding of Climate Impacts on Agriculture

<u>Research, Modeling and Monitoring</u>
Some important work has been completed with respect to research and modeling projected climate impacts to agriculture, but more remains to be done. Needed actions include, but are not limited to:

- Studies of infrastructure and capital associated with relocating crops or shifting between crops; and economic studies of crop relocation or crop shifting, including comparative cost studies of moving or losing certain crops;
- Studies that evaluate the climate benefits of organic materials as soil amendments, such as compost, biochar, and digestate;
- Research supporting the beneficial use of agricultural by-products for renewable energy and organic fertilizers;
- Studies to quantify carbon sequestration and water saving potential of compost use in agricultural setting such as irrigated croplands and rangelands;
- Cumulative impact studies: As discussed in this chapter, agriculture faces multiple changing climate variables and multiple climate risks, and these threats occur against the backdrop of other stressors such as farmland conversion. More research

is needed to understand the compound and cumulative impacts of these risks, to develop more accurate projections to inform risk management strategies;
- Plant and animal breeding research, including research on pest and disease resistance, drought resistance, heat and chill resilience, and stress tolerance;
- Research on changing water needs for agriculture in times of more sustained higher temperatures and extreme heat events;
- Research on climate impacts on vector-borne diseases in animals, along with action to preserve and enhance monitoring, testing and reporting capacity for such diseases, especially in light of reductions in federal funding from the Centers for Disease Control and Prevention for such activities;
- Research on climate change risks to food safety;
- Research on temperature changes and other climate stresses on livestock;
- Further research on temperature changes and other climate stresses on crops;
- Further studies on barriers to efforts to prepare for climate risks and ensure the long-term sustainability of California agriculture, including possible strategies for overcoming such barriers;
- Creating an online "research needs" forum where agricultural stakeholders, including farmers, ranchers and industry groups, can share their needs, observations, and ideas directly with scientific researchers; and promoting cooperative research that involves farmers and ranchers in the research process, including "on-farm" research projects;
- Studies of the economic and social risks of negative climate impacts on California agriculture;
- More crop-specific and location-specific studies of climate risks, and modeling projections of productivity effects and impacts to help facilitate the development of specific, actionable management activities to reduce climate risks (e.g. strategies for salt water intrusion for agriculture located in areas susceptible to such risks)
- Further research on climate impacts on weeds and invasive plant species, insect pests, and pathogens affecting crops;
- Further research on climate impacts on pollinators, including native pollinator species;
- Studies of the ability of California's beneficial species to control new or worsening invasive species problems; and
- Studies of the effectiveness of different cropping practices, e.g. organic, crop rotation, fertilization, for addressing climate risks to agriculture.

<u>Visualization Tools</u>

Climate research and data will need to be translated into tools that can be used by agricultural producers involved with on-the-ground management of agricultural resources. Tools may include:

- An early effort at mapping California agricultural vulnerability was developed as part of the Third Climate Change Assessment but the mapping effort needs to be refined

to consider additional variables and more fully assess the vulnerabilities to California's water resources and livestock systems in a spatially explicit manner, and to modify the mapping to accommodate future projections of climate, land use, and socio-economic variables;
- Vulnerability maps showing projected climate risks to California agriculture, should be integrated in state visualization tools such as Cal-Adapt and the California Geoportal;
- Climate risk visualization tools tailored more specifically to agricultural producers should be developed, supported, maintained, and publicized.

Outreach and Education

It will be important to disseminate information regarding the results of continuing research on climate risks to agriculture, the development of best management practices for dealing with such risks, and any expanded business, funding, or risk sharing opportunities that can enhance resilience. This information must be shared with farmers and ranchers, decision makers, and other partners in a format that is easily accessible and readily usable in order to promote timely action to protect agricultural resources from climate risks.

Efforts to foster this type of outreach and educational might include:

- Working collaboratively with partners (such as USDA Climate Hubs, USDA Natural Resources Conservation Service, University of California Cooperative Extension, Resource Conservation Districts, and the California Agricultural Commissioners and Sealers Association) to provide information on climate risks as well as financial and technical assistance to farmers and ranchers interested in adopting practices that create resilience against climate risk;
- Establishing an international exchange program to facilitate the learning and adoption of new tools and techniques to create resilience in farming and ranching in the face of climate risks;
- Developing a comprehensive list of adaptation strategies that have worked throughout the world to reduce climate risks to agriculture, and promote such strategies in California if relevant and useful;
- Hosting a recurring conference focused on preparing for climate risks to agriculture for farmers, ranchers, researchers, government agencies, and other partners;
- Continuing integration of agricultural climate risk considerations into broader state efforts to prepare for climate risks;
- Recognizing and publicizing the efforts of innovative farmers and ranchers who are proactive in preparing for climate risks and adopting practices that foster resilience; and
- Providing online materials, in addition to the visualization tools discussed above, regarding climate risks to agriculture (such as changing water availability, extreme

weather events, loss of winter chill and other temperature changes, possible shifts in pests and disease, possible shifts in pollinator lifecycles, etc.).

ACTIONS NEEDED TO SAFEGUARD BIODIVERSITY AND HABITATS

Develop management practices to help safeguard species and ecosystems from climate risks

1) Improve habitat connectivity and protect climate refugia

Promoting habitat connectivity and protection of refugia will aid in species migration and movement and propagate ecological processes across the landscape. We must utilize existing programs such as NCCP and planning documents such as the State Wildlife Action Plan to continue improving connectivity between existing terrestrial, aquatic, and marine conservation areas in addition to creating new conservation areas where applicable. Priorities for creating, maintaining or restoring conservation areas should include landscape features that will ease the transition to future climatic conditions for species supported by the habitat (e.g., low fragmentation, climatic and elevational gradients, groundwater resources, etc.). Coordination should be promoted among state, federal, and private landholders to encourage consistency across management approaches to maximize biodiversity and promote large-scale connectivity.

2) Implement adaptive management studies to refine approaches for conserving biodiversity, especially for species and communities vulnerable to climate change

As mentioned in the 2009 CAS, the original CA State Wildlife Action Plan (2005) articulated an approach for designing monitoring programs to support adaptive management, which is still relevant today. Actual case studies that implement adaptive management are needed to further understanding of the relative merits of alternative management strategies for conserving biodiversity in the face of rapidly changing climate conditions. NCCP plans already incorporate adaptive management and may provide opportunities to study and refine approaches for managing biodiversity in the era of climate change. Vulnerability studies should help inform where adaptive management studies should be focused and which species and natural communities should be included in such studies.

Enhance biodiversity monitoring in California to detect climate impacts and inform responses

There continue to be gaps in the monitoring of resource conditions that can support effective management decisions in the era of climate change. A comprehensive, statewide approach to biodiversity monitoring is needed to help develop baseline ecological information and to detect changes in terrestrial and aquatic species and habitat patterns on the landscape. Monitoring and observing changing conditions is critical to refining climate impact and species/habitat response models and to informing the development of forward-looking conservation strategies and management actions that account for changing conditions.

The CDFW Species and Natural Communities Monitoring and Assessment Program, or simply Resource Assessment Program (RAP), was designed to help inventory, monitor, and assess the distribution and abundance of priority species, habitats, and natural communities in California. As such, RAP provides a basic infrastructure for addressing biodiversity inventory and monitoring needs in the state. With additional support, this program could be expanded to meet the need for comprehensive, state-wide biodiversity monitoring to support forward-looking management actions that are responsive to a changing climate. Climate considerations should be integrated into monitoring strategy design and the development of monitoring priorities; and strategic monitoring priorities may be informed by other state efforts including CDFW's State Wildlife Action Plan, DWR's California Water Plan, CalFire's Forest and Rangeland Assessment Program, State Water Resource Control Board's (SWRCB) Basin Plan, and the type of statewide climate vulnerability assessment discussed above.

Support Environmental Stewardship Across Sectors

1) Promote Nature-Based Solutions for Adapting to Climate Risks

Nature-based solutions can be a cost-effective means for addressing climate risks, and also provide additional benefits including benefits for habitat and biodiversity. The State should encourage and support the consideration of nature-based approaches for preparing for climate risks where such approaches are available. In order to support informed decision making, funding is needed for studies that help quantify the benefits of ecosystem services that reduce climate risks.

2) Create, maintain and support tools that help resource managers determine when and where to focus conservation activities that will protect biodiversity in the face of climate risks

Improved modeling of the impacts of climate change on wildlife, fish, and plants will be necessary at a scope and scale appropriate for management application. Associated predictive and planning tools are also necessary to ensure that resource management actions are informed by best available science, and such tools require maintenance over time and support to encourage user adoption. As noted above, CDFW developed the Areas of Conservation Emphasis (ACE) Mapping and Modeling Tool to provide a spatial model that can be used to identify areas of biological or conservation interest to guide conservation priorities. Tools such as ACE should continue to be maintained and updated with new biological data developed over time, in order to support biodiversity conservation planning and management decisions within CDFW and other state agencies. Determining what biodiversity-related information and tools would be useful to other agencies in their climate change planning efforts will also be necessary to manage the needs of wildlife, habitats, and humans in tandem.

Improve Understanding of Climate Risks to Biodiversity and Habitats

As further described below, continued research is essential to improve understanding of climate risks to biodiversity and habitats in order to inform management responses that might

reduce risks to biodiversity and promote resilience. One overarching need is to improve baseline information; there are still significant data gaps with respect to California's biological resources. Baseline information provides a reference point against which future changes in biodiversity can be assessed. Continued and enhanced predictive modeling combined with monitoring of certain species will be also be needed to guide resource management decisions. Further information is also needed regarding the interactions between plants, animals and their environment, especially as the timing of life cycle events shift in response to climate change. Finally, there is a need to continue vulnerability studies and the identification of critical connections and corridors.

In addition to informational needs around biological resources, it would be useful to consolidate and analyze non-habitat baseline information such as current land uses and land use policies throughout the state, as well as whether municipalities and permitting agencies have incorporated climate change impacts into their land use planning (i.e. General Plans, Local Coastal Programs). This information will be an important part of determining the best opportunities for habitat restoration and land acquisition as part of a larger effort to create a well-connected system of conservation areas, minimize the impacts of climate change to the greatest extent possible, and plan appropriate strategies for long term conservation and management actions.

It is important for the state to coordinate with other research efforts, including the efforts of federal, academic and regional collaboratives, in order to benefit from collaborative work and optimize resources. As noted in the introduction to this document, there is also a need to ensure consistency in data sets and tools developed and utilized by different state entities.

Research needs related to climate impacts and risks to biodiversity and habitat are described below. Additional information on these types of needs may be found in the August 2011 CDFW Climate Change Research Considerations document, the February 2012 CDFW Climate Change Research Needs document, the California Climate Research Plan, and the forthcoming 2015 update to the State Wildlife Action Plan.

1) <u>Completing habitat and vegetation mapping</u>

High-resolution, state-wide vegetation mapping following the National Vegetation Standard is needed to identify movement of vegetative communities, detect changes in their composition, and identify any new assemblages created throughout time. This information may provide insight into how species will move in accordance with changes in the location of their required habitat. Vegetation mapping can also be directly tied to the California Wildlife Habitat Relationships system, for example, to identify which species will likely be impacted most by these environmental changes. Additional funding and resources are needed to sustain existing efforts related to vegetation mapping, for example through the CDFW Vegetation Mapping and Classification Program.

2) <u>Refining regional connectivity analyses</u>

The California Essential Habitat Connectivity Project was a state-wide effort to identify large remaining blocks of intact habitat or natural landscape and model essential connectivity areas between them that need to be maintained, particularly as corridors for wildlife. Finer-scale, regional corridor modeling and connectivity analyses are needed to help prioritize land acquisition and protection. Corridor prioritization exercises, for example those currently taking place in the Northern Sierra Nevada Foothills and Desert regions of California, should be replicated in other parts of the state. Work to identify critical habitat linkages has also been undertaken along the north-central coast of California led by the Science and Collaboration for Connected Wildlands in conjunction with many other agencies and organizations.

3) Additional climate vulnerability analyses

As described below, more research is needed to understand species and habitat vulnerability to climate change. Vulnerability studies will need to be refined and updated periodically to ensure that best available science informs management decisions. Training and tools may need to be developed to help translate vulnerability findings into management actions. Additional funding and resources may be needed to support vulnerability studies over time.

- A comprehensive, statewide climate change vulnerability analysis at the habitat scale is needed to better understand climate risks to California's biodiversity. Vulnerability information at this scale will support ecosystem-based conservation planning and management efforts, and can also be used to increase our broader, ecoregional understanding of the vulnerabilities of biodiversity to climate change. Existing and future species and taxa-specific vulnerability assessments can also be compared against habitat assessment results to gain further insight into climate risks and inform development of strategies that can help protect biodiversity resources.
- As mentioned earlier in this chapter, a subset of rare plants in the state have already been analyzed for climate vulnerability, however, follow-up coverage of additional rare plant species is needed. Species most likely to be at risk from climatic changes, such as those found in higher elevations, ephemeral systems, vernal pools, etc., should be high priorities for examination.
- A state-wide vulnerability assessment of mammal species of special concern is also necessary.
- A state-wide vulnerability assessment is needed for invertebrates. Examining certain invertebrates will contribute to our knowledge of how some pollinators will be impacted by climate change, with implications for agriculture and other ecosystem services. These species are already being impacted by changes in phenology that have been linked to climate change, and more information is needed on species future vulnerability.
- Marine and aquatic habitat climate vulnerability assessments are also needed. For more information on climate and marine habitat, please see the Oceans and Coastal Ecosystems and Resources section of this document.

4) Understanding extreme events and disturbance regimes

Research is needed regarding the risks posed by extreme events or disturbances (e.g. fire, flooding, drought, insect outbreaks, invasive species, etc.) to ecosystem function, resilience, and services. This will provide additional insight into how some existing stressors or processes may be exacerbated by climate change.

5) Identifying opportunities to address the emissions that contribute to climate change

Carbon storage can be one of the benefits provided by healthy ecosystems. Additional research is needed to quantify baseline carbon information associated with natural systems, and to identify and prioritize conservation and restoration opportunities with carbon sequestration benefits. Pilot projects can help refine understanding of the greenhouse gas storage capacity associated with natural systems.

Information Sharing and Education

1) Create and maintain partnerships that support biodiversity conservation in a changing climate

Collaborating with other agencies and partners supports not only the transfer of data and information, but ensures that conservation priorities with respect to climate change are clearly communicated within the broader conservation community. Communication is imperative to identifying and promoting common goals, and to support adaptation planning and implementation to conserve biodiversity. Collaboration will also promote complementary actions across jurisdictions on adjacent landscapes, which is vital to achieving our objectives related to habitat connectivity. State agencies should continue to pursue national, regional, and local coordination and promote initiatives to conserve biodiversity beyond the borders of California such as through the Western Governors' Association, West Coast Governors Alliance on Ocean Health, Association of Fish and Wildlife Agencies, the Trilateral Committee for Wildlife and Ecosystem Conservation and Management, and the National Fish, Wildlife, and Plants Climate Adaptation Strategy. Continued engagement with partners in the CDFW Climate Change Stakeholder Group will also be important and should be supported.

2) Promote public education and outreach on climate change impacts to biodiversity

Increasing communication with the public and partners on climate change impacts to biodiversity will raise awareness of this important issue and help create support for state actions that promote biodiversity conservation. State agencies should develop a collaborative messaging campaign centered on California's climate activities to safeguard natural resources, while highlighting the importance of nature-based action.

Many state agencies have staff that interface regularly with the public through education or outreach programs, which provide opportunities to engage the public on this topic. Agencies should work with partners to develop information to be used for public interpretation and classroom education related to biodiversity conservation in the face of climate change. Opportunities may be available at visitor centers in hatcheries, State Parks, wildlife areas, or other facilities run by the state. Helping to

educate the public on climate change issues may have the additional benefit of promoting public involvement in data collection activities across many locations with limited costs through citizen science.

3) Provide support for the continuation of the CDFW Climate College and educational outreach efforts and link those efforts to broader state climate literacy programs

As noted in the Introduction to this document, it is necessary to build internal capacity for state entities to operationalize climate risk considerations into their activities. The CDFW Climate College provides a useful template for a departmental climate literacy program. The CDFW Climate College and related educational efforts should continue to be supported, and those efforts should be linked to any broader state climate literacy efforts.

ACTIONS NEEDED FOR IMPROVED EMERGENCY MANAGEMENT IN THE FACE OF CLIMATE IMPACTS

Improve Integration of Climate Impacts and Projections into All Phases of Emergency Management

Promote the implementation of the Climate Adaptation Planning Guide (APG) and Inclusion of Climate Risk Reduction in Hazard Mitigation Planning Efforts

The State will continue to promote APG implementation and principles of sustainability, resilience and hazard mitigation through collaboration with key public and private sector organizations through mechanisms including:

- Local hazard mitigation plans encouraged under federal law;
- Emergency operations plans required under federal law;
- Local general plan safety elements required by California law;
- Encouraging LHMP adoption into Local Government General Plan Safety Element;
- Sustainable Communities Strategies of metropolitan planning organizations;
- Local Coastal Programs under the California Coastal Act;
- Strategic Fire Plan for California;
- The Central Valley Flood Protection Plan;
- California Water Plan and other flood planning documents; and
- The Energy Assurance Plan.

These mechanisms relating to transportation planning, fire, flood, energy and coastal planning are discussed in their respective sections in this document.

Hazard mitigation efforts should consider the vulnerability of these community resources to climate risks:

- Essential Facilities – hospitals, medical facilities, police and fire stations, waste management facilities, emergency operations centers, shelters, schools, etc.
- Transportation Systems – airways, bridges, tunnels, roads, railways, waterways, etc.
- Lifeline Utility Systems - potable water, wastewater, landfills, oil, natural gas, electric power, communication systems.
- High Potential Loss Facilities - nuclear power plants, dams, military installations, etc.
- Hazardous Material Facilities
- Facilities Supporting Vulnerable populations
- Economic elements - major employers, financial centers, etc.
- Areas of special consideration – high-density residential or commercial development resulting in high death tolls/injury if damaged.
- Historic, cultural, and natural resources areas

<u>Continue to support the integration of climate risks in state and local government emergency planning efforts and enhance capacity to respond and recover from climate risk</u>
Emergency management grants, planning assistance and guidance, mutual aid agreements and post-disaster recovery and hazard mitigation, all play key roles in effective emergency management efforts. As California agencies plan for climate change, there may be opportunities for joint projects, information sharing, and shared funding opportunities with local and regional partners as well as with other States. Preparing for climate risks may also offer additional benefits for overall resilience in emergency situations; for example, increasing energy and water security to prepare for climate risks will help California better prepare and respond to earthquakes and terrorist attacks and will help to ensure first responders, the military and other emergency services can continue to operate during emergencies and disasters.

Support Risk Sharing Mechanisms

As noted above, public and private insurance and disaster relief provide important risk sharing mechanisms. Efforts to reduce climate risks through hazard mitigation activities, including but not limited to fire hazard reduction, minimizing new development in areas most vulnerable to hazards, and improved flood management, will be important to managing risks and supporting sustainable insurance and disaster programs. Specific recommendations regarding National Crop Insurance and the National Flood Insurance Program may be found in the Agriculture and Oceans and Coastal Resources sections of this document respectively.

Better Understanding of Climate Impacts on All Phases of Emergency Management

<u>Assess adequacy of surge and response capacity in light of climate projections for more frequent and more severe weather events</u>
Climate change is projected to increase the frequency and severity of natural disasters related to flooding, fire, drought, extreme heat, and storms (especially coupled when coupled with sea-level rise). This may require preparing for additional emergency surge capacity across the various emergency functions identified in the State Emergency Plan and for additional

emergency response capacity. The State should assess the adequacy of its current emergency surge and response capacities. Funding for this type of assessment may be needed.

Research and monitoring

As discussed in this document, the State has already invested significant resources to conduct and support initial climate vulnerability and cost assessments in a variety of sectors. As noted in the various sections of this document, additional research is still needed to continue to expand and refine information about the climate vulnerabilities of California's populations, infrastructure, property, food and agriculture, and biodiversity. Monitoring and research related to extreme weather events including flood, drought, heat, fire, and related losses will be especially important for emergency management and public safety. Coordination between sectors will help to maximize research and monitoring funding, information sharing, and will help facilitate well-integrated actions to build safe and healthy communities.

Climate Risk Communication and Education

Integrate climate projections into the MyHazards and MyPlan tools, and continue to update and maintain the MyHazards and MyPlan tools

As noted above, the MyHazards and MyPlan tools provide important information for individuals and local and regional governments to plan for hazards. As the climate changes, it will be important to integrate future climate projections into the tools. The Cal-Adapt tool, discussed in the Introduction to this document, is a climate projection visualization tool, and might be used to help integrate climate projections into My Hazards and My Plan. The tools will need to continue to be updated and maintained as new information and risk management strategies are developed.

Increase outreach efforts to prepare for extreme events

Increasing outreach efforts can help households and business better understand and prepare for climate risks and extreme events such as fires, floods, storms, drought and extreme heat. Funding may be needed for such outreach efforts, but prospective emergency planning can help lower emergency response risks and costs. The state should support outreach to encourage emergency preparedness actions including the development of evacuation plans and preparedness kits. These outreach efforts should tailored to be culturally and linguistically relevant for California's diverse populations.

Training for first responders and other emergency managers on climate risks

First responders and other emergency managers play a key role in emergency management; and first responders are directly at risks from increasingly frequent and severe risks such as fire and floods. As noted in the Introduction to this document, state agencies and departments should be provided with the resources to enable climate training for staff. Climate training for emergency managers is critically important for both public health and safety and for the safety of first responders.

ACTIONS NEEDED FOR SUFFICIENT, RELIABLE AND SAFE ENERGY

The state will need to continue enhancing California's energy adaptation efforts and ensure that California has a sufficient, reliable, and safe energy infrastructure to meet current and future energy demand as well as the state's clean energy goals. In implementing any of the adaptation strategies, consideration will also be given to other socio-economic and environmental objectives, such as habitat protection, ecosystem services, environmental justice, public health, and economic feasibility. Further collaborative work that is needed includes the following:

Protect existing energy facilities and consumers from impacts of climate change

- Conduct vulnerability and adaptation studies for the energy sector in coordination with private entities managing energy resources with the goal of generating actionable research products; make research results available with a geographical context via Cal-Adapt.
- Support the energy component of local cross-sector adaptation efforts, such as expanding the CaLEAP (California Local Energy Assurance Planning) website.
- Promote use of sustainable woody biomass materials for power generation to reduce fire risks to transmission lines and hydropower watersheds consistent with the 2012 Bioenergy Action Plan.
- Install smart grid and microgrid technologies to better protect reliable operation of the grid during extreme climate-related events.
- Evaluate the cost effectiveness of potential measures to maintain the efficiency of thermal plants during heat waves or other extreme climate-related events.
- Evaluate hydropower adaptation options to accommodate reduced or increased runoff and storage and evaluate operational changes or investment options (e.g., more pumped storage) to maintain the value of California hydropower resources even with climate change.
- Continue development of the Integrated Forecast and Reservoir Management (INFORM) project in coordination with private entities and DWR to demonstrate its ability as a modern decision support system for management of major water reservoirs to both private entities and DWR.
- Investigate strategic use of high temperature, low sag conductors for transmission lines where climate change impacts make conventional conductors vulnerable.
- Explore the use of seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation for the forthcoming summer season (*Summer Electricity Supply and Demand Outlook* – a CEC annual publication).

Diversify energy supply to reduce vulnerability to extreme weather-related events and climate change

- Diversify the energy supply portfolio as needed by: (1) enhancing the local utility distribution grids with smart grid features and expanding distributed generation; (2) exploring and developing energy storage technology applications; (3) evaluating state properties and buildings (and other government properties) for distributed and centralized power generation options; (4) encouraging in-state and out-of-state transmission system expansion and upgrades to reduce vulnerability to extreme events and long-term changes; and (5) expanding transmission access to renewable resource areas in preferred geographic locations consistent with the Renewable Energy Strategic Plan developed as part of the 2012 IEPR Update proceeding.
- Explore post-2020 greenhouse gas emissions targets for the energy sector (including transportation, electricity generation, and the rest of the energy system) that are compatible with the 2050 goal of reducing GHG emissions by 80 percent from 1990 levels.
- Improve our understanding of the environmental and public health implications of potential energy scenarios for California to avoid unintended consequences, such as negative impacts to wildlife, habitats, air quality, and water quality.
- Adopt environmentally benign and cost-effective options to maintain the efficiency of thermal power plants during heat waves. Improve environmentally acceptable and cost effective approaches for dealing with the efficiency of thermal power plants on extreme hot days.
- Improve our understanding of how climate change impacts the estimation of energy demand and assessments of energy supply (e.g., availability of hydropower in the summer).

<u>Promote energy demand side measures that facilitate climate adaptation</u>

- Investigate all available measures that will allow the delivery of high quality energy services at the lowest costs and with the minimum amount of energy feasible, such as deep energy efficiency retrofit programs with an integrated regulatory paradigm across water, electricity, and natural gas, green buildings, cool roofs, cool pavement, cool vehicles, urban greening, demand-side management and automated demand response, smart grid, permanent load shifting (from peak to off-peak), energy conserving land use practices, and zero net energy homes.
- Promote the expanded use of smart energy meter data to provide residential and commercial customers better access to their energy use profiles and allow them to take advantage of improved energy management systems that promote higher energy efficiency and better overall energy management. Suitable protections and policies should be put in place to protect vulnerable and low-income households from cost impacts, including time-of-use pricing, in order to ensure, among other things, access to air conditioning for heat emergencies.

- Broaden the use of automated demand response capabilities and systems to make it easier for future residential, commercial, and industrial end users to participate in demand response programs and tariffs.
    - Retrofit existing buildings through the Energy Commission's AB 758 program.
    - Implement Executive Order B-18-12 that directs state agencies to take immediate steps to green the state's buildings, reduce greenhouse gas emissions, and improve energy efficiency.
    - Explore the feasibility of considering climate change in cost-benefit analyses of energy efficiency standards for buildings (Title 24) and appliances (Title 20), such as increased ambient temperatures in the 16 climatic zones used to set building standards rather than the current practice of using historical climate data.

<u>Enhance energy-related climate change research</u>

- Coordinate climate change research with all the state agencies supporting or using climate change science via the Climate Action Team (CAT) Research Working Group. The Energy Commission will continue to provide leadership to the CAT Research Working Group. This group will also assist with the coordination of research activities with federal agencies.
- Continue to support and enhance the State Climate Change Research Catalog, which will provide basic information about past and current climate change research projects that have been or are supported by the State.
- Specify energy-related research in the California Climate Research Plan (the Research Plan) being developed by the CAT Research Working Group. This plan will represent a unifying vision on how the different state agencies intend to support climate research, forming a well-coordinated and integrated overall research program for California. Likely energy-related topics will be to:
    - Continue climate monitoring, analysis, and modeling for development of down-scaled climate change scenarios for California to support improved vulnerability assessments for energy and other sectors, better energy forecasts, and adaptation planning by local governments and private entities.
    - Improve vulnerability assessment methods for existing energy infrastructure and update assessments to inform more targeted adaptation options in the short- and medium-term based on the revised climate change scenarios.
    - Continue development and testing of supply and demand forecasting methods, such as seasonal (a few months in advance) probabilistic forecast of summer temperatures to determine the adequacy of electricity generation and new hydroelectric supply forecasting methods.
    - Continue the legacy of research, development, and demonstration for successful adaptation that also reduce GHG emissions, strengthen the green economy and maintain California's leadership in energy technology innovation, including transportation. Examples include energy storage, renewable energy efficiency, microgrid resilience, and efficiency improvements for buildings and vehicles, and low carbon transportation fuels. The discussion in the Research Plan will be fully

compatible with efforts in this area in the Energy Commission and the CPUC via the Electric Program Investment Charge (EPIC) and research supported by the Air Resources Board and others on this topic. The strength of the Research Plan will be in its capability to show how the different programs support each other.

- Identify and find solutions to regulatory, legal, institutional, and socio-economic barriers that can hamper the implementation of promising adaptation measures.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA FORESTS

Improve Forest Management Practices and the Capacity of the Forest Sector to Withstand and Recover from Climate Impacts In Order to Protect the Value and Continued Productivity of Forest Resources

(1) Continue and Enhance Coordinated Efforts to Reduce Wildfire Risks and Promote Fire Safe Communities

As called for in the 2010 Strategic Fire Plan, the State continues to reduce wildfire risks and promote fire safe communities in a number of ways including:

a) By identifying, mapping, evaluating, and monitoring fire hazard threats under current and projected climate conditions;
b) Helping to articulate and promote the use of land use planning to help reduce fire risk;
c) Assisting in the development of local county and regional plans that address fire protection and landowner objectives and responsibilities;
d) Increasing awareness regarding wildfire risks and safety precautions (such as using fire resistant building materials and clearing vegetation and other fire hazards near buildings) in individuals and communities;
e) Working with federal and local partners to integrate fire management practices with community and landowner priorities;
f) Calibrating the level of resources devoted to protecting assets from wildfire risk according to community values identified in planning efforts; and
e) Addressing post-fire recovery actions to restore natural resources, minimize flooding, address impacts of silt, sand, gravel from denuded slopes on water quality (so called "sedimentation").

The State must continue to refine understanding of how climate impacts will change wildfire risk. As that understanding develops, education efforts to communities and individuals must reflect the best available science regarding anticipated climate impacts and the state of wildfire risk in California. A cost-benefit analysis should be performed to estimate the probability and magnitude of loss of property, injury and loss of life to wildfire, as well as the necessary investments and actions to reduce wildfire risk in the face of expected climate impacts. This type of analysis might be done as part of updates to the Strategic Fire Plan. Funding to support this type of expanded climate and cost analysis may be necessary, and collaboration with partners and stakeholders would be necessary.

Wood waste from needed fire hazard reduction efforts might be used for biomass energy. The Electric Program Investment Charge (EPIC), which is further described in the Energy section of this document, might help provide funding to support utilization of biomass generated from forest fire hazard reduction efforts, perhaps focusing on development of small distributed power/heating facilities that could utilize existing sawmill infrastructure as well as the workforce in rural communities. Any such funding would have to be consistent with the current EPIC investment plan.

(2) Provide Funding to Support, Maintain and Expand Seed Banks and Revive State Tree Nurseries

As noted above, at a time when climate impacts on California forests are accelerating, and more tree loss and extinction is threatened, capacity in the State Nursery Program has been diminishing, with the suspension of nursery services. In order to ensure the ability to undertake restoration work following fires, to maintain the genetic diversity of California forests, and to protect tree species, including iconic species like the giant - continuing support for the State Nursery Program is critical. Seed processing and storage does not take the place of nursery production of seedlings (small immature plants); the availability of seedlings is particularly important for reforestation efforts following a fire.

With adequate funding, the State Nursery Program could:

- Maintain or expand seed banks to preserve genetic material from representative California tree species;
- Continue to promote the use of genetically appropriate native species in reforestation efforts; and
- Continue or expand work with the Natural Resources Conservation Service, Resource Conservation Districts, the US Forest Service, and private reforestation nurseries to increase the availability of reforestation seedlings available to small landowners.

(3) Assess and Implement Cost-Effective Forest Watershed Protection and Restoration

Forests provide a broad range of ecosystem services, including flood protection, improving the quantity and quality of water supplies for downstream communities, shading and energy savings, and improvements to air quality. Investments in forest protection and restoration can be a cost-effective way of protecting communities from the impacts of climate change such as more extreme weather and changing water availability.

The State should help incentivize best management practices for land management for better upper watershed protection, and encourage further cost-benefit analyses; while such cost-benefit analyses would require funding and staffing support, implementation of cost-effective ecosystem investment programs could be self-sustaining.

The Department of Water Resources and CAL FIRE might work together to identify potential areas for collaboration, such as further cost-benefit analyses and integrated regional water management plans.

(4) Improve Understanding of Trade-offs Between Different Management Responses to Expected Forest Climate Impacts

As described in more detail in the Biodiversity and Habitat section of this document, the rapidly shifting impacts and conditions associated with climate change are fundamentally altering long-standing paradigms for natural resource management. Species are not only changing in response to climate change, but geographic locations of suitable habitat are also changing as temperatures and precipitation patterns change. Natural resource management efforts must now occur in the context of these multiple shifting variables; various types of natural management approaches in response to unfolding climate changes are further described in the Biodiversity and Habitat section of this document. Continued research into the relative strengths and weaknesses of possible forest management approaches is needed and will help inform forest land owners, managers and regulators on how to best protect forest health and productivity in the face of climate impacts.

Certain public lands, such as National Forest System Experimental Forests and CAL FIRE Demonstration State Forests, are particularly suitable for near-term and longer-term research into the efficacy of various forest management approaches in the face of climate change. These experimental and demonstration forests function as living laboratories for forest scientists. Enabling funding is needed to support necessary research into forest management options to protect forest health and resilience in the face of climate risks.

Iterative refinements to chosen management strategies will be necessary as both climate science continues to improve and knowledge about natural resource management in the face of climate change also improves (this type of iterative refinement is sometimes referred to as "adaptive management").

Statewide Assessment of Potential Cost Savings from Urban Forestry Investments

As noted above, urban forests provide myriad benefits, including cooling benefits that can reduce urban temperatures, public health impacts from climate change, and energy needs. Although research has been done on the quantification of potential benefits at the residential, project and city level, a thorough statewide assessment of potential opportunities, has yet to be done. A thorough assessment should include an evaluation of potential benefits as well as the cost of achieving such benefits. While the assessment would require funding, it could identify opportunities for urban forestry investments that might generate significant energy and cost savings for the State and California communities. A 2003 study by the USFS, Pacific Southwest Research Station, suggested that there were significant, cost-effective urban forest investment opportunities. According to the 2003 study, planting 50 million trees in California to shade east and west facing walls could reduce peak energy demand by 4.5% over 15 years, for a savings of $7.6 billion (with projected cost of 50 million trees estimated to be $2.5 billion). The

California Energy Commission is well positioned to lead this type of statewide assessment, in coordination with CAL FIRE, the California Department of Public Health and the California Environmental Protection Agency. Funding for a CEC assessment of this sort might come from the EPIC program, but would have to be consistent with the current EPIC investment plan. Any cost-justified recommendations suggested by the assessment would require funding support for implementation. CAL FIRE might help implement the urban forestry investments through its Urban and Community Forestry Program. CAL FIRE might also develop additional tools to help local and regional governments utilize urban forestry data for making planning decisions.

Improve Understanding of Forest Climate Impacts to Support Improved Forest Management Responses

(1) Improve Monitoring

Both the Forest Carbon Inventory and FRAP rely on data generated by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA), which is the nation's on-going forest census program. FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. FIA data necessarily has error estimates as results are extrapolated from sampled forest plots and measurements are only taken at periodic intervals; however, greater accuracy can be obtained by increasing the number of sampled forest plots (this is called "densification" of survey plots) and/or by measuring more frequently. State support for densification and increased frequency of FIA measurements of California forests would allow for better forest management that is more responsive to changing climate impacts. For instance, better data would allow for improved mapping of pest outbreaks, spread of invasive species, and tree mortality – which has implications for wildfire risks and forest management interventions. As noted below, improved monitoring will also aid in evaluating different management options that might be used to address expected climate impacts. Current estimates of carbon stocks on forest lands are highly variable and additional monitoring and research to refine methods are needed.

(2) Better Modeling of Vulnerabilities and Climate Impact Trends

Some research has been done to understand how expected climate impacts (changing temperatures, changing water availability, more frequent and severe wildfire, changes in pests and invasive species) will affect the geographic shifts of tree species in California, but more of this type of trend analysis is needed. This analysis will have important ramifications not only for California's commercial tree species, but also for California's biodiversity and habitat more generally. Better understanding of climate impacts and geographic shifts in tree species will help inform and improve forest management options. Having a better understanding of the potential cost ramifications of expected forest climate impacts (i.e. impacts to forest health and forest productivity, loss of property/injury and other health impacts/and loss of life from wildfire risks, impacts to water supplies, etc.) and better cost-benefit analysis of investments to make the forest sector more resilient against the impacts of climate change would also be helpful for prioritizing forest sector climate strategies.

As FRAP (the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program) already produces periodic assessments of the state's forest and rangeland resources and carbon stocks, FRAP could be enabled to undertake necessary forest climate vulnerability (including relevant economic analyses) and trend analysis to support improved California forest management. Additional funding or staffing may be necessary to enable this type of work.

(3) Identify Priority Landscapes and Support Actions to Increase Forest Resilience
As climate changes rapidly over the coming decades, species (including trees) will be stressed and forced to adapt to new conditions. Some areas of the state may be able to serve as safe havens, or areas of refuge (also called "refugia") for climate stressed species. For instance, as the Southern Sierra Nevadas – Blue Oak Climate Scenarios map in **Box 39** illustrates, the mid-elevation areas of the Southern Sierra may be such an area of refuge for tree species that are unable to survive in higher temperature conditions that will start to occur in the lower elevation areas of the State.

CAL FIRE, through FRAP and in coordination with partners, should continue to identify potential niches in existing landscapes that may provide refugia for plants and wildlife in light of expected climate impacts. Listed species habitat requirements and diverse gene pool preservation needs to be considered to allow for species to respond to climate change. As noted in the Biodiversity and Habitat section of this document, preserving the biodiversity and limiting habitat fragmentation has important economic, public health and social dimensions. Additional funding or staffing may be necessary to enable this additional work to identify priority landscapes for protection.

Information Sharing and Education

As noted throughout this section, California has many key partners and stakeholders with respect to its forest resources. These partners and stakeholders include: the USFS, USDA Natural Resources Conservation Service, Resource Conservation Districts, local governments, industrial and non-industrial timberland owners, numerous nongovernmental organizations, and residents who enjoy and use California forests and forest resources. Information sharing and coordination with partners and stakeholders will continue to be important in order to monitor and protect forest resources in the face of growing climate threats such as fire, increased temperature, pests and invasive species, and changing water availability. Coordination may take the form of collaboration on research and management strategies, including fire risk reduction plans. Given the substantial federal ownership and management of California forest lands, coordination with federal partners, including USFS, will continue to be particularly important as climate impacts escalate.

Interagency collaboration on forests will also continue to be important, and should be reflected in the State's many on-going climates and energy related policy efforts and programs with a forestry nexus; these include the:

- California Forest and Rangelands Strategy Report and Assessment (CAL FIRE),
- Bioenergy Action Plan (California Energy Commission),
- Assembly Bill 32 Scoping Plan and Forest Carbon Inventory (California Air Resources Board),
- California Wildlife Action Plan (California Department of Fish and Wildlife),
- State Water Plan (Department of Water Resources),
- Public health and air quality programs which may be impacted by particulate matter from wildfires, and
- California Climate Research Plan and 4th Climate Assessment.

In order to assist incorporation of expected climate impacts into forest management decisions, education must be made available to forest land managers. With enabling funding, CAL FIRE and/or the University of California Cooperative Extension program could offer this type of technical, education assistance to forest managers.

ACTIONS NEEDED FOR SAFEGUARDING OCEAN AND COASTAL ECOSYSTEMS AND RESOURCES

Improve Management Practices for Coastal and Ocean Ecosystems and Resources and Increase Capacity to Withstand and Recover from Climate Impacts

(1) Hazard Avoidance for New Development

In order to minimize the adverse effects of sea-level rise and storms, it is important to carefully consider decisions regarding areas vulnerable to flooding, inundation and erosion. The state should not build or plan to build, lease, fund, or permit any significant new structures or infrastructure that will require new protection from sea-level rise, storm surges or coastal erosion during the expected life of the structure, beyond routine maintenance of existing levees or other protective measures, unless there is a compelling need (*e.g.* coastal-dependent marine terminals or marinas that must necessarily be sited in areas at risk). If the state is building or planning to build, lease, or permit structures that will require additional new expenditures for sea-level rise protection during the expected life of the new structures, the state should ensure that the project proponent:

a) Minimizes risks through siting, design and engineering;
b) Ensures viable funding sources for building, monitoring and maintaining the new sea- level rise protections;
c) Ensures that any new protections must consider how risk changes over time, ensures that actions to reduce risk in the short-term do not increase risk in the long-term; and ensures that any new protections are capable of being augmented over time;
d) Designs protection in a manner that maximizes conservation of natural resources and public access.

As discussed in the Emergency Management section of this document, it is important to note that actions to reduce risk in the near term (such as developing protections for near-term sea-

level rise) may encourage development patterns that actually increase risk in the longer term. Development must be carefully considered in light of local vulnerabilities, principles laid out in this section, and any recommendations resulting from the State Coastal Leadership Group described below.

(2) Encourage Innovative Design of New Structures/Infrastructure in Areas Vulnerable to Sea-level Rise

Where there is a compelling need for structures and infrastructure in areas susceptible to sea-level rise, storm surge and erosion, best available material science and structural design should be utilized to minimize pooling water on roadways, ensure maximum durability and public safety, and otherwise incorporate expected impacts into building plans. The State should propagate relevant design standards for engineering and construction in areas susceptible to sea-level rise, storm surge and erosion and priority should be given to development of green or nature-based infrastructure when appropriate. Efforts in other states affected by hurricanes (Florida, Georgia, Louisiana, etc.) should be studied to illuminate the potential impacts of severe storms in California.

(3) Enhance Integration of Climate Risk Considerations, Including Extreme Weather Events and Sea-Level Rise, into Emergency Management Activities

For a discussion of the integration of climate risks considerations into emergency management activities, please see the Emergency Management section of this document.

(4) State Coastal Leadership Group

Although there is a lot of work in California to address sea-level rise, coastal storms and erosion, the urgency of the situation requires more active management and coordination to understand what is working on local, regional and state levels that can be expanded and to leverage resources and better integrate work in an on-going manner. The OPC will lead an inclusive, collaborative, science-based process to inventory existing actions to reduce risks from sea-level rise, storms and erosion and to collaborate with others to improve the capacity of entities at multiple scales to more effectively act to reduce these risks. OPC will work with the California Coastal Zone Management Agencies (Coastal Commission, BCDC and Coastal Conservancy), the state coastal land owners (State Lands Commission, Department of Parks and Recreation) and other state entities and with consultation with local land use planning authorities, tribes, federal partners, and other stakeholders.

This process will involve activities such as:

- Conducting a science needs assessment in partnership with the CA Ocean Science Trust and the OPC's Science Advisory Team to identify key information needs and the opportunities for existing and new science to inform management and reduce risks.
- Engaging state partners to assess progress and future plans and leverage resources.
- Engaging non-state entities working on many scales to learn what is working, what could be expanded and what else needs to be done.
- Collaborating with FEMA, NOAA, USGS and the Army Corps of Engineers and

state agencies such as the Coastal Conservancy, Coastal Commission, BCDC and the Department of Water Resources on improving mapping of areas at risk of flooding due to sea-level rise, storms and shoreline change.

- Bring resources and expertise to assist the State Lands Commission, Coastal Commission and others address the issue of changing boundaries between public trust lands and private lands.
- Providing resources on funding sources and mechanisms for supporting actions to understand and reduce risks on many scales.
- Describing a range of tools that can be utilized to reduce risk while maximizing conservation of natural resources and public access, consistent with the public trust doctrine.
- Supporting state agencies to have the capacity to take effective action.
- Improving coordination and sharing of information needed to leverage resources and improve consistency and effectiveness.

The OPC will consider how to support innovative practices including managed retreat and use of natural processes and habitats to reduce risk from flooding, inundation and erosion; and will also address expected impacts to public access and use of beaches, trails and recreational areas along the coast.

(5) Support Pilot Projects for Innovative Shoreline Management Techniques

Particularly during the State Coastal Leadership Group, the state should continue to support local and regional governments and other entities implementing innovative shoreline management projects. Pilot project may provide valuable insights into best practices for managing shorelines in the era of rising sea levels and storm surges.

(6) Continue to Study and Support Investment in Cost-Effective Green Infrastructure to Reduce Flood Risk and Stormwater Runoff and to Maximize Associated Co-Benefits

As noted above, there can be significant cost savings and co-benefits associated with the use of green infrastructure, such as wetland restoration and urban forestry, to improve water quality and flood protection. Co-benefits may include greenhouse gas reductions that can reduce the pace and scale of climate impacts, habitat for wildlife, and improved air quality. For example, wetlands have the potential to reduce subsidence in the Delta, thus reducing pressure on levees which in turn reduces risk of levee failure and flooding. *See DWR's Twitchell Island Project in the* Biodiversity and Habitat *section for more information.*

(7) Addressing Climate Impacts in Local Coastal Programs and General Plan Guidelines

Under existing law, Local Coastal Programs (LCPs) and General Plans are key tools for addressing sea-level rise, storms and shoreline change. The Coastal Commission is in the process of developing more specific guidance for addressing sea-level rise and other climate change related land use and coastal resource protection issues into LCPs. Continued investments to update LCPs is necessary since most LCPs currently do not include plans for reducing risk from sea-level rise. In addition, the Governor's Office of Planning and Research (OPR) will also be providing a 2013 update to its General Plan Guidelines (GPG 2013). The GPG

2013 will be a resource for decision-makers, planners, and the public for the development and implementation of local general plans. The GPG 2013 will include advice on how general plans can address needed preparation for climate impacts.

(8) Support and Continue Progress Toward a More Integrated Ecosystem Approach to Management of Ocean Resources

Ocean acidification, changing ocean temperatures, rising sea levels, changes in oxygen levels, changes in ocean circulation, more extreme weather events, and cumulative and synergistic impacts, are rapidly changing marine habitats. Species ranges, species interaction, reproductive success, and many other variables are shifting. There is need to move away from a focus of only looking to management approaches that focus on single-species management. A more integrated approach might include the tenets of ecosystem management, a process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political and cultural needs of current and future generations. While recognizing the importance of a more integrated approach, it is important to recognize that managers will continue to work within the confines of existing regulatory requirements, laws, and responsibilities as they relate to single species. A more integrated approach will be better suited to highly dynamic changing variables. For instance, the Pacific Fishery Management Council is developing an ecosystem-based approach to managing fish stocks in the offshore waters of Washington, Oregon, and California. Ecosystem-based management as defined by the Council "recognizes the physical, biological, economic, and social interactions among the affected components of the ecosystem and attempts to manage fisheries to achieve a stipulated spectrum of societal goals, some of which may be in competition." The Pacific Fishery Management Council is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976. In addition, the Delta Reform Act of 2009 adopted an ecosystem approach to restoring the Delta, along with the co-equal goal of improving statewide water supply reliability.

(9) Continued Development of State Sediment Master Plan and Sediment Management Activities

The Coastal Sediment Management Working Group (CSMW) is a collaborative taskforce of state, federal, and local/regional entities, chaired by the U.S. Army Corp of Engineers South Pacific Division and the California Natural Resources Agency. The CSMW is developing a comprehensive state Sediment Master Plan ("SMP") for the conservation, restoration, and preservation of valuable sediment resources along the coast of California. Sediment includes materials such as gravel, sand, silt and clay formed by natural erosion such as precipitation, wind, and stream flows. Humans have substantially altered natural sediment transport processes within California's coastal watersheds, reducing storm protection, habitat and recreation along the coast. The goal of the SMP is to reduce shoreline erosion and coastal storm damages, provide for environmental restoration and protection, increase natural sediment supply to the coast, restore and preserve beaches, maintain or improve coastal access, improve water quality along coastal beaches, and optimize the beneficial use of material dredged or excavated from ports, harbors, wetlands, and other sediment sources. For instance, the types of hybrid levees discussed in this Safeguarding California Plan would utilize dredged sediment from nearby flood control channels for marsh restoration. That dredged

sediment is currently disposed of in landfills. Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS) Program is implemented by state, federal and local partners, including the Bay Delta Conservation and Development Commission (BCDC). BCDC is working, in part with the CSMW, to prepare sediment management plans that integrate the successful Long Term Management Strategy for dredging with flood control planning, wetlands restoration and other aspects affecting sediment processes throughout the San Francisco Bay system.

(10) Water Management Responsive to Saltwater Intrusion Issues

For information about saltwater intrusion and water management activities, please see the recommendations for continuing to mainstream climate considerations into water management in the Water section of this document.

Better Understanding of Evolving Trends that May Impact Ocean and Coastal Ecosystems and Resources

(1) Better understand the impacts and opportunities associated with offshore renewable energy development

Renewable energy development helps to reduce greenhouse gas emissions from fossil fuel use and can help reduce the pace and scale of climate impacts on ocean and coastal ecosystems and resources. M arine renewable energy has the potential to play a role in meeting California's renewable portfolio standards and energy demand; however, marine renewable energy development can also have some negative impacts on coast and ocean ecosystems and resources including noise and light pollution and impacts on avian and other flying species. In response, the California Marine Renewable Energy Working Group; is an interagency group chaired by the California Ocean Protection Council was formed with the following goals:

- Address uncertainties in regulatory processes for marine renewable energy projects in California;
- Address the information needs of state agencies and stakeholders to inform potential impacts and user conflicts with marine renewable energy projects; and
- Facilitate the development of agreements and joint state-federal committees to improve coordination of state and federal permitting processes.

As noted above, it will be important to understand the benefits and impacts of ocean renewable energy development in the larger context of other expected climate impacts and traditional stressors on ocean and coastal ecosystems and resources.

(2) Support Reform of Federal Flood Insurance Program

As noted above, there were $68 billion of California assets insured under the Federal Flood Insurance program as of August 2012. However, continuing issues with respect to the financial integrity of NFIP may pose serious threats to the economic well-being and health of Californians. The State should support appropriate continuing reform of NFIP and implementation of the 2012 Biggert-Waters Flood Insurance Reform Act while engaging in risk communication efforts and other efforts described in this chapter.

Better Understanding of Climate Impacts on Ocean and Coastal Ecosystems and Resources

(1) Further Vulnerability Assessments and Cost Analyses

Additional vulnerability assessments and cost analyses are needed to fully assess California's risks to climate impacts and appropriate responses to reduce those risks. Every community potentially impacted by sea-level rise will need to prepare vulnerability and cost assessments that include but are not limited to consideration of recreational and environmental losses to the evaluation of cumulative and synergistic impacts, the importance of hazard avoidance, and the importance of adequately accounting for the environmental and recreational costs and benefits of strategies. Appropriate resources are needed for local governments and communities to not only prepare vulnerability assessments and cost analyses but also for the training and tools to apply the results to adaptation planning and implementation. Specifically, local vulnerability assessments are needed at scales that enable and inform planning and project implementation. The State has already invested significant resources to conduct and support vulnerability and cost assessments across sectors and a sampling of additional needs are listed below. An Adaptation Planning Guide for local and regional governments has also been developed.

a) Water Supply, Wastewater and Stormwater: An assessment of the state's wastewater and stormwater facilities is needed to identify vulnerabilities of aging infrastructure and system capacities in light of more extreme weather events and sea-level rise projections in the NRC report and as incorporated into the OPC's guidance to state agencies on planning for sea-level rise. Any such assessment should include cost analysis of system upgrades and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
b) Hazardous Waste Sites and Facilities: An assessment is needed for toxic release vulnerabilities from the state's hazardous waste facilities and hazardous waste sites in light of more extreme weather events and sea-level rise projections in the NRC report. The assessment should include recommendations for addressing vulnerabilities, including cost analysis of recommendations and cost analysis of potential public health, environmental, and property damage. Funding for the assessment would be needed.
c) Underground Storage Tanks (USTs): An assessment is also needed to address toxic release vulnerabilities from the state's USTs, not just in coastal areas, but also in inland areas susceptible to flooding. This need is further described in the Water section of this document.
d) Energy and Transportation Infrastructure: Additional needs with respect to vulnerability studies for energy and transportation infrastructure are described in the Energy and Transportation sections of this report.
e) Cumulative and Synergistic Impacts: As noted above, ocean acidification, changing ocean temperatures, rising sea levels, and changes in oxygen levels are compounding other stressors on ocean and coastal habitats and resources such as pollution and overfishing. Development of ocean renewable energy projects, and other offshore energy development, may also present new stressors on ocean and coastal habitats and resources.

The cumulative impact, and any synergistic dynamics among the stressors, is not well understood, and the potential implications for commercial fish and shellfish species and human health are also not fully understood. A more robust scientific understanding of cumulative and synergistic impacts, accompanied by a science-informed trade-off analysis framework, is critical to supporting innovative management techniques that are responsive to the new, and rapidly changing, marine conditions. Further, there is a need for OPC to continue supporting data layers within the California Geoportal to underpin decisions that will be made by permitting agencies. Funding support to enable studies of such cumulative and synergistic impacts is needed.

f) Economic Costs to Californians As noted above, there have been some studies to date of the economic impacts of sea-level rise to some California communities, and there has been some study of potential impacts from more extreme weather events. However, more information about the cost of expected climate impacts is needed to inform and evaluate management options. Needed economic cost studies include resource economics studies that study the value of services provided by ocean and coastal investments (e.g. improved water quality, enhanced soil stability, recreation and tourism opportunities, benefits from intact ecosystems, etc.). Funding support to enable such studies is needed.

g) Marine Species and Ecosystems See Biodiversity and Habitat section of this document for information regarding the need for a comprehensive, state-wide vulnerability assessment for marine species and ecosystems in California.

(2) Continued Modeling Scientific models are tools used to generate predictions and explanations. Models must be built, tested for accuracy, and revised. Models add greatly to our understanding of the possible outcomes from and consequences of changes to a system.

Along the coast, the main drivers of change will be changing water conditions (water level, waves, storms, extreme events, acidification, or temperature), and changes to the shoreline (sediment supplies, addition or removal of structures, development patterns). Models may be used to predict changes in the California shoreline, expected storm surges, pollution inputs, estuarine and near shore impacts, and sediment movement in coastal areas in the era of climate change. Modeling is important to examining the full extent of consequences associated with various sea-level rise projections along with storm wave conditions and the dynamics at coastal inlets. Continued development and refinement of models for climate impacts on California's ocean and coastal ecosystems and resources will be important. Funding to support such work will be needed.

(3) Continued Support and Investment in Monitoring Efforts

Monitoring changes to biological, chemical and physical processes is critical to continue advancing knowledge of climate impacts on coastal and marine ecosystems and resources and to support informed management responses that incorporate the best-available science on changing ocean and coastal conditions. Partnerships to enable funding and staffing of these efforts will be important. The Ocean Protection Council (OPC), in partnership with the Ocean Science Trust and the OPC's Science Advisory Team, will lead a process to identify priority

monitoring needs to improve management of ocean and coastal resources under a changing climate. This process will address topics such as:

a) Ongoing monitoring and assessment of coastal inundation damages, for purposes of statewide flood planning;
b) Monitoring of offshore meteorological parameters and wave heights to obtain data for storm surge modeling and meteorological forecasting; and
c) Estuarine monitoring for changes to wetlands, sediment, changes in salinity, etc.

Information Sharing and Education

(1) Invest in Risk Communication Efforts, Emphasizing Disclosure of Risks that Have Not or Cannot Be Addressed in an Economically Feasible Manner

The State should invest in efforts to raise public awareness and understanding of sea-level rise and accompanying risks of flooding, erosion, infrastructure and property damage, and permanent submersion of coastal lands, salt water intrusion, toxic releases and other public health impacts. The state should also invest in efforts to raise awareness of the limitations of flood insurance and disaster relief, and the costs associated with response and recovery efforts associated with various anticipated sea-level rise impacts. Finally, the state should invest in efforts to raise awareness regarding options to protect new and existing structures and infrastructure from sea-level rise; awareness raising efforts should include discussion of any relevant benefits from employing green infrastructure, cost estimates, awareness and support for protecting vulnerable communities, and funding sources for protective measures. For example, California State Parks are one important venue to communicate risk and disseminate information. There are 114 coastal units in the State Park System – encompassing some 340 miles of the coast, and including coastal portions of State Parks, State Recreation Areas, Natural Reserves, and State Beaches. In 2011, 34 million visitors attended coastal parks. Each of those visitors presents an opportunity to communicate about climate change.

(2) Improve Maps and Tools and Provide Training to Incorporate Best-Available Climate Science into Planning and Operation and Management Decisions for Assets at Risk from Sea-level Rise

As sea-level rise projections and storm surge projections continue to be refined, maps and tools reflecting those projections must be developed and updated to support flood management planning, hazard planning, capital investment and development decisions. Training in the use of these maps and tools must also be provided so that best available knowledge about expected impacts can be fully integrated into routine governmental decision making, for instance for land use planning, transportation planning and operation and management, and the siting and operation and management of energy infrastructure.

(3) Sustainability Modeling Tools for Fishery Managers

Utilizing data collected from monitoring efforts, and best available understanding of cumulative and synergistic impacts from climate and other stressors, sustainability modeling tools should be developed to assist fishery managers. These tools should be consistent, to the

extent it serves the State, with relevant ecosystem-based management approaches propagated by the Pacific Fisheries Management Council as described above. California's network of MPA's provide scientist with an unprecedented opportunity to utilize and create tools to assess trends in oceanographic conditions that fishery scientists and managers may then use to determine the effects of these changing conditions on fisheries.

(4) Public Health Risk Communication Efforts

As noted above, climate impacts to ocean and coastal ecosystems and resources have numerous public health implications. Flooding, permanent inundation, and more extreme weather events may cause: toxic exposures from USTs and hazardous waste sites and facilities, increased pollution from stormwater and wastewater systems, contamination of fish and shellfish, and serious property damage including damage to transportation and energy systems and critical infrastructure including hospital facilities. In-situ instrumentation will help provide better data to inform needed beach closures to limit health risk exposures and consumption advisories. CDPH and SWRCB already have programs in place that could be used for these continuing public health risk communication efforts.

ACTIONS NEEDED FOR IMPROVED READINESS FOR CLIMATE-RELATED PUBLIC HEALTH RISKS

Improve Capacity of Communities to Prepare, Respond and Recover from Climate-Related Health Risks

Planning for Climate Change and Water-Related Public Health Risks

Climate change will present new challenges to providing safe drinking water. Any new state plans for drinking water or infrastructure investments to provide safe drinking water should consider climate risk implications.

The state's Drinking Water Program, which was transferred from CDPH to the State Water Resources Control Board on July, 1, 2014, has participated with US EPA, other states and representatives of several of California's water utilities on the USEPA National Drinking Water Advisory Council Climate Ready Utility Workgroup. The workgroup developed findings and recommendations relating to the development of a program enabling water and wastewater utilities to prepare long-range plans that account for climate change impacts. The findings and recommendations were published (Climate Ready Water Utilities, December 2010) and placed on the US EPA website.

The state's Drinking Water Program will continue to work with public water systems in the State to evaluate and permit innovative new sources of drinking water such as desalinization plants.

California should also begin to examine and identify the vulnerability of its public water systems to climate risks such as salt water intrusion, sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses will be needed. These analyses should be coordinated with other state agencies, water agencies and local agencies. Other priorities include advancing

the science and policy needed to expand the role of recycled water as a drinking water supply. This work involves developing regulations to guide the use of recycled water for recharging groundwater and surface water reservoirs subsequently used as drinking water sources ("indirect potable reuse") and, and eventually directly as a water source for drinking water systems ("direct potable reuse"). Emergency regulations regarding the use of recycled water for groundwater recharge were completed and became effective June 18, 2014.

Evaluate Health Care Infrastructure Resilience

The Public Health workgroup of the Climate Action should convene a discussion with state agencies (including CDPH's Emergency Preparedness Office, the Office of Statewide Health Planning and Development and Emergency Medical Services Authority), healthcare industry partners and other stakeholders to discuss measures to improve resilience of the health care sector to climate impacts, and how such efforts can be coordinated with related federal efforts. Any assessment should also consider health care "surge capacity"—the ability to provide care to large numbers of patients in the immediate aftermath of an extreme event (heat wave, flood, storm, etc.) and the resilience of the health care workforce.

California should also begin to examine the vulnerability study of its health care infrastructure to climate risks such as sea level rise, wildfire and extreme weather events. Funding for such vulnerability analyses, and the implementation of any recommendations for reducing vulnerabilities, will be needed. A 2009 study funded by the Public Interest Energy Program at the California Energy Commission, indicated that a 55-inch sea level rise increase (which is within the range of sea level rise projections for San Francisco in 2100), would increase the number of health care facilities along San Francisco Bay that are at risk of a 100-year flood from 15 to 42. (For more information on risks associated with sea level rise in California, please see the Oceans and Coastal Ecosystems and Resources section of this document.)

Support Implementation of Recommendations in the 2013 State of California Extreme Heat Guidance Document

The State of California has developed *Preparing California for Extreme Heat: Guidance and Recommendations*. The State should support implementation of its recommendations. As the document notes, the implementation of some recommendations will require additional resources.

Support Development of Public Health Planning Tools for Local Communities

Enhanced climate and health-sensitive warning systems are needed. For instance, the California Environmental Health Tracking Program, which is a collaboration of the California Department of Public Health and the Public Health Institute, funded by the CDC, has conducted a study to determine if heat alerts accurately predicted times when people suffered the most heat illness. The methodologies that the National Weather Service (NWS) uses to issue heat alerts and warnings for local areas do not incorporate explicit health criteria. Working with the CDC, NOAA and the NWS, state and local health scientists can provide their expertise to enhance the sensitivity of NWS heat products so that California's population and health systems can be better warned and prepared to take countermeasures during heat emergencies.

Public health surveillance is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice. Such surveillance can serve as an early warning system for impending public health emergencies; can document the impact of an intervention, or track progress towards specified goals; and can monitor and clarify the epidemiology of health problems, to allow priorities to be set and to inform public health policy and strategies.

Surveillance depends on the most accurate and latest data available. California's local health jurisdictions, CDPH, and the CDC employ a variety of public domain and commercial surveillance systems to capture syndromic and ongoing surveillance data. These systems vary from a simple system collecting data from a single source, to electronic systems that receive data from many sources in multiple formats, to complex surveys. When considering or employing a health surveillance system, jurisdictions should use the CDC's *Guidelines for Evaluating Surveillance Systems* to address the need for a) the integration of surveillance and health information systems, b) the establishment of data standards, c) the electronic exchange of health data, and d) changes in the objectives of public health surveillance to facilitate the response of public health to emerging health threats (e.g., new diseases).

Tools that provide public health data and information to public health officials will be an important part of efforts to detect, track, prepare, and respond to climate-related health risks. California should collaborate with federal and local partners to support development and enhancement of such tools.

Better Understanding of Evolving Trends that May Impact Public Health in the Era of Climate Change

<u>Healthy Energy Efficient Buildings</u>

Constructing and upgrading buildings to be more energy efficient can provide tremendous benefits including lower utility costs, greater energy security, improved air quality, reducing emissions that cause climate change, and the creation of green jobs. However, if construction or upgrades are performed improperly, health risks may arise. For instance, if proper ventilation is not part of design, then indoor air quality may be compromised and can be exacerbated by changing climate conditions. US EPA released a 2011 document entitled "Guidelines to Ensure Healthy Indoor Air during Home Energy Upgrades". The Guidelines provide a step-by-step process for conducting assessments to evaluate indoor air conditions and the potential for risks that may arise during residential energy upgrades.

California includes in its 2008 and newly adopted 2013 Energy Efficiency Standards for New Residential and Nonresidential Buildings ventilation requirements that meet or exceed current minimum state and national ventilation requirements. These requirements are consistent with best practices for the design of ventilation systems for newly constructed buildings, as well as, the additions and alterations of existing buildings. In June of 2013, the California Energy Commission (CEC) also published the draft Action Plan for the Comprehensive Energy Efficiency Program for Existing Buildings (the "Action Plan") in order to meet the intent and requirements

of legislation that requires the CEC develop a comprehensive program to achieve greater energy efficiency in the state's existing buildings. The programs and standards that are developed according to the final Action Plan may include strategies to meet or exceed national and state requirements for whole house and multi-family ventilation including: heating, ventilation and air conditioning (HVAC) systems and equipment; combustion safety; contaminant distribution and source ventilation that are identified in the EPA Protocols for Home Energy Upgrades. The Action Plan also establishes building industry outreach and education goals for job training that includes health and safety considerations. Support for implementation and compliance with the state's energy efficiency standards and the Action Plan will be important to realizing all the benefits of energy efficient buildings.

Low Allergen or Nonallergenic Urban Greening to the Extent Feasible

As noted above, there are still no definitive conclusions on how climate will impact air-borne allergens, particularly at the regional level, but models indicated that pollen will likely increase in many parts of the United States and there may be shifts in the seasonal timing of allergen production and other changes to air-borne allergens. In order not to exacerbate public health issues associated with air-borne allergens, urban greening programs should consider low allergen or nonallergenic species to the extent that such species are otherwise regionally suitable.

Better Understanding of Climate Impacts on Public Health

Further Development and Support of Local Vulnerability Assessments

As noted above, some initial local vulnerability assessments, for communities, have been developed for selected communities, like Fresno, Los Angeles and San Francisco. However, all California communities face climate risks to public health, and there is still a need for further development and support of local vulnerability assessments for climate-change health risks (such as risks relating to heat, air quality, fire, flooding, and water availability and quality). Conducting geographically-specific vulnerability assessments and the identification of vulnerable populations can help guide efforts to design and implement strategies to address local risks and needs of high risk groups. The February 2012 ASTHO Climate Change Population Vulnerability Screening Tool discussed above should be revised to include improved data and additional stakeholder input; and vulnerability analyses for additional communities should be undertaken. CDPH's four year CDC BRACE grant will expand this planning for ten additional counties; however, funding to expand and support these efforts so that local public health partners can be actively involved may be necessary.

Increase Capacity to Monitor Climate-Related Deaths and Illnesses

Continued actions to improve disease reporting and surveillance will aid efforts to understand and respond to emerging climate risks to public health. These actions may include: coordinating with federal and regional rapid surveillance efforts; upgrading the California Death Registration System to provide for continuous monitoring of abnormal death patterns, including heat-related death; and improving surveillance programs for infectious diseases including vector-borne, water-borne and food-borne diseases.

Social Vulnerability Mapping for Climate Change

Multiple screening tools for social vulnerability now exist, such tools reflect a variety of conceptual frameworks, methodologies, and data. These tools have varying strengths, weaknesses, assumptions and limitations. CDPH should convene a meeting with various state entities and other partners who have developed such social vulnerability tools in order to identify gaps that may be filled by collaborative research and to examine best practices for developing social vulnerability assessments for Cal-Adapt.

Regional Studies of Aeroallergens

Significant gaps still exist with respect to California's ability to monitor potential shifts in air-borne allergens. Funding to enhance allergen monitoring, identification and forecasting would support efforts to better understand how allergens are shifting in response to climate change, and would help support the development of policies to help reduce these health risks for Californians in light of these changing conditions.

Information Sharing and Education

Capacity Building to Raise Awareness and Foster Action to Address Climate Risks to Public Health

Outreach efforts are important to ensure that public health and medical professionals are prepared and educated on climate risks. Health professionals are uniquely positioned to help raise community awareness about risks to public health from a changing climate and a health framing may help more members of the public to consider climate risks and actions. In addition to capacity building efforts described in the Introduction to this document, a grant program for local health departments and professional medical and nursing associations could be established to support the development of courses on climate and California health risks for the staff and constituents of such organizations. Funding and adequate staffing to support such a grant program would be required. Any such capacity building courses for local public health, medical and nursing professionals should include information about the health impacts of climate change, as well as information related to the prevention and management of climate-related illnesses (e.g., heat illness) and promoting resilience.

Public Education on How to Reduce and Prepare for Climate Health Risks

The Public Health workgroup of the Climate Action Team together with other relevant state entities, should develop culturally and linguistically relevant educational materials for diverse populations (e.g., vulnerable communities, school-age children, businesses, and labor) using best practices in climate change education. Materials should promote an understanding of various health risks associated with California's changing climate, including, but not limited to, risks associated with extreme weather, heat waves, heat and outdoor labor, air quality, aeroallergens, wildfire, floods and sea level rise, and drinking water, and describe strategies and actions that foster preparedness.

Public education campaigns should be designed to disseminate this information. The campaign should not only utilize existing resources to disseminate information (e.g., the bepreparedcalifornia.ca.gov website and public health advisories), but should also involve collaboration with partners and innovative modes for disseminating information. Additional funding and staffing will be needed for this effort.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO THE TRANSPORTATION SECTOR

Better understanding of evolving trends that may impact transportation systems

In addition to changing climate conditions, transportation continues to evolve in California. Preparing for climate impacts on California's transportation system must be considered in conjunction with the evolving landscape of California's transportation sector. For instance, there might be a need to:

(1)Better understand the impact and opportunities associated with vehicle electrification and other advanced clean cars on timing and demand for energy supplies (at the same time that climate impacts are occurring and causing changes to energy demand) and better understand the reliability of energy supplies for all vehicles in the face of expected climate impacts. The California Energy Commission already does some of this type of work, for instance in its Energy Demand Forecast, and could further this type of analysis in collaboration with other agencies.

(2) Better understanding of likelihood of land subsidence events that may compromise transportation systems and steps that can be taken to avoid such subsidence if possible. This type of enhanced knowledge will likely take collaboration between a number of entities including the California Department of Water Resources (DWR), Caltrans, SWRCBS, and local and regional governments. Subsidence and more specific recommendations regarding avoiding subsidence are included in the Water section of this document.

Improve the reliability of California's transportation system in the face of expected climate impacts

Action is needed to translate the findings of vulnerability studies described above into actions that improve the reliability of California's transportation system in the face of expected climate impacts. This might include:

(1) Continued integration of climate impact considerations and best available climate science in transportation planning, design, programming, construction, operations and maintenance and updating such efforts as the state of climate science evolves; and

(2) Implementing actions needed to ensure transportation fuel availability and functioning of fuel distribution infrastructure in light of expected climate impacts;

(3) Prioritizing improvements to address climate vulnerabilities in transportation systems, including prioritizing those projects that protect key evacuation routes and modes first; and

(4) For new construction and repairs, using state-of-art materials/infrastructure design to optimize transportation system resilience (against extreme heat, challenges of standing and moving water during extreme weather events including storms and floods) with continued research on materials and design to enhance resiliency of transportation systems.

Further enable incorporation of anticipated climate impacts into transportation plans

As noted above, pursuant to SB375 MPOs have been developing sustainable community strategies for incorporating regional greenhouse gas emission reduction targets in regional transportation plans. As also noted above, the 2013 document "Addressing Climate Change Adaptation in Regional Transportation Plans - A Guide for California MPOs and RTPAs" provides guidance to MPOs and RTPAs on possible steps to incorporate climate impacts into long-range transportation planning. As the 2013 guidance document notes, there is currently no requirement to incorporate climate impacts into regional transportation planning, and MPOs and RTPAs have varying capacity and resources to do so. The Strategic Growth Council currently administers a grant program for cities, counties, MPOs, regional transportation planning agencies, joint power authorities and councils of governments to assist with implementation of SB375; a certain amount of that grant funding is prioritized for projects in disadvantaged communities. A similar grant program might help enable incorporation of climate impacts into sustainable community strategies and/or regional transportation plans.

Better understanding of expected climate impacts to inform transportation planning

(1) There is a continued need for regional climate model downscaling, particularly near major population centers, to provide more detailed information regarding anticipated, California-specific climate impacts - so that such information can inform transportation planning. This type of work will be further described in the forthcoming California Climate Research Plan.

(2) There is also a need for better understanding of the specific vulnerabilities of transportation infrastructure (ports, roads, airports, transit systems) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As noted above, transportation infrastructure in California is managed by a variety of federal, state, local/regional, and private entities. These types of infrastructure vulnerabilities would likely need to be conducted by the entities most directly responsible for the particular infrastructure in question; enabling funding, staffing and/or other technical assistance for the vulnerability assessments might be necessary. For instance, for Caltrans to do a complete vulnerability assessment of the 50,000 lane miles, bridges and culverts under its jurisdiction would require approximately $5 million. The most appropriate form of assistance for a

vulnerability assessment would be dependent on what type of entity is conducting the assessment (for instance, grant assistance might be appropriate for local/regional entities).

(3) There is a need for better understanding of specific vulnerabilities of fueling infrastructure: (refineries, pipelines, marine terminals, underground storage tanks, and fueling stations) to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with transportation infrastructure, the entities most directly responsible for the fueling infrastructure in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary; and the appropriate form of assistance would vary according to the assessment.

(4) Better understanding of the specific vulnerabilities of energy systems supporting refineries, fueling stations, transit systems, and other important parts of California's transportation system to both extreme weather events (flooding, fire, storms) and other climate impacts (sea level rise, coastal erosion, rising temperatures).

As with the above, the entities most directly responsible for the particular energy systems in question would be best situated to conduct the necessarily vulnerability assessments. Funding, staffing and/or other technical assistance for such assessments might be necessary. The CEC, ISO, and PUC would likely be the entities involved in this type of assessment. The work of these entities is further described in the Energy section of this document.

(5) In order to aid prioritization of needed changes in transportation planning and operations, the vulnerability assessments referenced above should include consideration of both the probability of impacts and the magnitude of potential damages, transportation disruptions, injuries and loss of life.

Information Sharing and Education

(1) While many agencies are beginning to incorporate climate impacts and considerations into planning and operations, information sharing and collaboration between agencies could expedite the learning process regarding best practices for transportation management in the era of climate change. The state could help convene an interagency task force on reducing risks to California transportation; such a task force should include federal, state, local/regional agencies and appropriate transportation, water, energy planning professionals. Caltrans might be an intuitive choice for leading such a convening effort.

(2) An interagency task force on reducing risks to California transportation might assist in the development of training tools and guidance for transportation professionals regarding incorporating climate impacts and considerations into transportation planning, design, programming, construction and operation and maintenance. The development of such tools and guidance may require funding and staff support.

ACTIONS NEEDED TO PREPARE FOR CLIMATE RISKS TO CALIFORNIA WATER RESOURCES

Vigorously prepare California for flooding

Flooding currently presents a clear and present danger to public health and safety that will only worsen with climate change. As noted above, more than seven million Californians are currently exposed to flooding hazards within 500-year floodplains. California remains underprepared for this current and growing threat, and the following actions are recommended:

- Protect taxpayer investments by requiring that DWR and SWRCB formally consider and account for climate risk in all water infrastructure planning, design, permitting, and funding, including loans and grants to local agencies;

- Expand the Western Observing and Forecasting System to allow for offshore observations that will provide greater forecast lead times for coastal communities;

- Conduct a vulnerability assessment of critical State-owned infrastructure located in the state's floodplains;

- Expand piloting and begin implementation of forecast-based operations to allow more flexibility to operate existing reservoirs for changing climate conditions;

- Given the concentration of State government facilities and functions in Sacramento, prepare a catastrophic disaster response and recovery plan for the Sacramento metropolitan area, in collaboration with local and regional governments and other partners;

- Continue work to implement critically needed repairs to California's levee system; and

- Reconnect rivers to their floodplains, rehabilitate upper watershed source areas, and provide more natural floodplain features and functions that slow, spread, capture, and infiltrate floodwaters throughout a watershed. Specifically,

    - improve stewardship of forests and headwaters to reduce the risks of catastrophic wildfire and downstream flooding impacts; and

    - expand existing and establish new flood bypasses.

Support regional groundwater management for drought resiliency

While California's largely decentralized regime for groundwater management presents significant challenges to adapting to climate change, it presents significant opportunities as well. For example, regionally managed groundwater recharge, storage, and conjunctive use (the coordinated management of surface and groundwater) can play a key role in compensating

for the loss of natural water storage as the Sierra Nevada snowpack diminishes. Many local and regional groundwater management agencies also have the authority and capacity to: 1) establish thresholds for groundwater drawdown, quality, and subsidence; 2) monitor groundwater conditions; and 3) take actions to manage demand when needed to avert problems. State level support and oversight should be provided where needed to ensure the success of local and regional management efforts.

California must take steps now to ensure that its aquifers will help make its water systems climate resilient. Below are some recommended actions. Funding and staffing will be needed to implement many of these actions.

- Promote better understanding about California's groundwater, conjunctive use, and the potential risks associated with changing climatic conditions, including examples of groundwater crises already occurring in the state and projections on the condition of California's groundwater basins in 20 years, based on current groundwater management practices and climate projections.

- Strengthen and expand the California Statewide Groundwater Elevation Monitoring (CASGEM) Program established by SB 7x-6, to ensure continued groundwater level monitoring in areas where voluntary monitoring is not occurring, statewide prioritization of basins, and identifying basins subject to critical overdraft. Support a statewide evaluation of current groundwater conditions and management efforts, by analyzing CASGEM data and reviewing the content and implementation of groundwater management plans; from this assessment, develop guidelines to promote best practices for regional groundwater management.

- Develop and fund a state program for monitoring drought impacts on groundwater resources, including for remote sensing-based monitoring of land subsidence associated with groundwater extraction, as drought conditions cause water users whose surface supplies are curtailed to increase their groundwater use, depleting basin storage and sometimes creating impacts to others by inducing migration of poor-quality groundwater into pumping zones or accelerating land subsidence.

- Improve the State-level integration of existing groundwater data (quality and quantity) and information with surface water data and information.

- Promote groundwater recharge and storage by:

    - streamlining and aligning regulatory programs, as appropriate, to support increased conjunctive use and groundwater banking;

    - developing tools to help characterize and delineate groundwater recharge areas;

- evaluating economic and water security benefits from more sustainable management practices;

- developing estimates of storm water capture and groundwater recharge potential, and a tracking database to inform water resource planning and permitting decisions;

- developing guidelines for coordinating land use planning and protection of groundwater recharge areas;

- incentivizing local and regional efforts to use low impact development techniques in new development and retrofits through State loans and grants;

- incentivizing reduced pumping in overdrafted groundwater basins and increasing groundwater recharge through State loans and grants;

- modernize the state's storm water regulatory program to incentivize storm water capture and infiltration, and protect the infiltrative capacity of hydrogeologically vulnerable areas;

- complete rulemaking for groundwater recharge with recycled water (indirect potable reuse);

- identify obstacles to increasing most efficient use of water by agriculture and develop programs, policies and practices to overcome these obstacles; and

- develop and adopt salt and nutrient management plans consistent with the State Water Boards recycled water policy.

- As part of IRWM plans, provide multi-agency support for local pilot projects that could become part of a system of regionally-based, strategic groundwater drought reserves; such pilot projects should be prioritized for high-use basins.

- Work with local and regional groundwater management agencies in impacted, vulnerable, and high-use basins to develop and refine groundwater thresholds for quality, level, and subsidence, conduct monitoring needed to determine if thresholds are being met, and take actions needed to sustainably manage groundwater.

Diversify Local Supplies and Increase Water Use Efficiency

Climate change is adding to other stressors to make water supplies from major sources like the Colorado River and the Sacramento-San Joaquin Delta less reliable. Increasing regional self-reliance and diversification of local water supplies will enable Californians to better respond to

changing economic and climactic conditions while ensuring a reliable water supply for the diversity of the state's water needs. California's water agencies utilize a variety of water management measures to improve local water supply reliability. These measures include agricultural and urban water use efficiency, local storage, conjunctive use, increasing stormwater capture and infiltration, recycled water, and ocean and brackish water desalination. Since the early 2000s with the start of the Integrated Regional Water Management (IRWM) there has been increasing emphasis on regional collaboration in the implementation of water management measures. With the passage of SB7x7 in 2009, urban water suppliers are required to set and meet 2015 and 2020 water use targets and agricultural suppliers are required to adopt agricultural water management plans and report on the implementation of efficient water management practices. The Delta Stewardship Council's Delta Plan requires water suppliers to reduce reliance on water from the Delta.

- The State should continue to support regional water management planning and project implementation through additional funding for the IRWM. The IRWM Grant Program funds a wide variety of regional water management actions. The IRWM Program is intended to support flexible implementation of actions needed to address regional objectives and needs. As such, the IRWM funds water supply, water quality, flood management, and environmental protection and restoration.

- The State should develop a 2030 Statewide Urban Water Use Efficiency Plan with the goal of requiring urban water suppliers to continue the improvements in water use efficiency from the 20x2020 program. Accounting for population growth, continuing the current 20x2020 program will keep the total volume of urban water use in 2020 at the same volume as in the year 2000. The goal of the 2030 program is to replicate the 20x2020 success and keep the volume of 2030 urban water use the same as the 2020 level.

- Agricultural water suppliers with irrigated acreage equal or greater than 25,000 acres should begin utilizing the methodologies for quantifying agricultural water use efficiency in the "Proposed Methodology for Quantifying the Efficiency of Agricultural Water Use" by 2020. Quantifying water use efficiencies can provide valuable information to water suppliers and highlight efficiency improvements, and climate risks to California water will be increasing over time.

- Provide targeted funding for:
    - agricultural and urban water suppliers for projects that plan and implement sustainable water solutions serving disadvantaged communities
    - urban and agricultural water use efficiency research and development programs for development, testing and implementation of new technologies
    - the "Save Our Water" media campaign so it can achieve the same visibility and outreach as the California Public Utilities Commission's energy reduction campaigns.

- Set a statewide target of 1 million acre-feet (MAF) of recycled water use annually by 2020. DWR, with SWRCB, should prepare a comprehensive report of regional recycled water conditions to guide expanded use of recycled water including assessment of a 'fit for purpose' concept for urban, agricultural and environmental applications and a cost benefit analysis.

- State should promote the SWRCB's stormwater use target of 500,000 AF per year.

- Develop a coordinated streamlined permitting process for desalination projects that provides strong environmental protection.

- State entities, including SWRCB, DWR, CDPH, and CDFA, together with stakeholders should work to develop comprehensive data collection on water diversion, delivery, and use. This will assist in measuring program performance for this and other strategies.

Reduce Sacramento-San Joaquin Delta climate change vulnerability

As noted above, the Sacramento-San Joaquin Delta is vulnerable to climate risks such as flooding, sea level rise, and stress on aquatic habitat. Several planning efforts are underway to further the co-equal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem.

Reducing climate change vulnerability in the Delta will depend on completion and implementation of the Water Quality Control Plan, the Delta Plan and the BDCP. At the same time, as discussed elsewhere in this chapter, regions that depend upon water from the Delta will need to develop far more regional self-reliance, through a variety of measures, to ensure long-term water supply reliability.

Prepare California for hotter and dryer conditions and improve water storage capacity

While drought is a normal part of the water cycle in California, drought conditions are becoming more common and more severe. California's water infrastructure provides the ability to manage some degree of hydrologic uncertainty and variability through operational tools such as water transfers, reservoirs, and conjunctive surface water and groundwater use. However, it is not sufficient to address extreme or prolonged drought conditions.

As noted above, a variety of measures may be utilized to mitigate potential shortages during drought, including minimizing reliance on imported water, improved water conservation and water use efficiency, expanded water recycling, improved stormwater management, desalination, groundwater remediation, conjunctive use, firming up existing water transfer agreements, and entering into spot transfer or short-term water transfer agreements. The state has made substantial investments, through grant programs, in helping local water

agencies improve their water supply reliability and take other actions that reduce their vulnerability to droughts.

The state can further improve California's ability to deal with the risks of more frequent and severe drought conditions by:

- Improving drought prediction at the one-month to two-year timescales critical for making operational decisions in managed water systems, and for helping those relying on unmanaged water supplies assess their risks, through investing in research and related hydroclimate monitoring to improve prediction. From an operational perspective, improving drought predictive capability is probably the single most important action the state could pursue.

- Reducing the drought vulnerability of small water systems, especially those in at-risk rural areas dependent on unreliable groundwater sources, through state financial assistance programs and through lowering the threshold for requiring public water systems to prepare Urban Water Management Plans (UWMPs) from 3,000 or more connections to 2,000 or more connections.

- Improving the understanding of wildfire risks to water infrastructure, and support actions to reduce those risks. The hotter, dryer climate conditions that result in drought, also create risks of more frequent and severe wildfires that can further impact water supplies that are already otherwise stressed by increased water demand and decreased flows. Wildfire is already a significant cause of system damage for small water systems in rural areas. The damages experienced by Denver Water facilities following Colorado's 2002 fire season illustrate potential risks to large water system infrastructure in the Sierra Nevada. Wildfire risk planning should be included in large water agencies UWMPs.

- Improving flexibility in our water transfer systems. Streamlined water transfers in times of extreme drought will strengthen California's resilience to climate change.

- Improving water storage capacity, including supporting regional groundwater management as further discussed above.

Address water-related impacts of climate change on vulnerable and disadvantaged populations and cultural resources

Just as different regions of California will experience the impacts of climate change differently, so will the diverse populations of California. Indeed, some people—including those who are ill or unemployed, the very old and the very young—may be more sensitive or vulnerable than others, making them less capable of coping with climate change. For instance, the increased flood risk due to climate change may disproportionally impact poor communities, due to their location as well as their lack of mobility. Disadvantaged communities already grappling with

drinking water quality and supply problems are unlikely to have the capacity to deal with the additional challenges—deeper and longer droughts, deteriorating water quality—that climate change may bring to their water resources. Climate change may also negatively impact water resources that are important for tribal subsistence and cultural purposes.

Climate impacts are experienced locally, in communities. Targeted assistance in the form of outreach, information, funding, investments and community engagement will improve the likelihood that communities will support, implement, and benefit from adaptation strategies that can improve community resilience. For these reasons, water planners and their partners must ensure equitable access to information and resources and explicitly recognize, target, and prioritize efforts to ensure that the most vulnerable Californians are prepared for climate risks to water; for instance, by establishing stable long-term funding sources for the provision of safe drinking water to small disadvantaged communities. A Tribal Advisory Committee helped to develop the content in the California Water Plan 2013 Update, and continued engagement with tribal nations will continue to be important when managing water resources in the era of climate change.

Continue to mainstream climate considerations into water management

As noted above, DWR has made great progress in mainstreaming climate considerations into its many operations. It began climate research as early as 1987, has integrated climate considerations into the California Water Plan since 2005, convenes a Climate Change Technical Advisory Group, and offers climate literacy classes for its staff.

Further actions can help mainstream climate considerations in all the state's water management activities. For instance, in order to reduce institutional barriers to preparing for climate risks, the Water Boards will use relevant, peer-reviewed climate science to identify climate adaptation criteria and processes for incorporating climate change considerations into all Water Boards' programs, such as water quality permits or guidelines for infrastructure loans and grants. The State Water Board and DWR should develop funding criteria to discourage construction of new water infrastructure in high-risk areas. In coastal groundwater basins, which are vulnerable to increased salt water intrusion as a result of sea level rise, the Water Boards will support and encourage measures such as recycled water injection and groundwater storage during wet years to make coastal aquifers more resilient to climate change impacts.

Utilize low impact development and other methods in State and regional stormwater permits to restore the natural hydrograph

The Water Boards are encouraging permitees to use a watershed approach to "slow the flow" of water, using urban runoff best management practices to achieve multiple benefits, such as reduced pollution, water supply augmentation, flood protection and habitat enhancement. Municipal stormwater permitees are required to exercise their land use authority to implement development programs that require installation of stormwater controls at new developments and significant redevelopment projects. The permits adopted require the use of Low Impact Development techniques but also recognize that alternative or regional projects can be

beneficial. These techniques range from onsite tree planting to installation of porous pavement to designing recharge wetlands and must be monitored to measure their effect on water quality. In collaboration with other State, regional and local agencies, the Water Boards will identify data needs to enhance planning decisions associated with preparing for climate risks and incorporate that data gathering in their permitting authority.

Urban trees can help filter and remove pollutants from stormwater, and also reduce stormwater runoff. Continued and expanded support for urban forestry and urban greening will be important not only for water-related benefits, but to reduce heat island impacts and reduce energy demand as California experiences climate impacts. For more information on urban forestry and heat island effects, please see the Forestry and Public Health sections of this document.

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

Despite state laws requiring demonstration of "adequate water supplies" for development and extensive requirements for both land use and water resource planning, these processes continue to lack integration allowing land use decisions to be made that may conflict with water resource plans or imperil sustainable management of water resources. Currently, General Plan Guidelines lack the specificity to ensure that water supply and water quality issues created by new development are adequately analyzed and addressed; in an era when climate risks present escalating challenges to water resources, new development must be carefully integrated with sustainable water management efforts. The Governor's Office of Planning and Research will engage local land use authorities and water agencies and amend the General Plan Guidelines to promote local land use decisions that are consistent with local sustainable water management.

Closer integration of Urban and Agriculture Water Management Plans and Integrated Regional Water Management Plans into General Plans and local climate action plans and/or resilience plans, through better coordination and harmonized planning requirements, will help establish consistent sustainability goals across these planning processes. Water sustainability should also be given consideration for addition to the requirements of Sustainable Communities Strategies that are required for each of the state's Metropolitan Planning Organizations (MPOs). Increased coordination between land use and water planners may also reveal opportunities for improvements in stormwater management and the use of recycled water, both important strategies for improving resilience.

Protect and restore water resources for important ecosystems

As noted above and in the Biodiversity and Habitat section of this document, climate change presents a variety of escalating risks to important ecosystems in California. In order to reduce these risks, the state should continue its efforts to restore key wetlands and to ensure adequate water quality and supply for important ecosystems. Collaboration between state

entities working on water issues and ecosystem management issues will also continue to be important.

Better understand climate risks to California water and develop tools to support efforts to prepare for climate risks

Additional information and tools are needed to adequately prepare for climate risks to the California water sector.

For instance, more research is needed regarding:

- the relationship between snow pack, rainfall, and groundwater recharge and quality;
- land-cover and ecosystem responses to changing precipitation and runoff conditions;
- how water quality in rivers, lakes and aquifers will be affected by changes in precipitation, timing of flow, and temperature;
- how water flow management can help support climate-stressed aquatic species; and
- the role of extreme precipitation events and implications for within-year variability on our water supply.

It will also be important to continue and enhance monitoring of changing water conditions. Monitoring allows tracking of changes in snow-covered and rain-dominated portions of key watersheds, and direct observation of climate changes can help refine climate projections and models.

It will no longer be adequate to manage California water resources based on historical trends, and decisions support tools for water managers that reflect climate projections are needed to help guide water management and planning decisions.

APPENDIX B: ACKNOWLEDGMENTS

The Safeguarding California Plan was prepared by the California Natural Resources Agency. Deputy Secretary for Climate Change and Energy Ann Chan led the overall plan development. This document was made possible by the hard work of numerous contributors. Below is a list of State agencies, organizations, individuals and events that have provided input into the Safeguarding California Plan. Valuable tribal and stakeholder input also shaped the final document.

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- Transportation: Garth Hopkins and La Nae Van Valen
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Advisory, Reviewing and Contributing State Entities:

- Bay Conservation and Development Commission
- California Air Resources Board
- California Coastal Commission
- California Department of Conservation
- California Department of Fish and Wildlife
- California Department of Food and Agriculture
- California Department of Forestry and Fire Protection
- California Department of Insurance
- California Department of Parks and Recreation
- California Department of Public Health
- California Department of Transportation
- California Department of Water Resources
- California Energy Commission
- California Environmental Protection Agency
- California Fish and Game Commission
- California Health and Human Services Agency
- California Independent System Operator
- California Labor and Workforce Development Agency

- California Ocean Science Trust
- California Public Utilities Commission
- California State Coastal Commission
- California State Coastal Conservancy
- California State Lands Commission
- Delta Conservancy
- Delta Protection Commission
- Delta Stewardship Council
- Department of Toxic Substances Control
- Governor's Office of Planning and Research
- Governor's Office of Emergency Services
- Ocean Protection Council
- State Water Resources Control Board

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- Mike Jani, Chief Forester and President of Mendocino Redwood Company
- Mark Wiegardt, Whisky Creek Shellfish Hatchery
- Elizabeth Baca, MD, MPA
- Cody Hooven, Senior Environmental Specialist, Port of San Diego
- Forrest Shearer, Professional Snowboarder

Guest Speakers at Public Workshops and Listening Sessions:

- Gary Griggs, University of California Santa Cruz
- Kathleen Sloan, Yurok Tribe Environment Program
- Ken Topping, FAICP, California Polytechnic State University-San Luis Obispo
- Angelo J. Bellomo, County of Los Angeles Department of Public Health.
- Michael F. Wehner, Lawrence Berkeley National Laboratory
- Mike Chrisman-Former Secretary of the California Natural Resources Agency and former Director of the Southwestern Partnership Office of the National Fish and Wildlife Foundation
- Maximilian Auffhammer, University of California, Berkeley
- Jayant Sathaye, Lawrence Berkeley National Laboratory and University of California, Berkeley
- David Sapsis, California Department of Forestry and Fire Protection (presenting materials from Malcom North, United State Forest Service, Pacific Southwest Research Station and Department of Plant Sciences, University of California, Davis)

Public Workshops and Listening Sessions

- July 12, 2013: Advance Tribal Outreach & Listening Sessions-Sacramento, CA
- July 18, 2013: Advance Tribal Outreach & Listening Sessions-Sacramento, CA
- September 30, 2013: California Natural Resources Agency- Sacramento, CA
- October 2, 2013: Yurok Tribal Office- Klamath, CA
- October 8, 2013: Ronald Regan State Building-Los Angeles, CA
- October 10, 2013: University of California, Merced-Merced, CA
- October 11, 2013: Truckee Town Hall-Truckee, CA
- January 22, 2014: California Energy Commission, Sacramento, CA
- January 27, 2014: Milton Marks Conference Center, San Francisco State Building, San Francisco, CA

APPENDIX C: GOVERNOR'S EXECUTIVE ORDER

EXECUTIVE ORDER S-13-08--by the Governor of the State of California

WHEREAS climate change in California during the next century is expected to shift precipitation patterns, accelerate sea level rise and increase temperatures, thereby posing a serious threat to California's economy, to the health and welfare of its population and to its natural resources; and

WHEREAS California is a leader in mitigating and reducing its greenhouse gas emissions with the 2006 Global Warming Solutions Act (Assembly Bill 32), the Low Carbon Fuel Standard (Executive Order S-01-07), the 2008 Senate Bill 375 and the Renewable Portfolio Standard; and

WHEREAS these efforts, coupled with others around the world, will slow, but not stop all long-term climate impacts to California; and

WHEREAS California must begin now to adapt and build our resiliency to coming climate changes through a thoughtful and sensible approach with local, regional, state and federal government using the best available science; and

WHEREAS there is a need for statewide consistency in planning for sea level rise; and

WHEREAS California's water supply and coastal resources, including valuable natural habitat areas, are particularly vulnerable to sea level rise over the next century and could suffer devastating consequences if adaptive measures are not taken; and

WHEREAS the country's longest continuously operating gauge of sea level, at Fort Point in San Francisco Bay, recorded a seven-inch rise in sea level over the 20th century thereby demonstrating the vulnerability of infrastructure and resources within the Bay; and

WHEREAS global sea level rise for the next century is projected to rise faster than historical levels with the Intergovernmental Panel on Climate Change predicting that global sea levels will rise by between seven to 23 inches this century and some experts predicting even higher rises; and

WHEREAS while climate models predicting global sea level rise are generally understood and improving, less information is available for sea level rise projections specific to California that accounts for California's topography, coastal erosion rates, varying land subsidence levels and tidal variations; and

WHEREAS billions of dollars in state funding for infrastructure and resource management projects are currently being encumbered in areas that are potentially vulnerable to future sea level rise; and

WHEREAS safety, maintenance and operational efforts on existing infrastructure projects are critical to public safety and the economy of the state; and

WHEREAS the longer that California delays planning and adapting to sea level rise the more expensive and difficult adaptation will be; and

WHEREAS the California Resources Agency is a member of the California Climate Action Team and is leading efforts to develop and implement policy solutions related to climate change adaptation regarding current and projected effects of climate change; and

WHEREAS the Department of Water Resources (DWR) is responsible for managing the state's water resources to benefit the people of California, and to protect, restore and enhance the natural and human environments; and

WHEREAS California's coastal management agencies such as the California Coastal Commission, the California Ocean Protection Council (OPC) and California State Parks are charged with managing and protecting the ocean and coastal resources of the state; and

WHEREAS the California Energy Commission's (CEC) Public Interest Energy Research Program has funded research on climate change since 2001 including funding the development of preliminary sea level rise projections for the San Francisco Bay area by the Scripps Institution of Oceanography/University of California at San Diego.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, by virtue of the power vested in me by the Constitution and statutes of the State of California, do hereby order effective immediately:

1. The California Resources Agency, in cooperation with DWR, CEC, California's coastal management agencies, and the OPC, shall request that the National Academy of Sciences (NAS) convene an independent panel to complete the first California Sea Level Rise Assessment Report and initiate, within 60 days after the signing of this Order, an independent sea level rise science and policy committee made up of state, national and international experts.

2. By March 31, 2009, the OPC, DWR and the CEC, in coordination with other state agencies, shall hold a public workshop to gather policy-relevant information specific to California for use in preparing the Sea Level Rise Assessment Report and to raise state awareness of sea level rise impacts.

3. The California Resources Agency shall request that the final Sea Level Rise Assessment Report be completed as soon as possible but no later than December 1, 2010. The final Sea Level Rise Assessment Report will advise how California should plan for future sea level rise. The report should include: (1) relative sea level rise projections specific to California, taking into account issues such as coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge and land subsidence rates; (2) the range of uncertainty in selected sea level rise

projections; (3) a synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems; and (4) a discussion of future research needs regarding sea level rise for California.

4. The OPC shall work with DWR, the CEC, California's coastal management agencies and the State Water Resources Control Board to conduct a review of the NAS assessment every two years or as necessary.

5. I direct that, prior to release of the final Sea Level Rise Assessment Report from the NAS, all state agencies within my administration that are planning construction projects in areas vulnerable to future sea level rise shall, for the purposes of planning, consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. However, all projects that have filed a Notice of Preparation, and/or are programmed for construction funding the next five years, or are routine maintenance projects as of the date of this Order may, but are not required to, account for these planning guidelines. Sea level rise estimates should also be used in conjunction with appropriate local information regarding local uplift and subsidence, coastal erosion rates, predicted higher high water levels, storm surge and storm wave data.

6. The Business, Transportation, and Housing Agency shall work with the California Resources Agency and the Governor's Office of Planning and Research (OPR) to prepare a report within 90 days of release of this Order to assess vulnerability of transportation systems to sea level rise that will include provisions for investment critical to safety, maintenance and operational improvements of the system and economy of the state.

7. By June 30, 2009, the California Resources Agency, through the Climate Action Team, shall coordinate with local, regional, state and federal public and private entities to develop a state Climate Adaptation Strategy. The strategy will summarize the best known science on climate change impacts to California (led by CEC's PIER program), assess California's vulnerability to the identified impacts and then outline solutions that can be implemented within and across state agencies to promote resiliency. A water adaptation strategy will be coordinated by DWR with input from the State Water Resources Control Board, an ocean and coastal resources adaptation strategy will be coordinated by the OPC, an infrastructure adaptation strategy will be coordinated by the California Department of Transportation, a biodiversity adaptation strategy will be jointly coordinated by the California Department of Fish and Game and California State Parks, a working landscapes adaptation strategy will be jointly coordinated by the California Department of Forestry and Fire Protection and the California Department of Food and Agriculture, and a public health adaptation strategy will be jointly coordinated by the California Department of Public Health and the California Air Resources Board, all as part of the larger strategy. This strategy will be facilitated through the Climate Action Team and will be coordinated with California's climate change mitigation efforts.

8. By May 30, 2009, OPR, in cooperation with the California Resources Agency, shall provide state land-use planning guidance related to sea level rise and other climate change impacts.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its agencies, departments, entities, officers, employees, or any other person.

I FURTHER DIRECT that as soon as hereafter possible, this Order shall be filed with the Office of the Secretary of State and that widespread publicity and notice be given to this Order.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 14th day of November 2008.

ARNOLD SCHWARZENEGGER
Governor of California

APPENDIX D: GLOSSARY

This glossary provides definitions for terms commonly used in discussing climate risks.

Carbon Sequestration This refers to the capture of CO2 from the atmosphere and its long term storage in oceans (oceanic carbon sequestration), in biomass and soils (terrestrial carbon sequestration) or in underground reservoirs (geologic carbon sequestration).[605]

Climate Climate in a narrow sense is usually defined as the "average weather" or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.[606]

Climate Adaptation Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.[607]

Climate Mitigation A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.[608]

Ecosystem Services Ecosystem services are commonly defined as the benefits people obtain from ecosystems. Ecosystem services include basic services - provisioning services like the delivery of food, fresh water, wood and fiber, and medicine - and services that are less tangible and harder to measure but equally critical: regulating services like carbon sequestration, erosion control, and pollination; cultural services like recreation, ecotourism, and educational and spiritual values; and supporting services like nutrient cycling, soil formation, and primary productivity.[609]

Exposure the nature and degree to which natural or social systems are subjected to climate variations.[610]

Extreme weather event: In most cases, extreme weather events are defined as lying in the outermost (“most unusual”) ten percent of a place’s history. Analyses are available at the national and regional levels.[611]

Downscaling Downscaling is a method for obtaining high-resolution climate or climate change information from relatively coarse-resolution global climate models[612]

Global Warming Global warming is an average increase in the temperature of the atmosphere

near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities. Also see Climate Change.[613]

Greenhouse Gas Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrochlorofluorocarbons (HCFCs), ozone (O3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).[614]

Hazard Mitigation Hazard Mitigation is sustained action taken to reduce or eliminate long-term risk to people and their property from hazards and their effects.[615]

Mainstreaming: A process of integrating climate change concerns in development efforts and other policy processes.[616]

Maladaptation Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead.[617]

Phenology: The timing of natural events, such as flower blooms and animal migration, which is influenced by changes in climate. Phenology is the study of such important seasonal events. Phenological events are influenced by a combination of climate factors, including light, temperature, rainfall, and humidity.[618]

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.[619]

Storm surge Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides.[620]

Vulnerability the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate.[621]

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(2) David B. Lobell, Angela Torney, Christopher B. Field, **Climate Extremes in California Agriculture**, California Energy Commission. Publication number: CEC-500-2009-040-F;

(3) Juhwan Lee, Stephen DeGryze, Johan Six, **Effect of Climate Change on Field Crop Production in the Central Valley of California**, California Energy Commission. Publication number: CEC-500-2009-041-F;

(4) Richard Howitt, Josue Medellin-Azuara, Duncan MacEwan, **Estimating the Economic Impacts of Agricultural Yield-Related Changes for California**, California Energy Commission. Publication number: CEC-500-2009-042-F;

(5) Christopher J. Costello, Olivier Deschenes, Charles D. Kolstad, **Economic Impacts of Climate Change on California Agriculture**, California Energy Commission. Publication number: CEC-500-2009-043-F; and

(6) L. E. Jackson, F. Santos-Martin, A. D. Hollander, W. R. Horwath, R. E. Howitt, J. B. Kramer, A. T. O'Geen, B. S. Orlove, J. W. Six, S. K. Sokolow, D. A. Sumner, T. P. Tomich, S. M. Wheeler, Potential for Adaptation to Climate Change in an Agricultural Landscape in the Central Valley of California, California Energy Commission. Publication number: CEC-500-2009-044-F.

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Vulnerability and Adaptation to Climate Change in California Agriculture. California Energy Commission. Publication number: CEC-500-2012-031;

(2) Jackson, Louise, Van R. Haden, Allan D. Hollander, Hyunok Lee, Mark Lubell, Vishal K. Mehta, Toby O'Geen, Meredith Niles, Josh Perlman, David Purkey, William Salas, Dan Sumner, Mihaela Tomuta, Michael Dempsey, and Stephen M. Wheeler. 2012. **Adaptation Strategies for Agricultural Sustainability in Yolo County, California.** California Energy Commission. Publication number: CEC-500-2012-032; and

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[79] Jackson, Louise, et al. 2012. ***Adaptation Strategies for Agricultural Sustainability in Yolo County, California.*** California Energy Commission. Publication number: CEC-500-2012-032.

[80] http://www.conservation.ca.gov/dlrp/lca/Pages/Index.aspx

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[88] http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0001-0050/sbx7_7_bill_20091110_chaptered.pdf

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[91] CA Public Resources Code, Division 9, Chapter 3 "Resource Conservation Districts" http://www.leginfo.ca.gov/cgi-bin/calawquery?codesection=prc

[92] *See e.g.*
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and New York, NY, USA, pp. 1-19. It should be noted that the terms "mitigation" and "preparedness" can be associated with different meanings in the disaster management context and in the climate change context; "mitigation" in the climate context generally refers to the reduction of greenhouse gases, however "mitigation" in the disaster management context refers to hazard mitigation activities that can be characterized as efforts to "adapt" or prepare for climate impacts.

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[180] See the "**Climate Risk Communication and Education"** section of this chapter.

[181] For more information, please see the Ocean and Coastal Ecosystem and Resources section of this document, the Forestry section of this document, the Water section of this document and the "**Support Risk Sharing Mechanisms"** section of this chapter.

[182] For more information, please see the Ocean and Coastal Ecosystem and Resources section of this document.

[183] For more information, please see the Ocean and Coastal Ecosystem and Resources section of this document.

[184] For more information, please see the Water section and the Ocean and Coastal Ecosystem and Resources section of this document.

[185] As described elsewhere in this document, climate risk communication and education can help shape choices that reduce climate risks by reducing exposure and vulnerability.

[186] For more information, please see the Forestry section of this document.

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[190] For more information, please see the Public Health section of this document.

[191] For more information, please see the Transportation section of this document.

[192] See e.g. discussion of use of state-of-art materials in the Transportation section of this document
[193] For more information on mainstreaming climate risk considerations, please see e.g. the Introduction section of this document.
[194] IPCC, 2012: Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea,K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, p. 9.
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FEMA's approval of the SHMP enabled California to receive approximately $160 million in Public Assistance grant funding and $40 million in Hazard Mitigation Grant Program funding following disasters that occurred between January 2007 and December 2009.
[199] For a discussion of the National Flood Insurance Program, please see the Oceans and Coastal Ecosystems and Resources section of this document.
[200] http://www.calema.ca.gov/HazardMitigation/Pages/Grants.aspx
[201] Climate change will produce changes to the hydrologic cycle that may be outside of current design standards for dams in some parts of the world. *See e.g.* Chernet, H, Alfredsen, K. and Midttomme, G. (2013) "Safety of Hydropower Dams in a Changing Climate." J. Hdrol. Eng., 10.1061/(ASCE) HE.1943-5584.0000836 (Apr. 27, 2013.
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[345] As noted in the introduction to this document, the Safeguarding California Plan is not meant to replace the 2009

California Climate Adaptation Strategy, but to add new recommendations and replace portions of the prior document where new information allows for updating and revision. Except where revisions and new recommendations supersede, the strategies in the 2009 CAS continue to be relevant and are carried forward

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[348] As noted in this section, oceans are a part of the global water system; the separate discussion of water management and oceans management in this document reflects administrative constructs that often separate oceans and water management. As climate change radically changes the earth's environment, a more holistic approach to resource management may be necessary to adequate address emerging climate threats.

[349] Sea ice melt contributes a small, but not insignificant amount, to sea level rise. An ice cube melting in a glass of drinking water doesn't change the level of liquid in the glass because the ice cube displaces its own weight in the water, and the melting process simply replaces the water which was previously displaced by the ice. However, freshwater contained in sea ice, is less dense than sea water, so although the amount of sea water displaced by the iceberg is equal to its weight, the melted fresh water will take up a slightly larger volume than the displaced salt water. *See*, Shepherd, A., D. Wingham, D. Wallis, K. Giles, S. Laxon, *and* A. V. Sundal (2010), recent loss of floating ice and the consequent sea level contribution, Geophys. Res. Lett., 37, *L13503,* is estimating that 1.6% of current sea level rise is caused by sea ice loss.

[350] *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*, National Research Council (NRC), 2012. Energy Commission's Public Interest Energy Research (PIER) Program, OPC, and the California Environmental Protection Agency (CalEPA) funded a 2009 study on sea level rise by researchers from Scripps Institution of Oceanography, the University of California San Diego, the California Department of Boating and Waterways, the U.S. Geological Survey, and the Hydrologic Research Center. The 2009 study projected California sea levels would rise approximately 16 inches by 2050 and 55 inches by 2100. As climate science continues to evolve, projections will continue to be refined and improved.

[351] Sea level rise projections in the 2012 report were expressed in metric units (i.e. 12-61 cm projected sea level rise by 2050 and 42-167 cm by 2100); for readability, this report expresses the projections in English units rounded to the nearest whole number. Due to plate tectonics, the land elevation of the northernmost portion of California's coast is actually rising about 1.5-3.0 mm per year. As a result, sea level rise projections for that area of the State differ. For the California coast north of Cape Mendocino, projections are that, relative to 2000, sea level change will range from -3 cm (i.e. approximately a 1 inch fall in sea level) to +48 cm (i.e. approximately 19 inch rise in sea level) by 2050, and +10 cm (i.e. approximately a 4 inch rise in sea level) to +143 cm (i.e. approximately 56 inch rise in sea level) by 2100. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future, National Research Council, 2012, pp. 3-4.*

[352] For more information on climate impacts and California agriculture, please see the Agriculture section of this document.

[353] The map in Box 45 shows areas vulnerable to approximately 16 inch sea level rise and areas vulnerable (in pink) to a 55 inch sea level rise (in red). Prior to the 2012 NRC study referenced in Footnote 5, the California

[354] http://www.coastal.ca.gov/climate/erosion.html *See also* Pendleton, L., King, P., Mohn, C., Webster, D.G., Vaughn, R. and Adams, P., Estimating the Potential Economic Impacts of Climate Change on Southern California Beaches, April 2009, CEC-500-2009-033-D. http://www.energy.ca.gov/2009publications/CEC-500-2009-033/CEC-500-2009-033-D.PDF noting that sea-level rise will not impact all beaches equally.

[355] http://www.coastal.ca.gov/climate/access.html

[356] The Impacts of Sea Level Rise on the California Coast, Paper from the California Climate Center, Prepared by: *Matthew Heberger, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore of the Pacific Institute, August 2009, pp. 2-3.* California Energy Commission. Publication number: CEC-500-2009-024-F http://www.energy.ca.gov/2009publications/CEC-500-2009-024/CEC-500-2009-024-F.PDF

[357] *See* Pendleton, L., King, P., Mohn, C., Webster, D.G., Vaughn, R. and Adams, P., Estimating the Potential Economic Impacts of Climate Change on Southern California Beaches, April 2009, CEC-500-2009-033-D. http://www.energy.ca.gov/2009publications/CEC-500-2009-033/CEC-500-2009-033-D.PDF *See also* King, Philip G., McGregor, Aaron R., and Whittet, Justin D., The Economic Cost of Sea-Level Rise to California Beach Communities,

A Paper from The California Department of Boating and Waterways and San Francisco State University, September 2011. http://www.dbw.ca.gov/PDF/Reports/CalifSeaLevelRise.pdf

[358] The Impacts of Sea Level Rise on the California Coast, Paper from the California Climate Center, Prepared by: *Matthew Heberger, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore of the Pacific Institute, August 2009, pp. 52-53.* California Energy Commission. Publication number: CEC-500-2009-024-F http://www.energy.ca.gov/2009publications/CEC-500-2009-024/CEC-500-2009-024-F.PDF

[359] Ibid.

[360] http://www.adaptingtorisingtides.org/wp-content/uploads/2013/03/ContaminatedLandsProfileSheet_20130326.pdf

[361] http://water.epa.gov/type/oceb/cre/upload/king_tides_factsheet.pdf

[362] http://www.californiakingtides.org/

[363] http://ceres.ca.gov/ceres/calweb/wetlands.html

[364] http://wh.er.usgs.gov/slr/coastalgroundwater.html

[365] Ibid.

[366] Ibid.

[367] Crooks, S., D. Herr, J. Tamelander, D. Laffoley, and J. Vandever. 2011. "Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities." Environment Department Paper 121, World Bank, Washington, D.C.

[368] http://bay.org/bay-restoration/the-horizontal-levee

[369] The National Flood Insurance Program: Past, Present,…and Future?, American Academy of Actuaries: Flood Insurance Subcommittee, July 2011. *http://www.actuary.org/pdf/casualty/AcademyFloodInsurance_Monograph_110715.pdf*

[370] http://www.insurance.ca.gov/wf-con-info/0040-flood-insur-fs/

[371] http://www.floodsmart.gov/floodsmart/pages/about/when_insurance_is_required.jsp

[372] http://www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13-13

[373] http://www.nytimes.com/2012/11/13/nyregion/federal-flood-insurance-program-faces-new-stress.html

[374] The Biggert-Water Flood Insurance Reform Act of 2012, Pub. L. No. 112-123. (See, 42 U.S.C. 4101, 4101(a), and 4101(b), *et. seq*.)

[375] See http://www.fema.gov/flood-insurance-reform-act-2012#1

[376] High Risk Series, United States Government Accountability Office, Report to Congressional Committees, Feb 2013, p. 17.

[377] The National Flood Insurance Program: Status and Remaining Issues for Congress, Rawle O. King, Congressional Research Service, February 6, 2013. http://www.fas.org/sgp/crs/misc/R42850.pdf

[378] High Risk Series, United States Government Accountability Office, Report to Congressional Committees, Feb 2013, p.61-75.

[379] Hurricane Sandy, Storm Surge, and the National Flood Insurance Program: A Primer on New York and New Jersey, Dr. Carolyn Kousky and Dr. Erwann Michel-Kerjan, November 2012. http://www.rff.org/RFF/Documents/RFF-IB-12-08.pdf

[380] http://www.fema.gov/severe-repetitive-loss-program

[381] See, 14 Cal. Code Reg. 15126.2, see also *Ballona Wetlands Land Trust v. City of Los Angeles* (2011) 201 Cal.App.4th 455, 134 Cal.Rptr.3d 194 fn, 9, *See also, Cal. Building Ind. Ass'n v. Bay Area Air Quality Man. Dist.* (2013) 218 Cal.App.4th 1171, 1195 ("A new project located in an area that will expose its occupants to preexisting dangerous pollutants can be said to have substantial adverse effects on human beings.")

[382] *See* http://oceanservice.noaa.gov/education/pd/tidescurrents/effects/climatechange_currents_lesson.html More information about the principal ocean currents affecting the coastal waters of California can be found in: Indicators of Climate Change in California, CalEPA and the Office of Environmental Health Hazard Assessment, April 2009, pp.72-74.

[383] Global Warming and the Science of Extreme Weather, John Carey, Scientific American, June 2011. http://www.scientificamerican.com/article.cfm?id=global-warming-and-the-science-of-extreme-weather and IPCC

Summary for Policymakers (2013): http://www.climatechange2013.org/images/uploads/WGI_AR5_SPM_brochure.pdf

[384] http://www.epa.gov/climatestudents/impacts/signs/precip-patterns.html

[385] *See* Burkett, V.R. and Davidson, M.A. [Eds.]. (2012). *Coastal Impacts, Adaptation and Vulnerability: A Technical Input to the 2012 National Climate Assessment*. Cooperative Report to the 2013 National Climate Assessment., pp. 150. http://downloads.usgcrp.gov/NCA/technicalinputreports/Burkett_Davidson_Coasts_Final_.pdf

[386] http://www.epa.gov/region9/water/npdes/stormwater-feature.html

[387] http://water.epa.gov/type/oceb/fact4.cfm

[388] http://www.epa.gov/gmpo/habpage.html

[389] For more information about the State's current sanitary sewer overflow (SSO) reduction program, see: http://www.waterboards.ca.gov/water_issues/programs/sso/ Some treatment facilities collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. During periods of heavy rainfall, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. As noted in the Water section of this document, severe weather and sewer issues are not unique to coastal communities.

[390] Karl TR, Melillo JM, Peterson TC, editors. Global climate change impacts in the United States. New York: Cambridge University Press; 2009.

[391] See U.S. Environmental Protection Agency: Combined Sewer Overflows http://cfpub.epa.gov/npdes/home.cfm?program_id=5

[392] *https://fortress.wa.gov/ecy/publications/publications/1201016.pdf*

[393] Billé R., Kelly R., Biastoch A., Harrould-Kolieb E., Herr D., Joos F., Kroeker K., Laffoley D., Oschlies A., and Gattuso J-P. 2013. Taking Action Against Ocean Acidification: A Review of Management and Policy Options. Environmental Management, Vol 52, Issue 4, pp 761-779

[394] William G. Sunda and Wei-Jun Cai. *Eutrophication Induced CO2-Acidification of Subsurface Coastal Waters: Interactive Effects of Temperature, Salinity, and Atmospheric PCO_2. Environmental Science & Technology 2012 46 (19), 10651-10659*

[395] R. Feely *et al.*, Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf, 320 Science 1490 (2008).

[396] Why Ocean Acidification Matters to California, and What California Can Do About it: A report on the power of California's State Government to Address Ocean Acidification, Center of Ocean Solutions (March 2012), p. 9.

[397] http://iopscience.iop.org/1748-9326/4/2/024007/fulltext/

[398] Ocean Acidification in the California Current: Predicting Impacts on Food Webs and Economies within a Context of Climate Change: http://www.coastalscience.noaa.gov/projects/detail?key=126

[399] Barton, Alan, Hales, Burke, Waldbusser, George G., Langdon, Chris and Feely, Richard A., The Pacific oyster, *Crassostrea gigas*, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects, 2012. http://www.aslo.org/lo/toc/vol_57/issue_3/0698.html

[400] http://www.annualreviews.org/doi/full/10.1146/annurev-marine-120710-100849

[401] Bograd SJ, Castro CG, DiLorenzo E, Palacios DM, Bailey H, et al. 2008. Oxygen declines and the shoaling of the hypoxic boundary in the California Current. *Geophys. Res. Lett.* 35: L12607

[402] *See* Grantham B, Chan F, Nielsen K, Fox D, Barth J, et al. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific. *Nature* 429: 749–54 for information on lethal hypoxic events in Oregon.

[403] The Impacts of Sea Level Rise on the California Coast, Paper from the California Climate Center, Prepared by: *Matthew Heberger, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore of the Pacific Institute, August 2009, pp. 2-3.* California Energy Commission. Publication number: CEC-500-2009-024-F http://www.energy.ca.gov/2009publications/CEC-500-2009-024/CEC-500-2009-024-F.PDF. Major funding for the report was provided through PIER. Additional support was provided by the Metropolitan Transportation Commission and the OPC.

[404] Heberger, Matthew, Heather Cooley, Eli Moore, and Pablo Herrera (Pacific Institute). 2012. ***The Impacts of Sea Level Rise on the San Francisco Bay.*** California Energy Commission. Publication number: CEC-500-2012-014.

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[405] Lempert, Robert, Ryan L. Sriver, and Klaus Keller (RAND). 2012. Characterizing Uncertain Sea Level Rise Projections to Support Investment Decisions. California Energy Commission. Publication Number: CEC-500-2012-056. http://www.energy.ca.gov/2012publications/CEC-500-2012-056/CEC-500-2012-056.pdf The study was partially supported by the U.S. National Science Foundation (Grant SES-0345925) and the Penn State Center for Climate Risk Management.

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[407] Griggs, Gary, and Nicole L. Russell (University of California, Santa Cruz). 2012. City of Santa Barbara Sea-Level Rise Vulnerability Study. California Energy Commission. Publication number: CEC-500-2012-039. http://www.energy.ca.gov/2012publications/CEC-500-2012-039/CEC-500-2012-039.pdf

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[410] http://OceanSpaces.org/

[411] http://coastalmanagement.noaa.gov/initiatives/shoreline_ppr_planning.html

[412] *See* http://www.habitat.noaa.gov/restoration/index.html

[413] Material science, engineering and construction design responsive to climate impacts is a growing field of study. In 2009, BCDC held an open international design competition for ideas responding to sea level rise in San Francisco Bay and beyond. http://www.risingtidescompetition.com/risingtides/Home.html Also *see e.g.* Wang, X., Nguyen, M., Stewart, M. G., Syme, M., Leitch, A. (2010). Analysis of Climate Change Impacts on the Deterioration of Concrete Infrastructure. Published by Commonwealth Scientific and Industrial Research Organisation ("CSIRO" is Australia's national science agency), Canberra. ISBN978 0 643 10364 1. http://www.csiro.au/Portals/Publications/Research--Reports/concrete-durability-report.aspx

[414] http://opr.ca.gov/docs/GPG_2013_One_Pager.pdf

[415] *See* the Introduction to this document, noting that recommendations in this Safeguarding California Plan are meant to work with existing laws and regulations; however, in order to fully implement actions to prepare for climate risks in California, some laws may need to be amended to better reflect new and changing climate conditions that did not exist when those laws were initially enacted, and new implementing authorities may be needed.

[416] Grigg, Rachel M., Using Ecosystem-Based Management as an Adaptation Strategy in the Pacific Fishery Management Council, April 2010. http://www.cakex.org/case-studies/1075 and *see* Pacific Coast Fishery Ecosystem Plan for the U.S. Portion of the California Current Large Marine Ecosystem: Public Review Draft (February 2013) http://www.pcouncil.org/wp-content/uploads/H1a_ATT1_FEP_DRAFT_FEB13_ELECTRIC_APR2013BB.pdf

[417] Fishery Conservation and Management Act of 1976 - Public Law 94-265, approved April 13, 1976; 16 U.S.C. 1801-1882; 90 Stat. 331; as amended by numerous subsequent public laws listed and identified in the U.S. Code.

[418] http://deltacouncil.ca.gov/legislation

[419] http://dbw.ca.gov/csmw/default.aspx

[420] http://dbw.ca.gov/csmw/pdf/SMP_Brochure27APR2011.pdf

[421] Green Infrastructure for the Global Warming Era: The Horizontal Levee - Nature's Low Cost Defense Against Sea Level Rise, Bay Institute, February 2013, p. 10. http://bay.org/bay-restoration/the-horizontal-levee

[422] http://www.bcdc.ca.gov/dredging/dredging_sediment.shtml For another example of collaborative work on sediment management and flood control at the local and regional level, see the Flood Control 2.0 project which will

develop a set of innovative approaches for bringing environmental benefits and cost-savings to flood protection infrastructure along the San Francisco Bay shoreline. http://www.sfestuary.org/our- projects/watershed-management/floodcontrol/

[423] See Box 48: Flood Insurance

[424] *See* the Emergency Management section of this document for a discussion of the Adaptation Planning Guide. http://resources.ca.gov/climate_adaptation/local_government/adaptation_planning_guide.html

[425] Schwarz, Christina V., Reiser, Brian J., Davis, Elizabeth A., Kenyon, Lisa, Achér, Andres, Fortus, David, Shwartz, Yael, Hug, Barbara, Krajcik, Joe, Developing a learning progression for scientific modeling: Making scientific modeling accessible and meaningful for learners, Journal of Research in Science Teaching, 632–654, August 2009.

[426] NOAA and the U.S. Army Corps of Engineers (USACE) are developing Infrastructure Systems Rebuilding Principles for Federal agencies, Tribal, State and local governments, non-governmental organizations, and the public to guide coastal restoration activities following Superstorm Sandy. Efforts to promote increased recognition and awareness of risks and consequences among decision makers, stakeholder, and the public is a major principle being advanced by NOAA and USACE.

[427] More information on climate impacts and transportation and energy systems may be found in the Transportation and Energy sections of this document.

[428] As noted below, sea level risk will significantly increase the risk of toxic releases associated with flooding and inundation of hazardous waste facilities and sites.

[429] The SLC California Marine Invasive Species Program is charged with preventing or minimizing the introduction of nonindigenous species to California Waters from vessels over 300 gross registered tons, capable of carrying ballast water.

[430] http://portal.gis.ca.gov/geoportal/catalog/main/home.page

[431] http://www.csc.noaa.gov/

[432] In additional to local, regional, state and federal regulation, international regulation is also relevant to ocean and coastal management. The United States has not ratified the 1982 United Nations Convention on the Law of the Sea, which has two implementation agreements (the Part XI Deep-Sea Mining Agreement and the Fish Stocks Agreement). However, the United States is a member of the International Maritime Organization (IMO), established by the United Nations in 1948, "to promote safe, secure, environmentally sound, efficient and sustainable shipping through cooperation." (IMO Resolution A.1011(26))

[433] In addition to innovative shoreline management efforts and LCPs described below, a number of California communities have begun the process of studying and preparing for climate impacts to coastal and ocean resources. These efforts include, but are not limited to: the San Diego Foundation Climate Initiative http://www.sdfoundation.org/CivicLeadership/Programs/Environment/Climate.aspx, the 2011 City of Santa Cruz Climate Change Vulnerability Assessment http://www.cityofsantacruz.com/Modules/ShowDocument.aspx?documentid=21198,and the work of the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) - which is a California Joint Powers agency established in 1992 to address coastal erosion, beach nourishment and clean oceans within the Central California Coast from Point Conception to Point Mugu. The agencies making up BEACON are Santa Barbara and Ventura Counties and the cities of Port Hueneme, Oxnard, San Buenaventura, Carpinteria and Santa Barbara. http://www.beacon.ca.gov/

[434] http://www.cdph.ca.gov/programs/Documents/BurdenReportOnline%2004-04-13.pdf Health is not distributed equally across our population and communities.

[435]California Health and Safety. Code, Division 1, Part 1, Section 152 http://www.leginfo.ca.gov/cgi-bin/displaycode?section=hsc&group=00001-01000&file=152

[436] Recognizing the impact that non-health policies have on health, as well as the complex relationship between sustainability and health, the State of California created a Health in All Policies Task Force in 2010. Created by Executive Order S-04-10 created and placed the Task Force under the auspices of the Strategic Growth Council (SGC), where it is charged with identifying "priority programs, policies, and strategies to improve the health of Californians while advancing the goals of improving air and water quality, protecting natural resources and agricultural lands, increasing the availability of affordable housing, improving infrastructure systems, promoting

public health, planning sustainable communities, and meeting the climate change goals". http://www.sgc.ca.gov/hiap/about.html

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[438] Hoshiko, S., English, P., Smith, D., & Trent, R. (2010) A simple method for estimating excess mortality due to heat waves as applied to the 2006 California Heat Wave, *International Journal of Public Health. 55:* 133-137. Reporting of heat illness and death is notoriously underreported, early estimates are often based on coroner's reports which indicate heat as cause of death, but more complete analyses are required to derive accurate statistics.

[439] Our Changing Climate: Assessing the Risks to California, July 2006, p. 5, CEC 500-2006-07. There is a growing body of research on the interplay between climate change and weather and human dynamics like conflict and crime. See e.g. Burke, Marshall, Miguel, Edward, Satyanath, Shanker, Dykema, John, and Lobell, David, Warming increases the risk of civil war in Africa, 10.1073/pnas.0907998106 PNAS November 23, 2009. http://www.pnas.org/content/106/49/20670.full

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[441] Preparing for Extreme Heat in California: Guidance and Recommendations, CalEPA and CDPH, 2013.

[442] http://www.c.d.gov/extremeheat/seniors.html and http://www.cdc.gov/extremeheat/medical.html

[443] Our Changing Climate: Assessing the Risks to California, July 2006, p.5 CEC 500-2006-077.

[444] Gambel, Janet, Reid, Colleen, Post, Ellen, and Sacks, Jason, A Review of the Impacts of Climate Variability and Change on Aeroallergens and Their Associated Effects, Global Change Research Program, National Center for Environmental Assessment, EPA/600/R-06/164, August 2008.

[445] See e.g. Nazaroff, William W., Exploring the Consequences of Climate Change for Indoor Air Quality, 2013 *Environ. Res. Lett.* **8** 015022 doi:10.1088/1748-9326/8/1/015022; Climate Change, the Indoor Environment, and Health, Institute of Medicine of the National Academies, June 7, 2011.

[446] Drinking Water Infrastructure Needs Survey and Assessment: Fifth Report to Congress, Office of Water, U.S. Environmental Protection Agency, EPA 816-R-13-006, April 2013, p.20. The report covers infrastructure needs eligible for, but not necessarily financed by, Drinking Water State Revolving Fund (DWSRF) monies - recognizing that legitimate and significant water system needs are not eligible for DWSRF funding such as raw water dams and reservoirs. http://water.epa.gov/grants_funding/dwsrf/upload/epa816r13006.pdf

[447] *See* Californian's Without Safe Water, California Water Plan, 2005 Update http://www.waterplan.water.ca.gov/docs/cwpu2005/vol4/vol4-waterquality-californianswithoutsafewater.pdf A 2013 update is currently being developed.

[448] http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf

[449] *See e.g.* Hurricane Sandy Rebuilding Strategy: Stronger Communities, A Resilient Region, Hurricane Sandy Task Force, Aug 2013, p. 27. http://portal.hud.gov/hudportal/HUD?src=/press/press_releases_media_advisories/2013/HUDNo.13-125

[450] *See* Climate Readiness discussion in the Drinking Water Infrastructure Needs Survey and Assessment: Fifth Report to Congress, Office of Water, U.S. Environmental Protection Agency, EPA 816-R-13-006, April 2013, p.15.

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[452] California Department of Water Resources, Groundwater Information Center: Land Subsidence. http://www.water.ca.gov/groundwater/well_info_and_other/land_subsidence.cfm

[453] Land Subsidence in the United States, U.S. Geological Survey Fact Sheet-165-00, December 2000. http://water.usgs.gov/ogw/pubs/fs00165/

[454] National Institutes of Health, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2465549/

[455] Centers for Disease Control and Prevention, http://www.cdc.gov/climateandhealth/effects/default.htm

[456] *See* California Department of Public Health, Vector Borne Disease Section, http://www.cdph.ca.gov/programs/vbds/pages/default.aspx.

[457] See Centers for Disease Control and Prevention, Division of Vector Borne Diseases, http://www.cdc.gov/ncezid/dvbd/about.html

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[467]http://www.niehs.nih.gov/research/programs/geh/climatechange/health_impacts/waterborne_diseases/index.cfm

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