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Preparing for the Effects of Climate Change – A Strategy for California

A Report by the California Adaptation Advisory Panel to the State of California

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SPECIAL THANKS

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The Pacific Council is responsible for convening the task force and the preparation of this executive summary and the full report detailing the work of the task force. The report represents the view and opinions of the task force members who participated in their individual, not institutional capacities. The Pacific Council takes no institutional position on policy issues. All statements of fact and expressions of opinion contained in its publications are the sole responsibility of the task force.

The full report can be downloaded at *www.pacificcouncil.org*. For further information about the Pacific Council or this Task Force Report, please write to the Pacific Council on International Policy, 801 S. Figueroa Street, Suite 1130, Los Angeles, CA 90017 or contact the Project Director, at 213-221-2010

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A Report by the California Adaptation Advisory Panel to the State of California on Critical Steps Needed to Adapt to the Effects of Climate Change

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CALIFORNIA natural resources AGENCY

ARNOLD SCHWARZENEGGER, *Governor*
LESTER A. SNOW, *Secretary for Natural Resources*

November 22, 2010

Fellow Californians,

California is a leader on climate change issues. With its ground breaking legislation under AB 32, which seeks to decrease greenhouse gas emissions to 20% below 1990 levels over the next 10 years, the state is setting a new standard by which all efforts across the country will be judged. However, despite our best state efforts to reduce greenhouse gas emissions, the effects of climate change will still be felt in all of our communities worldwide in the coming decades. Warmer, shorter winters and longer, drier summers will raise the risks of wildfires and heat waves. Sea level rise and more extreme precipitation patterns will cause flooding in low lying areas along the coast as well as inland. All of these effects and others will impact resources that underlie the health and prosperity of California, including our fragile water supply.

In response to growing concerns over climate variability, Governor Arnold Schwarzenegger issued Executive Order S-13-08 to identify how state agencies can respond to rising temperature and its effects. One of the main actions called for was the development of a statewide, multi-sector climate adaptation strategy based on climate change impact information generated by a team of scientists across the state. This effort engaged 12 agencies, numerous boards and commissions, and dozens of organizational stakeholders in a cross-disciplinary collaborative effort to identify the path forward. Throughout the process, the need for broad engagement from all sectors and regions became critically clear. It was for that reason that the first key recommendation in the strategy was to appoint a Climate Adaptation Advisory Panel to identify the biggest risks facing our state and make recommendations designed to reduce our vulnerability.

On behalf of the Natural Resources Agency, I want to thank the Pacific Council on International Policy for convening the task force that served as this panel and for producing this report. The diverse task force represents an illustrious group of concerned citizens from across sectors, regions and interests. Their dedication and commitment to the work throughout the 12-month process is a testament to the engaged leadership that will navigate our common future in a shifting landscape. Through proactive management and resilient design, we can effectively manage these effects and potentially turn negative impacts into positive outcomes.

Sincerely,

Lester A. Snow
Secretary for Natural Resources

FOREWARD

Preparing for the Effects of Climate Change – A Strategy for California

Adaptation to climate change has emerged the world over as a growing concern. Even with aggressive mitigation, California is unlikely to escape serious impacts from the continuing emission of greenhouse gases into the atmosphere. Scientists already are reporting effects. Average global temperatures are rising, bringing with them the potential for hurricanes, floods, and wildfires both more frequent and more severe. Over this century, scientists expect these trends to continue and intensify, threatening the State's valuable land, water, and other natural resources. Shorter, warmer winters, for example, are likely to decrease the Sierra snowpack, a major source of annual water supply on which many Californian's depend for drinking water and other purposes. Longer, hotter summers in the semi-arid southern part of the State could upend agricultural production and create ideal conditions for wildfires.

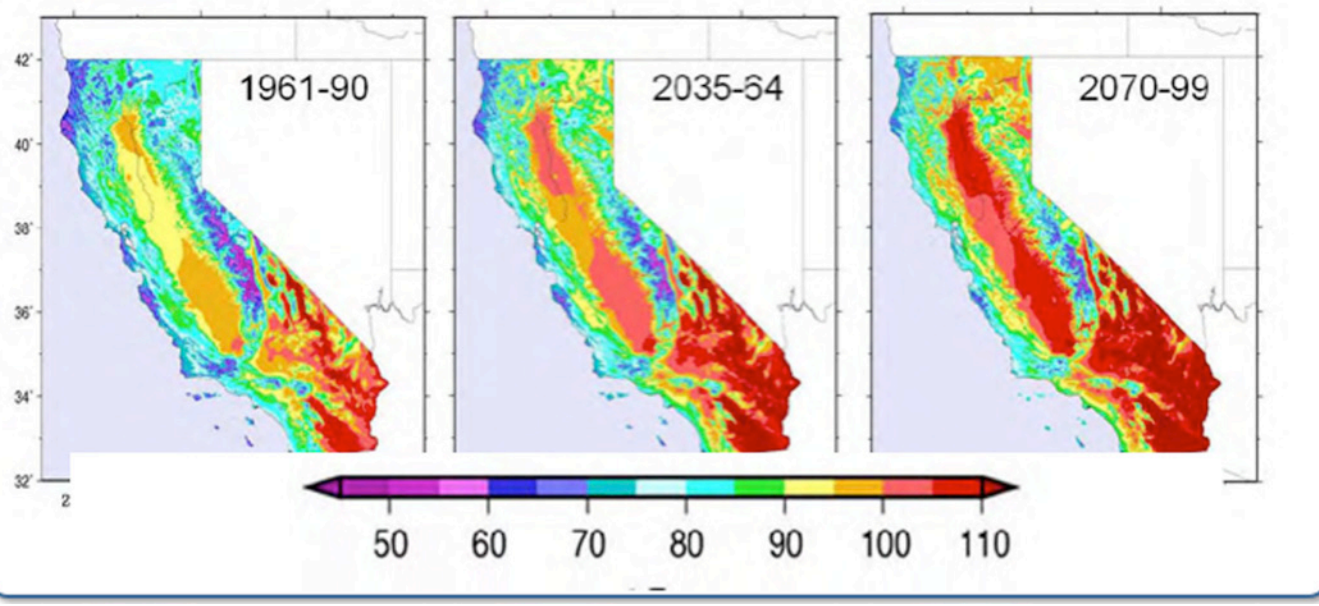
Among other impacts associated with climate change that California is likely to experience is the rising level of the Pacific Ocean. Although significant uncertainty remains, recent projections suggest as much as 55 inches – nearly 5 feet – of possible sea level rise by 2100. Should this occur, it would dramatically alter coastal landscapes, shoreline habitat, and wetlands. Flooding of low-lying homes and commercial and industrial development – not just along the 1,100 mile open ocean coastline, but along extensively built-up shorelines and floodplains across the State – could cause financial hardships. From the waterways of San Francisco Bay to the floodplains in the Central Valley to the southernmost port in San Diego, all will be affected.

Failure to anticipate and plan for climate variability and the prospect of extreme weather and related events in land development patterns and in natural resource management could have serious impacts far beyond what has already been experienced. The increasing intensity and frequency of climate events in the future will cause communities across the state to exist in emergency management response mode more frequently. In addition to the economic, human, and environmental impacts, operating in a state of emergency will result in hasty decisions with unintended negative consequences, greater costs, and poorer outcomes.

However, this need not and should not be our future. We can start now to change our planning management practices to significantly increase our ability to anticipate and better gauge the likelihood and extent of climate change effects. Until now we have relied on the assumption of a fairly static environment in which weather patterns and climate events are projected to happen with similar frequency and intensity as they have in the past. By recognizing the increasing variability in weather patterns, we can better protect ourselves from the risks posed by climate change today and in the future. This new approach represents a paradigm shift in resource management, planning, and development that must be integerated into decisions made throughout the state. It will require major changes in the way decisions are made today and a far greater appreciation and understanding of the risks the climate poses to our natural and built environments and the way we live. Starting today and continuing in the years and decades to come, we can adapt to these risks through hundreds, if not thousands, of resilient resource and land-use choices. In so doing, California will find itself far better equipped and more resilient to the inevitable adverse effects of a changing climate.

Pat Lavin
William Reilly
Mason Willrich

Figure 1. California Historical & Projected July Temperature Increase 1961-2099



Our Purpose

The Task Force on Adaptation to Climate Change was established in the spring of 2009 by the Pacific Council on International Policy (Pacific Council) to address the prospect of climate change for California. The goal is to develop a path forward in view of the growing knowledge of climate science[1] and in appreciation of the anticipated changes we are already seeing evidence of. Work has already begun among planners and policy makers in the state, not the least of which was the seminal work of the California Natural Resources Agency released last year, 2009 California Climate Adaptation Strategy.[2] The purpose of our work is to identify the most important next steps for California in preparing for climate change as seen from the perspective of a diverse set of stakeholders in the future of this state. It is not, for example, to recommend specific actions such as protecting a particular coastal resource from sea level rise through building a sea wall versus relocating the structure. Rather this effort aims to encourage that all major planning and development decisions throughout the State be made within a coherent, comprehensive framework to guide adaptation. The focus of the Task Force has been a strategic one: to ensure a science and analysis-based, collaboratively developed, and financially viable long-term approach to adaptation to guide decision-making at all levels.

To pursue this purpose, the Pacific Council convened a distinguished and diverse group of independent, experienced, and concerned Californians reflective of many of the interests across the state. Members represent a broad sweep of especially non-government perspectives, thus bringing important additional voices to the challenge of climate change adaptation (see list on pages 67-68).

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[1] National Research Council (2010a). America's Climate Choices: Advancing the Science of Climate Change. Washington, DC: National Academies Press.

National Research Council (2010b). America's Climate Choices: Adapting to the Impacts of Climate Change. Washington, DC: National Academies Press.

Intergovernmental Panel on Climate Change, "Fourth Assessment Report: Climate Change" (2007) (AR4), at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm#1

Thomas R. Karl et al., "Global Climate Change Impacts in the United States," A State of Knowledge Report from the U.S. Global Change Research Program, Cambridge University Press, 2009, at: http://www.global-change.gov/publications/reports/scientific-assessments/us-impacts

Climate Action Team, "Biannual Report to the Governor and State Legislature" (Draft, March 2009), and underlying research funded by the California Energy Commission's PIER Program, at: http://www.climatechange.ca.gov/publications/cat/index.html

"Indicators of Climate Change in California," compiled and edited by Linda Mazur and Carmen Milanes. California Protection Agency, Office of Environmental Health Hazard Assessment, April 2009, at: http://www.oehha.org/multimedia/epic/pdf/ClimateChangeIndicatorsApril2009.pdf

[2] California Natural Resources Agency, "2009 California Climate Adaptation Strategy," A Report to the Governor of the State of California in Response to Executive Order S-13-2008, at: http://www.climatechange.ca.gov/adaptation/index.html

Institute for Local Government, "California Climate Action Network: Best Practices Framework," http://www.ca-ilg.org/sites/ilgbackup.org/files/BestPracticesFramework_v5.0.pdf American Planning Association, "Policy Guide on Planning and Climate Change," adopted April 27, 2008, at: http://www.planning.org/policy/guides/pdf/climatechange.pdf

In view of the current economic conditions facing individuals, businesses, and the state today, it is reasonable to question the timeliness of this report. The reality is that the effects of climate change and the increased risks we face as a result of them are already being felt. We must better equip ourselves to deal with the current and growing variability of a changing climate by arming planners and decisions makers with the knowledge required to act in the face of uncertainty. It is precisely now when we are repositioning our economy, creating new jobs and green industries, and making choices about how best to invest in public infrastructure that the opportunity exists to think anew and incorporate the resiliency and adaptive actions that will be needed in the coming era.

Guiding Principles

During Task Force deliberations, a set of principles emerged as the foundation for climate adaptation decisions in California. These principles recognize the potential challenges presented by climate change and the need to address the issue with the best science available, in a comprehensive manner, and inclusive of the full range of stakeholders.

Guiding principles for all climate adaptation decisions

Science-based policy. Adaptation policies must be grounded on the best available scientific information on the effects of climate change and the risks they pose. The practice of assuming a static climate as the basis for decision making is no longer tenable. Because the science of climate change is evolving, as is the climate, policies will have to be revisited as more is learned.

Cost-effective actions. No regrets: Adaptation policies should encourage cost-effective actions that make sense in their own right and seek to minimize long-term costs and provide long-term benefits.

Aligned incentives. In recognition of the likely costs of adaptation to individuals, businesses both large and small, and communities, adaptation strategies should encourage timely actions and choices that foster resiliency and help overcome hurdles presented by financing, organizational, and other barriers.

Public engagement. Meaningful public engagement is needed at all levels – State, regional and local – and across all economic sectors. Engagement should be informed by climate science and embody cultural sensitivity in reaching out to communities most vulnerable to the effects of climate change. Especially important is the direct and sustained involvement of those who will have to bear the cost of adaptation measures – businesses of all sizes, property owners, and State taxpayers.

Coordination of planning and public decision making. Lead agencies are needed at every level of government to reconcile competing interests, forge compromises, expedite decisions on adaptation, and overcome barriers to action.

Our Approach

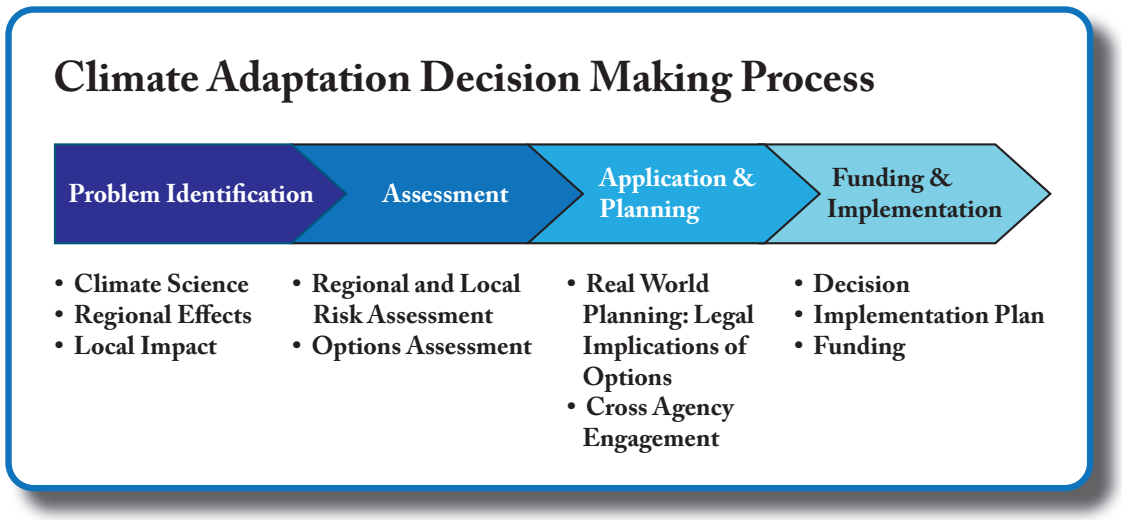
The Task Force sought to answer three critical questions: What are the key challenges triggered by accelerated climate change? What are the options for dealing with them? What are the gaps in planning and policy at the local, regional and state level for dealing with adaptation? To gain a perch on these questions, we focused on the most recognized threats from accelerated climate change facing the state:

1. Sea level rise
2. Water supply availability, changing patterns of rain and snowfall
3. Forest and rangeland fires

These were selected on the basis of the cumulative, multiple and tangible effects they will likely have, combined with the relative level of confidence of current climate science that they will indeed occur. By focusing on these three, we do not mean to imply that other impact areas are unimportant or worthy of careful attention. Indeed, rising temperatures may create various other effects including extreme heat, reduced air quality, loss of marine and forest biodiversity, and others. We expect that future policy reviews will focus on the impacts we have not had the capacity to include here.

The members of the Task Force, aided by scientists and experts, divided into teams to examine each threat. Recommendations were reached by working through illustrative case studies resembling the typical decision making process for major public planning or project approval. The exercise revealed capacity gaps and needs across all four of the stages of decision-making.

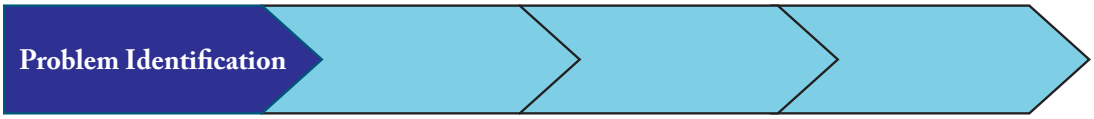
Figure 1:



Two tiers of recommendations resulted: 1) Those that span all three threats are listed as overall recommendations in the section that follows. 2) Those applicable in the specific threat areas (fire, water, and sea level rise) are listed in the subsequent sections.

Our Overall Recommendations

Recommendations for Immediate Action



Increase monitoring and data gathering on the uses of, and changes to, the state's natural resources and land-use patterns

More effective, comprehensive, and long-term data gathering in many areas such as resource usage, land use patterns, and changes in natural, managed, and human systems is required.

In order to anticipate and plan for the effects of climate change on both natural and human resources across the state, we need to improve our understanding of the current status and the pace of change. More effective, comprehensive, and long-term data gathering in many areas such as resource usage, land use patterns, and changes in natural, managed, and human systems is required. In addition, we need to invest in monitoring the impact of the actions we take. This information will enable managers to recognize emerging threats, learn from adaptive actions over time, and make necessary changes. With respect to the threats examined, the kinds of information to be collected and made available on a statewide basis are:

- Sea level rise and wave measurement, monitoring of saltwater intrusion in coastal acquifers, salinity changes in bays and estuaries, beach dynamics, coastal erosion rates, tetonic uplift rates, and changes in flooding patterns and wetland inundation, sedimentatin, and species;
- Precipitation rates and snow pack density and more comprehensive measurement of fresh water diversions and groundwater usage;
- Changes to forest ecosystems and vegetation management practices on public and private lands and urban expansion patterns at the forest/range land interface.

Such data gathering and monitoring is already underway in various areas and progress is being made in improving and expanding these activities. For example, the water legislation passed and signed in November 2009 which establishes a groundwater monitoring program for the first time and improves accounting for fresh water diversions.[3] The Task Force thinks the data gathering and monitoring in anticipation

[3] Senate Bill No. 6 Groundwater Monitoring and Senate Bill No. 8 Water Diversions and Use

of climate changes needs to be enhanced, however, and made available for adaptation planning and action by decision makers at all levels and sectors. The Task Force strongly endorses implementation of the recommendation of the Ocean and Coastal Resources section of the 2009 California Climate Adaptation Strategy calling for the collection of sea level rise and tidal data and the development of high-resolution topographic mapping of coastal areas. These should be collected bi-annually to facilitate monitoring of changing shoreline patterns.

The responsibility for overseeing data collection and monitoring should remain with existing regulatory and managing state agencies[4] such as the State Water Resources Control Board, state agencies involved in the Ocean Protection Council, the California Department of Forestry and Fire Protection, or relevant federal agencies.[5] However, a central repository for such information needs to be established. The state should explore funding sources such as federal grant programs and private foundations to assist with the research and monitoring needs. In addition, the strategy should identify protocols and funding mechanisms to assist local agencies in applying the data.

In addition, a single entity or working group needs to be responsible for specifying the range of climate sensitive resource uses to be monitored, the kinds of data to be collected on a statewide basis, and ensuring that the information is available in planning and development decision making at all levels of the state.[6]

Establish a Climate Risk Council (CRC) for California

A significant gap exists today in the ability of planners, developers, and decision makers to interpret and evaluate climate risk essential for effective adaptation planning.

There is need, therefore, for a credible, authoritative, and scientific professional entity to assess climate risks to the built and natural environments throughout the state. We recommend that this be accomplished through establishment of a Climate Risk Council (CRC). In brief, the CRC would be a small, scientific, guiding organization responsible for assessing the implications of climate science for California. In

[4] Some agencies regularly collecting and overseeing environmental and social trends are based at the state level, others at the federal level (National Aeronautics and Space Administration, the Census Bureau, Environmental Protection Agency, Bureau of Land Management, and so forth).

[5] Several federal agencies that regularly collect and oversee relevant environmental and social trends often at the state level include the Census Bureau, the Environmental Protection Agency, the Forest Service, and the Bureau of Land Management.

[6] The State Adaptation Strategy envisions this role for a sub-team of the State Climate Action Team Research Group. A report is expected this year that will identify the specific data gathering and analysis needs and recommend how to manage the process.

addition, it would be responsible for building capacity for climate risk assessment and decisions making at the regional and local levels throughout the state. The full range of CRC responsibilities is laid out in figure 2 below.

Figure 2:

Climate Risk Council Responsibilities

- ❑ **Compile, organize and assess** scientific information on accelerating climate change effects at the state and regional levels
- ❑ **Develop, periodically review and update risk-assessment protocols and guidelines:**
  - For conducting risk assessments at regional and local levels applicable in state infrastructure planning, and regional and local planning;
  - For risk characterization processes to be used by regional and local planners in adaptation planning;*
  - For evaluation of adaptation options, including cost-effectiveness, on all long-term projects
- ❑ **Conduct a public review process** under the Administrative Procedures Act in development of the protocols and guidelines
- ❑ **Advise public entities** responsible for carrying out long-term projects on how to incorporate risk assessment, risk characterization, and options assessments within their planning procedures and practices:
  - Advise State Office of the Insurance Commissioner to incorporate the best available risk characterization in the State's regulations pertinent to climate-sensitive insurance products;
  - Seek out the private insurance industry, builders and developers, public permitting officers, water and fire managers, and other relevant entities to develop risk-based approaches for climate change insurance, including incentives for property owners to make risk-reducing investments

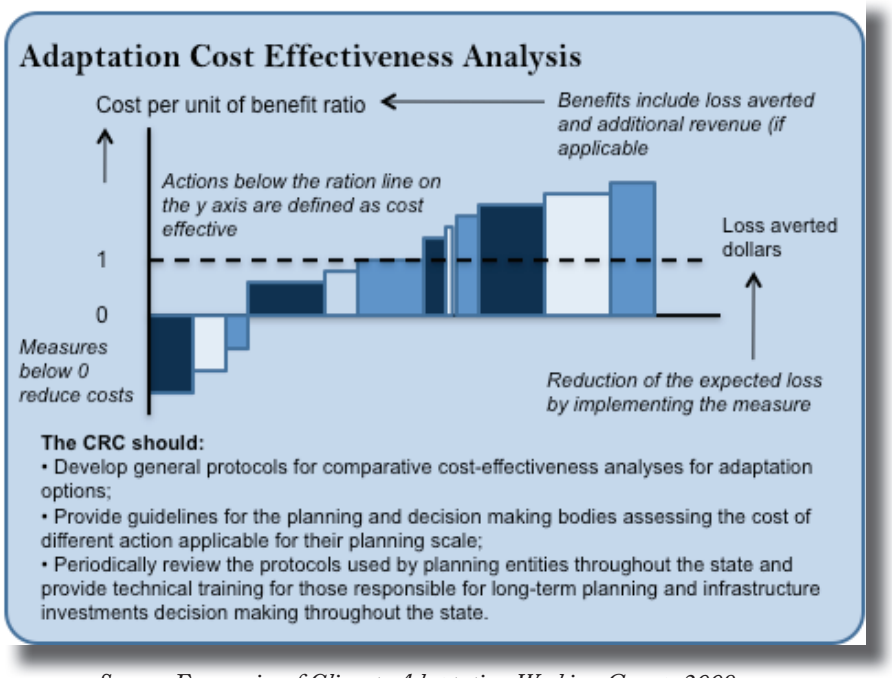
**Note: U.S. Environmental Protection Agency, "Risk Characterization Handbook," Principle Authors John R. Fowle III and Kerry L. Dearfield, Science Policy Council, U.S. Environmental Protection Agency, Washington, D.C. 20460. EPA 100-B-00-002, December 2000*

The CRC would draw on climate change and impacts research conducted and funded by other state agencies such as the California Energy Commission's Public Interest Energy Research Program (PIER).[7] These findings would be translated into periodically updated risk estimates relevant to specific locations and activities (major infrastructure development, climate risk insurance, and general planning guidance). It would develop protocols, guidelines, and tools for planners to facilitate assessment of climate risks and cost-effectiveness for all major infrastructure and long-term development projects under their jurisdiction. One necessary tool

[7] See Office of Environmental Health Hazard Assessment, Integrated Risk Assessment Branch, California Environmental Protection Agency, at: www.oehha.org.

for assessing adaptation strategies should be a cost-effectiveness assessment, as illustrated in Figure 3. Just as climate change science is evolving, so are the analytical techniques of risk and cost assessment. The CRC should be responsible, therefore, for incorporating more advanced and encompassing anaytical techniques as they prove useful in furthering its mission.

Figure 3:



Source: Economics of Climate Adaptation Working Group, 2009

The Council would be a relatively small State entity (with no more than five board members, with a designated chair), appointed by and reporting directly to the Governor.[8] To serve as knowledgable overseers of CRC activities, Council appointees will need to have experience with, and an appreciation of, climate change science, risk assessment, and economics. In addition to having the requisite technical proficiency, the Council will need to represent a breadth of stakeholders from across the private and public sector interests in the state. In view of the need to act now in anticipating the effects of climate change and setting the direction for cost-effective adaptation, the Task Force is recommending that it be established by the Governor. Once it proves its value and in order to meet the goal of infusing climate science and adaptation strategies into planning throughout the state, CRC will require endorsement and sustained support and authority from the state legislature.

The Council will require a professional staff and adequate funding. In particular, it will require an experienced and insightful executive director and a staff skilled in risk assessment, risk characterization processes, cost-effectiveness, and other

[8] Placement could be within , the Academy of Science and Technology of California or as a free-standing state Governor. supported entity, though neither would signal the high priority and importance of being within the office of the Governor.

relevant long-range anaytical techniques. They must be prepared to convey how this information can be applied to large scale development and infrastructure projects at the local, regional and state level. In launching the CRC, the professional staff should be drawn from the extent possible from within state agencies and departments (e.g., the Energy Commission, the Resources Agency, the Coastal Conservancy, and Cal-EPA).

Improve communication and coordination across sectors and levels of government for adaptation planning

The policies and practices for managing the built and natural environment in use today were developed at a time when it could be reasonably assumed that we were working with a stationary landscape and environment. In this more static world, managing the different resources and land uses was compartmentalized and spread across different agencies at various levels of government.[9]

Early experience suggests that adaptation planning outcomes are significantly improved with the creation of interagency/ interdepartmental working groups.

Dividing up the world this way has always been inhibitive, and is even less viable now. Preparing for the increasing variability and unknown effects of climate change will require a more comprehensive and collaborative approach to resource and land use management. Early experience suggests that adaptation planning outcomes are significantly improved with the creation of interagency and interdepartmental working groups. Groups that coordinate across jurisdictions are better able to avoid delays and identify cost-saving synergies.

The State should require comprehensive climate change impact assessment as a part of all long-term general planning and public and private sector development proposals. Such assessments should consider interactions of climate change impacts and responses across multiple sectors as well as interactions with other policy goals (e.g., urban development, provision of water, intermodal transportation, and greenhouse gas emissions reduction). Deliberation should include affected local, regional, and state jurisdictions in order to ensure alignment on planning targets and execution timelines. It is important that agencies and jurisdictions be required to align their respective long-range development plans, objectives, and decision making activities accordingly. The Task Force suggests that local and regional compliance with these requirements should be through a "carrots

[9] Recent research and a report from the National Academies of Sciences document how local managers often tend to await state or federal-level adaptation mandates, while higher-level authorities await local-level action. This sort of disconnect illustrates the need for designating relevant agencies to be given the lead while improving communication among all involved to identify priority action items and move forward

and sticks" approach, using funding and technical support mechanisms and, wherever possible, existing state-level authority.

The 2009 California Climate Adaptation Strategy (CAS) made significant progress toward integrated planning at the state agency level. The same must be required of regional and local adaptation planning throughout the state.[10]

One of the many possible ways to further integrate planning is to incorporate adaptation into the state's recently enacted vehicle-miles-traveled reduction strategy (SB 375). Adding adaptation to the already substantial responsibility of the metropolitan planning organizations (MPOs) responsible for implementing SB 375 will be challenging. Nonetheless, as major metropolitan infrastructure planning agencies that typically include participants from regional and local governments as well as a breadth of stakeholders from across agencies and interest groups throughout a region, the MPOs are well suited to address adaptation issues. This will need to be supported with adequate technical assistance, which could be accomplished by amending SB 375 to require that adaptation be a part of the Sustainable Communities Strategies scheduled to begin development in late 2010.

As major metropolitan infrastructure planning agencies that typically include participants from regional and local governments as well as a breadth of stakeholders from across agencies and interest groups throughout a region, MPOs are well suited to address adaptation issues.

Adaptation planning will require developing a better understanding of climate change among public decision makers (e.g., city council members and boards of supervisors) and agency staff (e.g., planners, environmental specialists, and engineers). They need training in interpreting climate science and risk assessment and in integrating this information into the planning process. While the Task Force recognizes the many time demands on decision makers and staff, focused professional development will enable better and more efficient climate-related decision making. To accomplish this on a broad scale, it will be necessary to identify best practices in developing the decision support that is central to risk characterization and cost-effectiveness analysis and to initiate a state supported education program aimed at planners and decision makers.

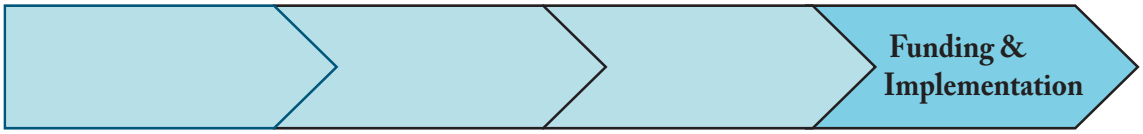
California's efforts in providing climate services should also dovetail with the National Climate Service (NCS) recently announced by the National Oceanics and Atmospheric Administration (NOAA) and still under development. To achieve

[10] The California Natural Resources Agency made great strides toward integrated planning at the agency level. Not only did the strategy development effort involve coordination with 12 state agencies, but the strategy calls for each agency to implement short term strategies immediately. It also calls for consideration of adaptation into the Strategic Growth Council and into the Sustainable Community Strategy. This is consistent with the CAS cross sector strategy #2 that gave rise to the recent amendment of California Environmental Quality Act section 15125.2.

cost-savings and avoid duplication of effort, the state should actively engage in discussions with the NOAA in shaping climate services to ensure that the NCS will meet the needs of California state, regional, and local decision makers.

Broad public recognition of climate change effects and the need to plan for them is essential if California is to be prepared. Moreover, while large scale adaptation projects will require public support, much adaptation will happen on a smaller scale in the decisions made by individual homeowners and business owners. The planners with responsibility for raising public awareness will need to better understand public attitudes and opinions and be well-informed in effective communications with the public. Outreach and stakeholder engagement on climate risks thus should be an integral part of the training of planners and government staff.

Important Issues for Further Study



Align incentives for proactive adaptive management and build funds to support large-scale projects

The upfront costs of adapting to climate change will not be trivial; yet to do nothing and rely on reacting after the fact to deal with the impacts would prove prohibitive. By virtue of the over $1 trillion in infrastructure that exists along the California coastline, expanses of agriculture, other development on the floodplain, and extensive residential development close to wildfire prone areas, much is at stake for California.

As already stated, some adaptation options can entail significant upfront cost. Though examining numerous financial mechanisms for funding adaptation is beyond the scope of the Task Force, we recommend that the state launch a feasibility study to explore mechanisms to fund adaptation and encourage resilient actions. Two among the many such mechanisms merit detailed study: one focused on funding for large-scale community or regional adaptation projects, the other focused on individual property insurance.

Explore ways to build local or regional climate adaptation funds

Many appropriate and long-term cost-effective adaptation actions will be beyond the financial capacity of individual homeowners, businesses, or even communities to execute. Protection and relocation of areas potentially threatened by impacts and the potential for economies of scale, will likely warrant taking actions on broad community or region-wide basis. Currently, the funds for such large-scale projects as protection measures, redevelopment, relocation, habitat migration, and restoration efforts, are not available. Although these funds may not be needed immediately, decisions about how funding for such projects will be secured, must be addressed in the near term.

Various options need to be assessed, including the feasibility of integrating funding requirements into long-term regional and local plans or creating funds for community-wide or regional-scale adaptative actions similar to redeveloptment funds.

We thus recommend that a study be initiated that examines options for funding large-scale adaption projects. Various options need to be assessed, including the feasibility of integrating funding requirements into long-term regional and local plans or the creation of a fund for community-wide or regional-scale adaptation strategies similar, for example, to redevelopment funds. Consideration should be given to community level funds secured by property taxation (voter approved) that, if established, could be leveraged in the capital markets for long-term adaptation infrastructure relocation and new development funding. Regardless of the level at which funding is developed – local, regional or state – planners and decision makers are going to have to select which projects are funded and which are not. The funding feasibility study should also consider the range of criteria that could be used to identify eligible projects. The study should be conducted by a task force assembled by the Strategic Growth Council and should complete its work within a year to enable progress on this important issue in the near future.

Study risk and cost sharing by homeowners and businesses

We recommend that a feasibility study be undertaken that examines approaches to long-term, mandatory homeowner adaptation-based flood insurance in coastal areas and in floodplains, as well as fire insurance in wild fire-prone areas. This study should be launched under the direction of the State Insurance Commissioner and in cooperation with the National Flood Insurance Program, the Association of State Floodplain Managers, the California State Lands Commission, as well as private sector insurers, to account for the very different insurance landscapes for flood and fire risks. The basic idea is that the price of the insurance should reflect the true risk to the built environment posed by climate change. To the extent that steps are taken to mitigate that risk (e.g., through improved construction standards) and the property is made more resilient, the cost of insurance would decline. Mechanisms

must be developed to reassess periodically the changing flood and fire risks in different regions as the climate changes. Special consideration must be given to accommodating low-income communities if the reformed insurance program is mandatory. Several proposals for climate change risk insurance are being considered at the national level (see also the Sea Level Rise section of this report). These initiatives may provide important starting points for the state-focused study.

Further study of the other important threats posed by climate change

Our work focused on three important threats posed by climate change. As stated earlier, this is not to imply that there are not other threats that are equally important or potentially harmful. An examination similar to ours should be undertaken that is focused on these additonal threats. For example, each threat posed by climate change has implications for public health. An assessment focused on public health impacts of climate change is equally needed. How to address these and like threats through prevention, preparation, and effective adaptation are important questions left to a future project.

Summary of Overall Recommendations

The Task Force recommends that the most important steps to be taken in the near term to set California on the best path for the future, include:

- First, as a basis for adaptation planning, the state needs to maintain, enhance, and expand the data gathering and monitoring responsibilities of the relevant government and research entities on the actual uses of, and changes to, the natural and physical resources most likely to be affected by climate change.

- Second, based on the information gathered, to develop the risk assessments that communities need as a starting point in considering alternative actions and in making informed choices. These choices will help communities along the coast gradually adjust to the rising level of the sea, help resource managers and people living at the wildland-urban interface better manage the forests to reduce the threat of fire, and help California to better manage one of the state's most precious natural resources, our water.

- Third, adaptation planning requires reaching across and beyond traditional agency and jurisdictional boundaries. The State must connect sectors and levels of government in order to proceed. These new relationships must be built on a foundation of information sharing, communications, and more comprehensive thinking and adaptative planning.

- The State needs to develop viable plans for funding the actions that will need to be taken to proactively manage the effects of climate change. Climate change insurance options and the creation of climate adaptation funds should be priority topics for further study.

- Finally, multi-stakeholder assessments must be undertaken for the important threats not covered by this report, namely, natural resources management and public health.

Specific Threats: Reports and Recommendations

Sea Level Rise

Focus

The Task Force focused primarily on coastal areas along California's open ocean, bay, and estuarine shorelines and associated hazards such as coastal flooding, coastal erosion, permanent inundation, and related land losses. Direct impacts from these processes typically have indirect effects on adjacent areas and even on distant communities and economic activities. We focus our recommendations on those areas most directly affected because if we minimize threats to those areas, impacts on others will also be reduced. Importantly, sea level rise and associated hazards are already occurring along the California coast; the potential of accelerated sea level rise could make them more widespread and severe in the future. The adaptation responses required to deal with sea level rise thus need to address near-term (immediate), mid-term (within the next 10-30 years) and long-term (~50 years and beyond) risks and changes.

The report does not include recommendations for specific adaptation strategies that address threats from sea level rise to coastal groundwater resources, as water supply and quality issues fall under the purview of the water team. This report also does not recommend specific adaptation strategies for climate change and sea level rise related threats to public health, marine life and resources, conservation of particular coastal species, or infrastructure (transportation, energy, and communication).

The California Coast

California's coast is at once one of the state's most desirable locations to live, work, and conduct business and one of its most attractive and resource-rich assets. More than three quarters of all Californians live in coastal counties. In 2007, total employment in counties bordering the ocean shore represented more than 65% of the state's total employment, generating more than 66% of the states wages and about 69% of California's Gross State Product. Population and economic activity in coastal areas continues to grow.[11] While specific projections for growth in coastal counties of California remain uncertain, the California Department of Finance population projections to 2050 assume growth similar to patterns observed over the state's recent history; the state's coastal areas thus can be expected to become even more populated and retain a dominant role in the state's economy.[12]

[11] J.T. Kildow, C.S. Colgan, and J. Scorse (2009), State of the U.S. Ocean and Coastal Economies 2009. The National Ocean Economics Program (NOEP), http://www.oceaneconomics.org.

[12] A. Sanstad, et al. (2009), Long-Run Socioeconomic and Demographic Scenarios for California. PIER Research Report, CEC-500-2009-013-F, California Energy Commission, PIER Program, Sacramento, CA.

Coastal areas are also among the most vulnerable locations to the dynamic forces of nature – coastal flooding, cliff and beach erosion, and damaging storms. In the past – against a backdrop of slow, gradual sea level rise – such extreme events have been relatively rare. That infrequency, together with the relatively lax development, insurance, and hazard disclosure policies, has permitted us largely to discount the risks we face when living in vulnerable areas. This combination of factors has fostered development of the shoreline with only minimal mitigation of the hazards, environmental impacts, and social justice implications.

Figures 3 and 4: Humboldt Bay and Eureka in northern California (left) and Mission Beach, San Diego (right) illustrate some of the diverse settings of California's coast – bays, inlets, beaches, cliffs and more - makes California's coast at once one of the state's most desirable and resource-rich locations. It is also among the most vulnerable to the dynamic forces of nature.

Photos: Robert Campbell, U.S. Army Corps of Engineers Digital Visual Library (left); "Vlastula", Wikimedia Commons (right)

Sea level rise has accelerated over the past 20 years a trend that in the coming years is expected to increase as a result of melting ice caps and glaciers and expanding water volume (thermal expansion), with potentially serious consequences for natural and human communities.[13] Recently, the state tentatively adopted a 55 inch sea level rise planning figure (estimated increase in average sea level above 2000 levels by 2100) proposed for use in siting decisions for new and upgraded critical infrastructure. Even greater increases may be possible. Examples of critical infrastructure improvements that will be impacted by sea level rise include strategic new levee improvements to protect the Delta and the state's water system, upgrades to port facilities, maintenance or relocation of coastal roads and bridges, and protection of major airports.

[13] D.R. Cayan, P.D. Bromirski, K. Hayhoe, M. Tyree., M.D. Dettinger, R.E. Flick (2007), "Climate change projections of sea level extremes along the California coast," Climatic Change 87(Sppl.1): S57-S73.

D.R. Cayan et al., Climate Change Scenarios and Sea Level Rise Estimates for the California (2009), Climate Change Scenarios Assessment. PIER Research Report, CEC-500-2009-014-F, California Energy Commission, PIER Program, Sacramento, CA.

Sea level rise (Figure 5), in combination with extreme events could result in more extensive damage. Hundreds of miles of valuable shoreline and habitat, millions of Californians, and trillions of dollars in assets and economic activity are potentially at risk.[14]

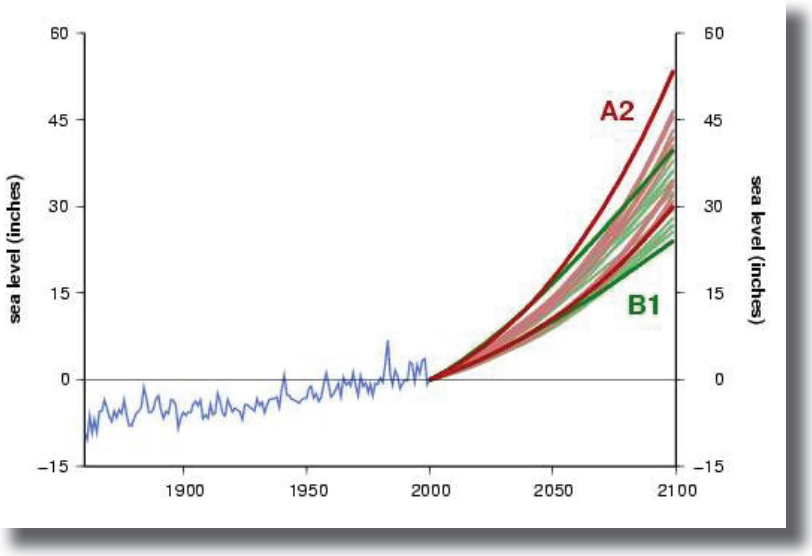


Figure 5: Historical and Projected Sea level Rise for California. Historical sea level rise observations (for San Francisco, shown in blue), relative to 1990, and future sea level rise projections using a lower (green, "B1") and higher (red, "A2") emissions scenario. Source: D. Cayan, United States Geological Survey

Current Coastal Management

Until now, Californians have primarily chosen to protect the shoreline against flooding and erosion through hard protection measures such as seawalls and soft protection measures such as beach sand replenishment. Along receding shorelines, hard protection measures typically have led to a loss of the beaches in front of them at the expense of public recreation and ecosystem values. Soft protection measures have often proven very costly while providing only temporary reprieve. Especially when faced with immediate threats, local governments have felt enormous pressure from affected homeowners and business to adopt expedited hard protection measures. In other instances, coastal residents and communities have chosen hazard mitigation measures that allowed them to continue to build in high-risk areas but reduce their risk from flooding, erosion, and storm-related loss. Typical measures have included land use planning, building codes, emergency management, and the provision of federal flood insurance. Long-term resilience for beaches and ecosystems can be enhanced through improved sediment supplies and upland connectivity of ecosystems.

[14] In 2000, 77% of California's population lived in coastal counties, amounting to over 26 million people (see: J. Kildow. and C. S. Colgan (2005), California's Ocean Economy. NOEP).

Finally, moving back from the shoreline has occurred only on an ad hoc basis in the past. Occasionally, individual homeowners decided to move back when threatened by erosion, cliff failure, or flooding, or decided not to rebuild on site after being damaged in a storm. To date there is no statewide policy for retreating from threatened coastal lands, and no concerted regional efforts have been undertaken to implement planned retreat. However the Coastal Commission now requires developers to sign seawall waivers (i.e., home owners cannot expect to protect their property with hard protection measures at a later time) as a condition of approval for projects located on eroding coastal bluffs.[15] On a local or project scale, however, there have been some successful managed retreat initiatives such as the Pacifica State Beach managed realignment project and the Surfers Point project at Ventura Beach (expected implementation in fall 2010) are two of them,[16, 17] and Monterey (1970s), where retreat has improved recreation and habitat while reducing long-term costs.

Public discussions of retreat have generally been highly contentious. Retreat can be extremely costly when implemented on an emergency basis. However, forward-thinking, large-scale managed retreat policies promise long term cost savings compared to potential losses, as a result of sea level rise. California can learn from the experiences of other coastal states in moving toward such planned retreat policies. For example, the Texas Open Beaches Act (OBA) and South Carolina's Beachfront Management Act employ different mechanisms that result in *de facto* planned retreat. Care must be taken in designing such policies to avoid loopholes and protect constitutional rights of property owners while asserting the public trust doctrine.[18, 19, 20]

[15] G. Griggs, K. Patsch, and L. Savoy (2005), Living with the Changing California Coast. University of California Press, Berkeley; see also: L. Ewing, and D. Sherman (eds., 1998). California's Coastal Natural Hazards. University of Southern California Sea Grant Program, USCSG-TR-01-98, USC, Los Angeles.

[16] Philip Williams & Assocs., Pacifica State Beach Managed Retreat, Beach and Estuary Restoration, available at http://www.pwa-ltd.com/projects/pr_cstl_Pacifica.html.

[17] Philip Williams & Assocs., Surfers Point, available at http://www.pwa-ltd.com/projects/pr_cstl_SurfersPnt.html. Both cases are further described at: NOAA, Managed Retreat Strategies, Case Studies: http://coastalmanagement.noaa.gov/initiatives/shoreline_ppr_retreat.html (last accessed June 7, 2010).

[18] TEX. NAT. RES. CODE § 61.001 (2010). The OBA defines public beach in terms of the vegetation line, creating a de facto rolling easement by preserving beach land seaward of the vegetation line for public access. As implemented by the TX General Land Office, OBA thus limits what structures can be built near to, and seaward of, the vegetation line. The effectiveness of the law thus hinges on the definition of the vegetation line.

[19] 48 S.C. CODE ANN. §§ 48-39-250 et seq. (2010). The Act creates a special permit, which is a hybrid between a setback and a rolling easement. The easement rolls only up to the setback line. Thus the permittee may build seaward of the setback line as long as he/she agrees to remove the structure should the beach erode "to the extent the permitted structure becomes situated on the active beach." The effectiveness of the law thus hinges on the establishment of the setback line.

[20] Memorandum from Will Travis and Tim Eichenberg, BCDC to BCDC Commissioners, "Using the Public Trust Doctrine to Adapt to Climate Change in San Francisco Bay" (Feb. 27, 2009), available at: http://www.bcdc.ca.gov/meetings/commission/2009/03-05_Public_Trust_Climate.pdf

M. Caldwell, C.H.Segall (2007), "No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access Along the California Coast," Ecology Law Quarterly 34, 533-578.

Case Study: Oakland International Airport

When Charles Kingsford Smith took off from the Oakland airfield for his historic U.S. – Australia flight in 1928 – just one year after airport construction had begun – no one could know that some eighty years later the Oakland International Airport would become the fourth largest in the state and one of the top hubs in the country. More than eleven million passengers came through Oakland in 2008, flying with ten commercial airlines on more than 140 flights daily.[1],[2],[3]

Owned and operated by the Port of Oakland, – an independent department of the City of Oakland – the airport until recently was one of the fastest growing airports in the US. A $300 million expansion and renovation project was completed in spring 2008, but high fuel costs and service cancellations due to the larger economic decline stymied plans to build a third terminal. In March 2010, the environmentally friendly improvements of Terminal 2 earned the US Green Building Council's Leadership in Energy & Environmental Design (LEED) Silver Certification.[4]

More recently, Port authorities have expanded their plans for renovations in the face of a new threat: sea level rise that could severely affect airport operations. The 2600 acres on which the airport sits have a maximum elevation of nine feet above Mean Sea Level (MSL). Its North Field, with three runways for general aviation operations, is currently not protected by dikes. During high tides and winter storms, those areas already experience significant flooding.[5] By contrast, the South Field, with one runway for commercial and cargo operations, is currently protected by a dike, which was first built in the late 1950s and which has served as the airport's primary flood protection system. That dike now requires repairs and upgrading to continue to serve that protective function. While storm and seismic events alone concern authorities, the prospects of an accelerating rise of the sea level add considerable concerns, especially for those areas only a few feet above MSL. Recent studies illustrate the extent of the potential impact of a flooding event with a four to five feet of sea level rise (see Figures).[6],[7]

While the Port has already requested $32 million in federal funds from the Water Resource Development Act 2010 for an Airport Perimeter Dike Improvement Project[8] – a long overdue investment in this regionally critical infrastructure – authorities are faced with the challenge of deciding how much sea level rise to plan for. While a 2008 internal Runway Safety Area Study assumed only four to five inches of sea level rise by 2050[9],

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[1] http://www.oaklandairport.com/airport_stats_yearend_stats.shtml

[2] http://www.oaklandairport.com/airport_stats_facilities.shtml

[3] http://www.flyoakland.com/press_releases_detail.aspx?ID=580&t=p

[4] http://www.flyoakland.com/press_releases_detail.aspx?ID=581&t=p

[5] Kristi McKenney, Aviation Planning and Development Manager for the Port of Oakland, communication to the PCIP Adaptation Task Force's Sea Level Rise Subteam, December 18, 2009

[6] E. Mazria and K. Kershner. (2007), Nation Under Siege: Sea Level Rise at Our Doorstep. A Coastal Impact Study Prepared by The 2030 Research Center. Santa Fe, New Mexico: 2030, Inc. / Architecture 2030. Available at: http://www.architecture2030.org/current_situation/cutting_edge.html

[7] Matthew Heberger, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore (2009), The Impacts of Sea Level Rise on the California Coast. PIER Research Report, CEC-500-2009-024-D, Sacramento, CA: California Energy Commission. Available at: http://www.pacinst.org/reports/sea_level_rise/report.pdf.

[8] http://www.stark.house.gov/index.php?option=com_content&view=article&id=1515%3Awater-resources-development-act-2010&catid=63&Itemid=104.

[9] URS Corporation, AGS Inc., and M. Lee Corporation (2008), Oakland International Airport Runway Safety Area Study, Phase 2: Revised Draft Conceptual Design and Implementation Strategy Report. Oakland, CA: URS Corporation.

the state currently suggests using a figure four times that (sixteen inches by 2050). This would have serious implications for the height and design of the perimeter dike, but would also raise questions of whether to reassign use of, and retreat from, certain areas, letting them revert to wetlands, or whether to defend existing uses. Financial restrictions and particularly governance hurdles at the state and federal level may restrict how creative airport authorities can be in finding the more economically sensible and environmentally appropriate solutions.[10]

Figure: Sea Level Rise of 1.25 m (~4 ft) [top] or 1.4 m (5 ft) [bottom right] Affecting Oakland International Airport [bottom left]

Sources counterclockwise from top: Architecture 2030, Note 6; Wikimedia Commons; Pacific Institute, Note 7.

[10] Kristi McKenney, Aviation Planning and Development Manager for the Port of Oakland, communication to the PCIP Adaptation Task Force's Sea level Rise Subteam, December 18, 2009.

Figure 6: Coastal cliff erosion threatens this apartment building along Pacific's open ocean coast. Source: Michael Macor, San Francisco Chronicle (Picture ID: ba-pacifica18_25_050097089

Overall Recommendations Specific to Sea Level Rise

To ensure continued safe, prosperous, and sustainable occupancy of the California coast, California must improve in three critical areas that are inadequately dealt with at present: (1) accept and develop a better understanding of the risks from long-term sea level rise and extreme events, (2) provide the incentives to individuals and developers to adapt to ever growing risks, and (3) improve the extent of collaboration and sense of common stewardship among individuals, businesses, communities, regions, and state agencies in order to realign how we coexist with a dynamic coastal environment.

To achieve these goals, important strengthening of existing coastal management approaches (such as setbacks) as well as innovative programs and approaches (such as rolling easements) are required. Sediment supplies and management will have to be improved. While additional scientific research and public input is required to arrive at a fully informed and widely accepted agreement for prioritizing adaptation actions, we believe that adaptation planning and implementation can and should begin without delay, with immediate actions implemented within the next one to five years. Even in economically challenging times, much can and must be done without significantly more resources. At the same time, we believe long-term adaptation cannot occur effectively without adequate resources and staffing. Thus, our immediate recommendations aim at doing the best with what we have, while investing in the technical, human, and financial capacity we ultimately need.




Recommendations for Immediate Action

1. Establish a consistent, statewide coastal hazards information database

California's existing knowledge of coastal hazards is inconsistent and inadequate for supporting coastal management. We thus recommend that concerted investment in research be made that establishes a current baseline, improves monitoring and prediction, as well as our understanding of the impacts of coastal hazards. Such information must be made available as an easily accessible, understandable, and locally usable tool for the public and decision makers. Specific examples of how to improve the database on coastal hazards include: improved geographic coverage of coastal erosion measurement of cliffs and bluffs, location-specific flood risk assessments using different sea level rise scenarios, and so forth.

Improving our understanding of coastal hazards should build on existing studies and understanding of coastal processes, as well as ongoing data collection activities (e.g., Light Detection And Ranging-LIDAR-, wave buoys). The information should be compiled into an easily accessible (digital) coastal hazards atlas for use by planners, permitting officers, resource managers, and others. It should be considered together with FEMA's flood maps to provide a robust planning tool that includes climate change and erosion hazards.

2. Educate and train coastal planners, managers and decision makers

Government staff currently in planning, advisory, and decision making positions vary in their level of understanding of climate change science, potential impacts, on-the-ground vulnerabilities, and the techniques and tools of adaptation planning.[21] Moreover, many experts, consultants, managers, and policymakers are trained relatively narrowly in particular fields, without fully understanding or considering related concerns outside their immediate sphere of responsibility. Such traditional professional training and sector divisions in governance can hinder effective solutions for issues like sea level rise that require the coordinated perspectives and input of professionals from multiple fields. Frequently, the lack of relevant know-how poses a formidable barrier to effective adaptation planning and implementation. Ultimately, changes in university curricula for planners and coastal resource managers are required to change this situation more fundamentally.

We recommend that coastal planners, managers, and affected decision makers at the state, regional, and local levels, including the consultants and experts decision makers commonly draw upon, have focused professional development, i.e., education and training opportunities to build the necessary capacity for effective adaptation. The

[21] Varying understanding and related information and training needs are reflected in continually high attendance at various adaptation training seminars offered to California coastal managers in southern and northern California, and documented in studies of California coastal managers, for example: J. Tribbia and S.C. Moser (2008), 'More than information: What coastal managers need to plan for climate change', Environmental Science & Policy 11, 315-328.

state and federal government must help build the necessary technical capacity among responsible staff at all levels of government through expansion of existing adaptation training on a continuing basis. A skills inventory needed for effective adaptation planning and implementation should be developed to help identify knowledge gaps and guide the development of training programs. Professional development credits should be given to staff and attendance of these trainings rewarded.

General Task Force Recommendations Applied to Sea Level Rise

Problem Identification: Improve monitoring

The existing tools and instruments for monitoring of the coastal and marine environment are limited, require ongoing maintenance, and in some instances upgrading and expansion. For example, LIDAR should be flown more frequently and cover the entire coast to better track coastal changes. The state is also in need of a higher-density network of tide gauge stations to track local variation in sea level rise.[22] In addition, adaptation strategies must be monitored for their effectiveness over time to give feedback to decision makers and to provide early warning if the measures taken need to be changed in light of continuously changing conditions. Wetland restoration must be conducted over many years to assess success. In some cases, monitoring must be a long term activity.

Monitoring is essential for an iterative or adaptive management approach, but funds are lacking to support it. Project-related funding is often limited to just a few years and interest among state and federal funders to commit to long-term monitoring, is limited.

Monitoring is essential for an iterative or adaptive management approach, but funds are lacking to support it. Project-related funding is often limited to just a few years and interest among state and federal funders to commit to long-term monitoring, is limited. For example, state bond funding can fund projects (such as wetland restoration, see Figure 7) or structures but cannot be used for long-term monitoring of the impacts and effectiveness of those projects. We thus recommend that mechanisms for long-term financing of monitoring of the environment and of implemented adaptation options be developed to enable local, regional, and state coastal managers to better manage coastal risks and to track the effectiveness of adaptation. This implies changing existing funding rules to enable long-term continuous support, as well as changing attitudes and policies to reflect recognition of the value and importance of these investments.

[22] Currently, California has only twelve tide gauge stations along the entire open coast that track sea level rise, on average 90 miles apart. For example, there is a tide gauge station in Monterey and one in San Francisco but none in between (Griggs, personal. communication to Task Force, May 2010).

Figure 7: Wetland restoration near the former Hamilton Air Force Base in Novato, California. Long-term monitoring is required to track and assess the success of restoration efforts and change adaptation measures as required. Photo: US Army Corps of Engineers

Assessment: Risk assessment and early disclosure

Since 1998, California has had a risk disclosure law for traditionally recognized hazards (e.g., floods, earthquakes, and fire). It has had a small but demonstrable effect on home prices in floodplains compared to those in non-floodplain areas, although it is unclear whether it has actually discouraged development in flood zones.[23] However, the effectiveness of risk disclosure on discouraging development in high-risk areas strongly depends on the timing of when developers and potential property buyers are informed of those risks. If disclosure comes late in the process, interest and investment is too far along to take environmental risks into account reasonably. A better approach should be taken in coastal development with those wishing to develop or purchase a home or business in areas potentially affected by sea level rise, erosion, and flooding.

We thus recommend that the state legislature strengthen the risk disclosure requirement by requiring it to occur earlier in coastal development and permitting processes. As sea level rise scenarios used for planning and decision making across the state are affirmed,[24] flood risks should be assessed and disclosed for current and

[23] A, Troy and J. Romm (2006), "An Assessment of the 1998 California Natural Hazard Disclosure Law (AB 1195)," California Policy Research Center, Berkeley, CA. Available at: http://www.uvm.edu/~atroy/cprctroy.pdf. For discussion of the importance of adequately functioning insurance markets, see the recommendation on risk and cost sharing below.

[24] Pursuant to Governor A. Schwarzenegger's Executive Order S-13-2008, the state has requested an assessment of defensible sea level rise projections for the West Coast from the National Research Council. This study is underway at the time of this writing.

adjacent future floodplains. The necessary risk information should be developed through the periodic coastal vulnerability assessments and related research, and/or certified by the risk assessments conducted for the State through the proposed Climate Risk Council. Integration of this information on FEMA flood risk maps, would provide an additional mechanism to ensure its visibility. Such risk information would need to be provided early in the process of buying or developing coastal properties. The risk disclosure will function most effectively if closely integrated with the individual insurance and hazard mitigation approaches suggested above.

Application and Planning: Multi-level and cross-sector communication and coordination for adaptation planning and stakeholder engagement

Require use of coastal vulnerability information in all long-term planning

The Climate Adaptation Strategy (CAS) released by the CNRA in 2009 recommends that California conduct periodic coastal vulnerability assessments to monitor and assess the risks arising from climate change and sea level rise. This information will only make a difference to coastal planning and decision making if it is actually used. However, use of this information is currently not mandated. Moreover, sea level rise projections alone will be insufficient to meet the information needs of coastal manager.

In keeping with the general recommendation for the CRC, we recommend that the information produced through the periodic statewide coastal vulnerability assessments becomes a required component of local, regional, and state planning efforts. The Local Coastal Program (LCP) process overseen by the Coastal Commission is one existing planning framework into which such climate risk and coastal vulnerability assessments could be integrated. At present, however, the California Coastal Act does not give the Coastal Commission the authority to require jurisdictions of the LCPs which have already been certified to revisit their plans in light of new climate risks. In June 2007, the California Ocean Protection Council passed a resolution encouraging Local Coastal Plan (LCP) amendments to address sea level rise, yet few local governments have even begun the process of considering such LCP amendments.[25] A more effective approach would be to authorize the Commission to require such inclusion in the future. Since LCP amendments are time-consuming and costly, such a requirement should be implemented over the course of regularly scheduled updates rather than on an arbitrary schedule.

The first of these periodic coastal vulnerability assessments is expected within five years of the release of the CAS. The assessments should consider high and low sea level rise projections using the best available science (e.g., IPCC projections, studies from the National Academy of Sciences, and other relevant scientific research).

[25] OPC, "Resolution of the California Ocean Protection Council on Climate Change," June 14, 2007, available at: http://www.opc.ca.gov/2007/06/resolution-of-the-california-ocean-protection-council-on-climate-change/.

Uncertainties in the science should be explained and assessed to the extent possible. These global projections should be downscaled to the coast of California, taking into consideration local tectonic land movements and other factors.

Regional projections should be provided for different planning horizons (e.g., thirty, fifty, and one hundred years). To be relevant to decision making, a supporting scientific effort is needed that translates sea level rise data into decision-relevant metrics such as coastal erosion rates, extent, frequency and change in elevation of flood events, groundwater salinity changes, wetland inundation risks, etc.(Figure 8). The state should encourage and fund such research and help link it effectively to decision makers[26]. Decisions with long-term implications in particular must be evaluated in light of the relevant long-term coastal change projections. Even before such improved sea level rise projections and the coastal vulnerability assessments are available; we support the general recommendation included in the CAS to pursue a "hazards avoidance" policy in all near- and long-term coastal land use decisions.

Figure 8: February 23, 2008, near high tide at Twin Lakes State Beach, Santa Cruz, CA. While many impacts of climate change and sea level rise will pose serious threats only in future years and decades, some coastal areas are already affected by the impacts of rising sea levels now. Planners and engineers thus require response options at varying planning horizons, where the actions taken today address immediate needs while not causing additional problems in the future or limiting future adaptation options. Photo by David Revell used with permission.

[26] S. Moser (2008), Building California's Climate-Related Decision Support Capacity and Fostering Social Science

[27] See, for example, P.C. Milly, D., J. Betancourt, M. Falkenmark, R. M. Hirsch, Z. W. Kundzewicz, D. P. Lettenmaier, and R. J. Stouffer (2008), "Stationarity Is Dead: Whither Water Management?" Science 319 (5863):573-574.

Plan for a changing coastal environment

Coastal management has long assumed a relatively stable sea level and coastal environment.[27] Flood risk maps have been updated far too slowly and infrequently to reflect changes in development and floodplains. They also don't include evaluations of the eroding shoreline. Future flood risk maps should include erosion, and FEMA should provide scenario tools to assess flood risks in light of different sea level rise projections. Similar to how coastal planners have come to incorporate projections of population growth and economic changes into coastal community planning, they now must also assume that the coastline in most places will be receding, beaches landscapes shifting, and species and wetlands trying to move inland as the ocean rises. Additionally, decision makers are likely to require a suite of near, medium and long term options to adapt to climate change. This will also require improvements to multi-scale socio-economic valuations to support decision making. In many instances, existing rules and regulations prevent or unduly delay implementation of the most appropriate response options.

We thus recommend that the Ocean Protection Council identify - together with the relevant stakeholders - priorities for modifying relevant rules, codes, standards, and procedures to account for changing sea level and associated coastal risks.

We thus recommend that the Ocean Protection Council identify - together with the relevant stakeholders - priorities for modifying relevant rules, codes, standards, and procedures to account for changing sea level and associated coastal risks. A review is needed to identify where institutional obstacles exist that hinder adaptation strategies to address near-term and long-term risks. Innovative technical designs for construction should also be encouraged. The result should be used to reform – in a cost-efficient and timely manner – coastal laws, rules, procedures, and design standards underlying planning and decision making. California should draw on the experience of other coastal states in similar efforts to reform coastal law, use the public trust doctrine to its full extent, improve hazard preparedness and mitigation, and protect coastal ecosystems.

Establish mechanisms of better communication, cooperation, and collaboration

Some early experiences with adaptation planning suggest that creating interagency and inter-departmental working groups improves adaptation efforts by helping to avoid delays, creating cost-saving synergies, overcoming institutional obstacles, producing more feasible and politically acceptable adaptation options, and avoiding unintended negative consequences of informed decisions.

We thus recommend that governments and private sector entities establish or improve mechanisms of communication, cooperation, and collaboration to facilitate adaptation planning across sectors and levels of governance. Planning and decision making entities should establish who the lead agency is, and jointly identify needed and relevant opportunities for exchange, information sharing, and coordination.

In many instances, lack of communication and coordination is already a problem; adaptation planning offers an opportunity to improve procedures more generally. (This recommendation reflects the State's Coastal Sector Strategies 1D and 3A.)

Outreach, education and meaningful engagement of the public

While most Californians have heard about climate change and understand at least in principle the need for greenhouse gas emissions reduction,[28] very little is known about how Californians think about climate change impacts, vulnerabilities, and adaptation. Much like other populations in the state, coastal residents are not well informed and equipped to engage constructively in adaptation decisions.

We recommend that the state and other funders support research and then develop, test, adjust, and launch a scientifically informed outreach campaign to coastal residents and businesses about climate change impacts on the coast and adaptation options. Research should be undertaken (and periodically updated) to assess the public's changing understanding and attitudes about coastal impacts and adaptation. This information should inform, together with the best social and behavioral science available, how best to educate and meaningfully engage the public on adaptation planning and policymaking. (This recommendation is consistent with the State's Coastal Sector Strategy 4A.)

Important Issues for Further Study

Funding: Explore ways to fund adaptation

As stated above, some adaptation options can entail significant upfront cost (e.g., alternative designs or relocation of infrastructure, structural protection measures, retreat, or land acquisition). Means and ways must thus be identified for governments and individuals to take preventative measures to adapt in a timely fashion to avoid unnecessary costs and reduce the negative impact of climate change. Because a thorough examination of financial mechanisms is beyond the scope of

[28] Public opinion surveys for the American public and for Californians in particular document general concerns about global warming, at least superficial understanding of the problem, its causes and some salient impacts, and generic support for taking action. Specific and deeper understanding remains limited.

See, for example, A. Leiserowitz, E. Maibach, C. and Roser-Renouf (January 2010), "Global Warming's Six Americas," Yale University, Yale Project on Climate Change and George Mason University, Center for Climate Change Communication, New Haven, CT and Fairfax, VA.

For California, for example, Next10 and the Field Research Corporation (2007), California Opinion Index: Global Warming. Palo Alto and San Francsico, CA.

The attitudes and understanding of California coastal managers more specifically has been documented in S.C. Moser. and J. Tribbia (2006/2007), "Vulnerability to inundation and climate change impacts in California: Coastal managers' attitudes and perceptions," Marine Technology Society Journal 40, 35-44.

the report, we recommend two such financial mechanisms for further study in the coastal region: one focused on individual property insurance, the other focused on community or regional adaptation funds.

Improve Risk and cost sharing by individual homeowners and business owners while continuing to provide insurance in coastal areas

Flood insurance in the US is provided almost exclusively by one insurer: the federal government through the National Flood Insurance Program. This program has been amended and changed numerous times to improve its fiscal stability and benefits to communities and homeowners, but still faces critical challenges (including level of adoption, compliance, repeat claims, reduction of risks, and fiscal viability).[29] For coastal flood insurance to be successful, the consensus view among experts is that it meet certain conditions; 1) must be mandatory; 2) the insurance premiums must reflect the actual risk; 3) insurance policies must be long-term and include premium guarantees for a certain periods; 4) risks and risk premiums must be reassessed periodically to reflect changes in scientific understanding and in the actual state of a dynamically changing coastline. This approach should structured to also incentivize private hazard reduction measures through low-interest loans accompanied by reductions in insurance premiums for the actions taken.[30] Consideration should also be given to turn "flood" insurance into a more comprehensive "hazard" insurance (ie., also covering erosion).

We recommend that a feasibility study be undertaken under the leadership of the California Department of Insurance (in collaboration with FEMA and other relevant organizations) that examines approaches to long-term, mandatory homeowner flood insurance in coastal areas through a cooperative agreement with the National Flood Insurance Program. Assuming a generally positive finding, the proposal should be subject to pilot-testing, monitoring, adjusting, and then implementing this approach statewide. The study should build on existing proposals for improving the program and identify the shortcomings of the current flood insurance program. It should also review insufficiencies in light of climate change, and propose mechanisms to improve the viability of providing homeowners insurance while decreasing the burden

[29] R.J. Burby (2001), "Flood insurance and floodplain management: the US experience," Global Environmental Change Part B: Environmental Hazards 3 (3-4):111-122. E.T. Pasterick. (1998), The National Flood Insurance Program. In Paying the price: the status and role of insurance against natural disasters in the United States, eds. H. Kunreuther and R. J. S. Roth, 125-154. Washington, DC: Joseph Henry Press.

The Heinz Center (2000), Evaluation of Erosion Hazards. Washington, DC: The H. John Heinz III Center for Science, Economics and the Environment.

[30] H. Kunreuther, and R. J. Roth Sr. (1998), Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States. Washington, DC: Joseph Henry Press.

H.C. Kunreuther, and E. O. Michel-Kerjan (2009), At War with the Weather: Managing Large-Scale Risks in a New Era of Catastrophes. Cambridge, MA: The MIT Press.

H. Kunreuther (2008), "Reducing Losses from Catastrophic Risks Through Long-term Insurance and Mitigation," Working Paper 2008-06-10. Philadelphia, PA: Risk Management and Decision Processes Center, The Wharton School, University of Pennsylvania.

on taxpayers or local and state emergency services. Mechanisms to compensate potentially steep increases in flood insurance premiums should be assessed to protect lower-income homeowners. The implications for further gentrification of the coastline must also be assessed and approaches to mitigate them, where practicable, should be examined. (This recommendation is consistent with the State's Coastal Sector Strategies 1A, 1B, 1D and 4A.)

Explore building local or regional climate adaptation funds

Many adaptation actions will go beyond the capacity of individual homeowners. In fact, in many instances the most appropriate and effective coastal adaptation strategies must be undertaken at the scale of communities or regions. Funds need to be developed for protection of critical infrastructure, land and easement acquisition (for example, land adjacent to current wetlands to enable inland migration as sea level rises), redevelopment, relocation and planned retreat, habitat restoration efforts, and supporting activities. Currently there is very little money available for such larger efforts, yet the demand for them will grow as climate changes and sea level rise accelerates.

We recommend that a study be initiated that examines the feasibility and institutional structure of a long-term approach to building a climate adaptation fund for community-wide or regional-scale adaptation strategies in coastal areas.

We recommend that a study be initiated that examines the feasibility and institutional structure of a long-term approach to building a climate adaptation fund for community-wide or regional-scale adaptation strategies in coastal areas. The study should examine mechanisms for building a multi-sourced, self-sustainable or even growing fund over time to finance larger adaptation measures that exceed the capabilities of individual homeowners or even individual communities. The study should explore the extent to which existing and innovative mechanisms (such as redevelopment funds, lease agreements, or public trust impact fees) can be used as models for such adaptation funds or whether adaptation can be accomplished through existing mechanisms. The study should examine the range of criteria that could be used to identify eligible projects. Furthermore, the study should examine how such a fund could be made attractive to the private sector as an investment opportunity. (This recommendation is consistent with but also goes beyond the state's Coastal Sector Strategies 4B and 4C.)

Case Study: San Francisco South Bay Salt Pond Restoration

San Francisco Bay is the largest estuary on the Pacific Coast and at once one of the most critical ecological habitats and one of the most desirable places to live in Northern California. The marshes and mudflats along the shoreline of the Bay provide food and shelter for fish and wildlife. Hundreds of thousands of birds that seasonally migrate back and forth between the Arctic and South America – half of all birds using the Pacific flyway – stop in the Bay to rest and feed. The Bay's fish provide food and recreation for some people and an economic livelihood for others. The salt produced from its waters serves as raw material for industry. The Bay's thousand miles of shoreline are home to millions of Californians and the base of a productive industry and diverse business community. The region's stunning beauty is the basis of its quality of life and a vibrant tourist industry which attracts millions of visitors every year.[1]

Over the past 100 years or more, development along the Bay's shores has resulted in significant infill of Bay waters and the draining and conversion of many of its wetlands. Moreover, to protect shoreline communities against periodic flooding during storms, various sections of the Bay have been protected by levees and armoring. Until the creation of the Bay Conservation and Development Commission in 1965 and the establishment of stricter ecological protections and development guidelines, neither the ecological value of wetlands to fish, birds and other species nor their water purifying, flood buffering, carbon sequestration, and erosion control services were fully appreciated.[2]

This paradigm shift is clearly recognizable in the South Bay Salt Pond Restoration Project, the largest tidal wetland restoration project on the west coast.[3] The project began in 2003 when state and federal agencies and private foundations purchased 15,100 acres of commercial solar evaporation salt ponds from Cargill Inc., an area the size of the size of Manhatten Island. At the same time, a stakeholder-intensive planning process was launched. Over the next several years, saltwater was slowly reintroduced to some of the former salt ponds to reduce salinity and begin the restoration process. Ecological changes were quickly documented (see Figure).

Source: California Coastal Conservancy (http://www.southbayrestoration.org/track-our-progress/island-ponds-before-after.html)

[1] http://www.bcdc.ca.gov/bay_estuary.shtml

[2] http://www.bcdc.ca.gov/history.shtml

[3] http://www.southbayrestoration.org/

In 2006, three different restoration alternatives were introduced for consideration in the planning process – alternatives that varied in the amount of tidal habitat versus open (managed) ponds that would be restored. The alternatives were developed with input from a Project Management Team, Science Team, Regulatory and Trustee Agency Group, and the public through a series of workshops and meetings. That same year, the first levees were breached, thus reconnecting 800 acres of former salt ponds to the open Bay. Thousands of shorebirds and ducks immediately returned to the newly opened ponds.

In 2007, a thirty year Restoration Plan was finalized, and three public Working Groups were established to guide the multi-phase implementation. With clever phased implementation, critical scientific input, ample stakeholder education and engagement, and regular briefing of elected officials at the local, state, and federal levels, the project encountered minimal conflicts, and so the restoration plan got adopted.[4] Since then, habitat, recreation, and flood protection features are being built at each of the three pond complexes while scientists monitor changes at the ponds to assess progress.[5]

The overarching project goal of that plan is the restoration and enhancement of wetlands in the South San Francisco Bay while providing for flood management and wildlife-oriented public access and recreation.[6] "The mix of habitats in the restoration alternatives is expected to benefit a diversity of wildlife, including special-status species and migratory birds, and to increase the overall abundance and diversity of native species in South San Francisco Bay. The restoration alternatives are designed to improve existing levels of flood protection and provide high quality public access and recreation opportunities."[7] At first the plan used the 2001 IPCC sea level rise projections, but has since adopted the 16 inch projection by 2050 suggested by the state.

To accommodate such updates in climate change science and other changes observed in the restoration area, the project uses adaptive management as an integral part of its planning and implementation process. Adaptive management consists of establishing base lines, implementing experiments, monitoring progress, deliberate learning, and adjustment of actions as the restoration proceeds.[8]

While funding support for the project to date has been good, maintaining adequate funding levels will require ongoing outreach. Particularly challenging is the financing of long-term monitoring because of current state bond rules and limited long-term commitment of federal or other funders. This could undermine the adaptive management approach to the restoration project.[9] The recent creation of the regional San Francisco Restoration Authority through AB 2954 offers new fundraising capacity to restore Bay wetlands. To ensure future success, however, the Salt Pond Restoration Project also needs to overcome regulatory and procedural obstacles, especially with the US Corps of Engineers, which can slow down progress or undermine the flexibility required for an adaptive management approach.

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[4] Nadine Hitchcock, Deputy Executive Officer for the California Coastal Conservancy, communication to the PCIP Adaptation Task Force's Sea level Rise Subteam, December 18, 2009; For project materials see: http://www.southbayrestoration.org/Project_Description.html.

[5] The project timeline was derived from http://www.southbayrestoration.org/track-our-progress/.

[6] Philip Williams & Associates, EDAW, H.T. Harvey & Associates, and Brown & Caldwell. (2006), South Bay Salt Pond Restoration Study: Final Alternatives Report.

[7] Ibid., p.1

[8] L. Trulio, D. Clark, S. Ritchie, A. Hutzel, and the Science Team. (2007), South Bay Salt Pond Restoration Project. Final Environmental Impact Statement/Report. Appendix D: Adaptive Management Plan.

[9] Nadine Hitchcock, note 4.

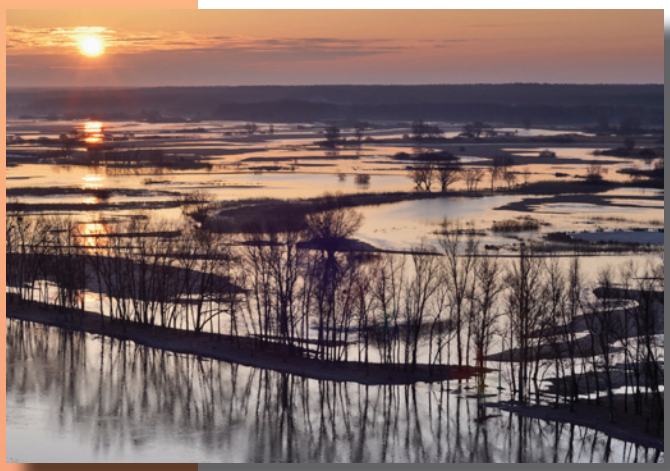
Water Supply

Focus

The Task Force focused primarily on the increased risks of reduced water supplies due to expected reduction in the Sierra snowpack, the increase in amount of precipitation that falls as rain as opposed to snow, and the potential for increased demand as a result of warmer average temperatures and population growth. We concluded that navigating these challenges to our already stressed water system will require a portfolio of both demand and supply side management strategies. To be resilient, California needs conservation-oriented management of existing water resources in addition to targeted investment in capture, storage, and conveyance improvements.

The California Water System

California's vast and complex water management systems face a variety of natural and man-made challenges that are being further complicated by climate change. The primary challenge is the current imbalance in supply and demand that is not only the result of variability of the semi-arid climate but also of the seasonal and geographic distribution of rainfall. The majority of precipitation falls and is captured in the northern and eastern regions of the state, while the majority of the population lives in the south and west. Additionally, the wetter months occur between October and March, while demand peaks in urban and agricultural areas during the summer. The projected changes in both population and climate over the next century are likely to further aggravate these imbalances by reducing supply, increasing demand, and altering the form and timing of precipitation.



Current Management and Investment

California's water management involves dozens of state and federal agencies, hundreds of regional and local government entities, and over 3000 local water suppliers. Efforts to coordinate the planning are evident across agencies and various forms of government in entities such as the Strategic Growth Council, the CALFED Bay Delta Program, the Delta Vision Task Force, and the Integrated Regional Water Management Program, among many others. The absence of a strong, state-level entity with a broad mandate to manage water resources makes coordinated, proactive action for broad public benefit difficult, slow, and costly, although some progress has been made in recent years.

The State Department of Water Resources (DWR) Integrated Regional Water Management planning processes, which promote and provide funding for integrated water resource planning, has been successfully implemented in several regions of the state. In addition, California has made significant though insufficient investment in water system improvements and protection over the past two decades. With the passage of Propositions 12, 13, 40, 50, 84 and1E, voters have approved approximately $15 billion in bonds to invest in our water systems.[31] These funds have been used to improve and protect water quality, expand local and regional surface and groundwater storage capacity, increase reliability, protect the Sacramento-San Joaquin Delta, fund local and regional conservation and efficiency programs, and much more. These programs have made progress in critical areas, but more will be required both to reduce the demand and increase available supply as the water situation in the state becomes increasingly challenging.

As a result of a series of bills that were passed by the the California legislature at the end of 2009, there are a number of new initiatives in place intended to develop a more sustainable water management system. The package of bills – known as the Safe, Clean and Reliable Water Supply Act of 2010 - include:

- Creation of the Delta Stewardship Council to develop a strategy for protecting the Delta's water supplies for human and ecosystem use
- Improved monitoring and measurement of water by implementing groundwater monitoring and improving accounting for surface water diversions
- Mandatory water conservation, with a goal of 20% reduction in urban water use by 2020 and a new requirement for agricultural water suppliers to develop water management plans and adopt certain best management practices
- Funding for a variety of projects, including operational improvements state-wide such as additional water storage (both groundwater and above ground), conjunctive use and reservoir re-operation projects, as well as other initiatives such as water conservation, watershed and ground water protection, and other projects

While the package takes important steps toward increasing investment in, and improving management of, our water resources, the bonds to fund these measures are pending at this time.[32] Moreover, the central focus of the measures is largely to address current challenges and risks to our water system. Our focus, however, is on preparing California for the coming challenges and risks presented by accelerating climate change.

[31] California Water Plan Update 2009, Volume 1Chapter 4 California Water Today

[32] In August 2010, the State Legislature vote to postpone consideration of the water bonds until 2012.

Impact of Climate Change

Impact on Supply

As a result of warmer temperatures, California's water supply will face a variety of threats that must be proactively managed. These include:

- **Reduced natural storage:** California relies on historic temperature ranges to manage its water supplies. Cold winter temperatures in the high mountains capture and store precipitation in the form of snow as it falls in the winter months for use in the spring and summer when snowmelt occurs. Warmer temperatures and shorter, warmer winter seasons will result in more precipitation falling as rain rather than snow, reducing the snow pack in the High Sierras (Figure 9). Additionally, higher temperatures will cause snow to melt faster and earlier. In fact, initial effects are already being felt in the Sierra Nevada mountains, where snowpack has diminished by about 10% since 1950 and annual spring melt off is happening somewhere between 10 to 30 days earlier on average.[32]

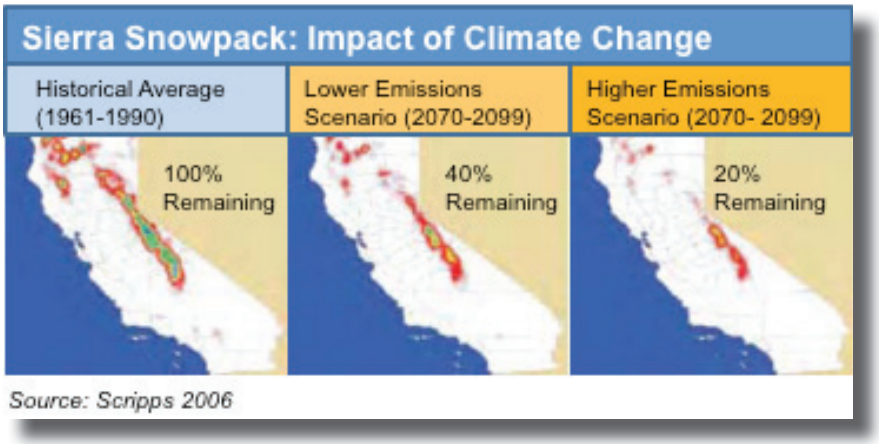


Figure 9: The Scripps Institute of Oceanography at U.C. San Diego projects that, by the end of the century, the California snowpack will have diminished by 60% to 80% depending on various scenarios for the level of green house emissions over the course of the century (Figure 1). The reduction in the snowpack in the High Sierras represents a third of all of the surface water storage capacity in the state. Therefore, the loss of as much as 70% constitutes roughly a quarter of all stored water supplies in the state.

- **More frequent and extreme flooding**: Flooding is expected to happen with greater frequency in the future as a result of more precipitation falling as rain and snow melting faster and therefore running off more quickly into streams and reservoirs. There is also the expectation of more severe storms as Earth's temperatures rise. These climate change effects could overwhelm our outdated water and flood management infrastructure, causing inundation and contamination of water supplies.

[32] Observed Changes in the Sierra Nevada Snowpack, California Climate Change Center, March 2009

- **Longer, drier droughts**: Sustained warmer temperatures may cause longer and drier droughts, reducing flows in the Colorado River and other river basins and potentially increasing the overdraft of underground aquifers that could compromise the integrity of these aquifers and increase potential for contamination of groundwater.

- **Salt water intrusion:** Warming is expected to cause the oceans to expand as a result of greater freshwater content and warmer overall temperatures. Sea level rise is already causing salt water intrusion into coastal water supplies. A particular concern is the Sacramento San Joaquin River Delta, which provides 23 million Californians with water. Much of the Delta currently lies below sea level behind a network of aging levees.

California will need to take action to prevent the most severe potential impacts of these climate change threats. Yet the timing and extent of these threats is not fully understood, and proactive management will require sustained attention to evolving science and investment in extensive measurement and monitoring of surface and groundwater conditions. California needs a functional institutional framework with the capacity to continuously monitor and iteratively plan for climate change impacts as new science and data become available.

Impact on Demand

In addition to changes in, and threats to supply, California will be facing significant increases in demand over the same period. Increases in demand will come from:

- **Increased rates of evapotranspiration:** Hotter drier summers are expected to increase the rate of evaporation of water from plant and soil surfaces and transpiration to support plant growth, meaning that plants will require more water to survive. Today roughly 48% of the water goes to the environment, 41% to agriculture, and 11% for urban use.[33, 34] Of urban use, nearly 50% is used for landscaping. As rates of evapotranspiration increase, so will demand for agriculture, urban landscaping, and environmental needs. Among climate change effects, the increased rates of evapotranspiration are likely to have the single most significant impact on increasing demand for water.

- **Increased demand for energy production:** Energy production is among the most water intensive activities in the state. Summers that are on average 5 to 10 degrees Fahrenheit hotter are expected to increase the demand for energy to cool homes, businesses, and industries that also may require cooling in the production process, e.g., refrigeration or freezing. This demand for cooling will occur in

[33] California Water Plan Update 2005, State of California, Resources Agency, Dept. of Water Resources 2005, Bulletin 160-05, Chapter 3, pg 9.

[34] An estimated forty to fifty percent of urban use is for landscaping

the context of a significantly expanded population. By 2050, the population is expected to have increased to 59.5 million and to 90 million by 2100[35] – largely in the southwestern urban areas of the state.

- **Increased demand for recreational use**: The same climate conditions are expected to increase demand for water for recreational uses such as water sports, pools, water parks, and other activities.

In the face of such significant changes to the hydrological cycle, threats to water supplies and projected increases in water demand across sectors – including agricultural, commercial and industrial, residential, and environmental – California will need careful planning and significant investment in order to ensure the availability of this already scarce resource. This means re-engineering and investing in our storage and conveyence infrastructure to adapt to diminishing snowpack and variation in form and timing of precipitation while reducing demand in virtually all sectors to make such infrastructure investments more fiscally manageable and physically possible.

Overall Recommendations Specific to Water Resources

Recommendations for Immediate Action

The Task Force asserts that it is most cost-effective and socially-desirable to begin to prepare immediately for continued and increasing climate variability. There are several critical actions we should take in the near term to protect ourselves against potential threats posed by climate change. These actions are important for the protection of the state's water system generally but are made more critical as a result of the threats posed by a warming climate.

1. Protect critical fresh water resources

California's fresh water resources are threatened by inundation from flooding as a result of sea level rise, extreme weather events, and more rapid run off. These effects

[35] "Population Projections" Demographic Research Unit of the California Department of Finance, 2008 ; DWR California Water Plan Update 2009

could cause salt water intrusion and overwhelm the flood management systems, causing contamination. We must protect the precious and limited resources we have from pollution and inundation.

a. Update flood management infrastructure and re-engineer flood management operations to reflect changes in the hydrological cycles

California's flood management infrastructure and practices are outdated and designed for the past not future climate. Significant investment is needed to improve the infrastructure, to reinforce and update storage and conveyance equipment, to re-engineer flood management practices to better respond to changes in timing of run-off, and to develop release critieria to support downstream planning. We must also change floodplain management to utilize the benefits both in terms of human protection and ecosystem. In order to do this, we will need to reduce and potentially discontinue major development on the floodplains, implement managed retreat in some areas and be prepared to compensate farmers to fallow land for use as floodplain during years with heavy precipitation.

Among the most important prioirites is the protection of the Sacramento San Joaquin Delta through which 40% of all California fresh water flows... Therefore, we highly recommend that California invest appropriately in Delta protection.

Among the most important prioirites is the protection of the Sacramento San Joaquin Delta through which 40% of all California fresh water flows. However, the majority of it is below sea level and maintained behind a system of aging levees, many of which are in similar condition to those that protected New Orleans prior to hurricane Katrina[36]. Therefore, we highly recommend that California **i**nvest appropriately in Delta protection. For starters, we should fully fund and implement the CALFED Levee System Integrity Program,[37] updating and reinforcing the 24 critical erosion sites identified by the U.S. Army Corps of Engineers in the Sacramento-San Joaquin Delta. In addition, we should expand and protect tidal wetlands that can protect the Delta as opposed to man-made armoring such as levees and sea walls, tidal wetlands naturally adapt to sea level rise, providing a natural, self-sustaining buffer for natural and human systems. The Task Force supports the call for protection of wetlands that is in the Climate Adaptation Strategy of December 2009 (CAS)[38] as a resilient adaptive strategy, particularly in the region of the San Francisco Bay and the Sacramento San Joaquin Delta. In order to protect and expand current wetlands, the inevitable and natural migration of these wetlands as a result of sea level rise must be accomodated.

[36] According to Jeffrey Mount, a geology professor at the University of California at Davis, there is a two in three chance that winter storm runoff or an earthquake will cause catastrophic levee failure in the delta over the next forty-five years. The failure of multiple levees would cause extensive flooding in the delta and likely force a shutdown of the state and federal pumps for months or even longer,

[37] Program funding and activity has accelerated significantly in the past year, but there remain significant gaps, and levee restoration programs in particular are significantly underfunded and behind schedule. Of the 200 miles of levees expected to be brought up to PL84-99 standards by 2007, only forty-five miles has been updated so far.

[38] Protection for tidal wetlands is called for in various places in the 2009 Climate Adaptation Strategy including strategy 1 of Biodiversity & Habitat adaptation, strategy 5 of the water adaptation sector

Increase protection of groundwater through stricter regulations on pollutants

Along with the expansion of and investment in groundwater storage (recommended below), there should be concerted investment in protection of those resources. Groundwater can become contaminated from a number of sources, including poor disposal of chemicals, leaking underground chemical or waste containment systems or piplines, over use of pesticides or herbicides, urban run-off and other causes. Increasing and enforcing chemical and waste disposal and containment laws while expanding support for water quality management programs in the rural communities, and public awareness in urban areas should be implmented to reduce point-source pollution of groundwater and protect our investments in such storage.

2. Increase conservation and efficiency in all areas of the economy and of the state

In order to reduce reliance on imports from outside the state and from the beleaguered Sacramento-San Joaquin Delta and in so doing reduce vulnerability to decreased water supply due to drought, inundation, and/or contamination, California must implement substantially enhanced water conservation programs. In this regard, California has significant opportunities to improve its water efficiency, particularly in urban areas. An average household in California consumes 240 gallons of water per day, whereas the national average is 170 gallons per day. These numbers are significant lower in Australia – with a similar climate and standard of living as California – where average household water use is as low as 34 gallons per day in some drought-prone regions.[39] According to an assessment by the Los Angeles Economic Development Corporation, urban conservation measures in Southern California alone could yield over one million acre feet annually – or roughly 25% of needed regional supply with little up front capital investment and the lowest sustained cost relative to other options.[40] In fact, adoption of new water efficient technologies can actually yield significant cost savings, as illustrated by an analysis of replacement value of various water intensive appliances and equipment.

[39] California data from the California Department of Water Resources California Water Plan Update 2005, December 2005; U.S. data from the United States Geologic Survey, Estimated Use of Water in the United States in 2005, Circular 1344; Australian data from the Queensland Water Commission, The 2008 Water Report, available online at: http://www.qwc.qld.gov.au/myfiles/uploads/water%20report/Annual%20Water%20Report%20July%202009.pdf

[40] LAEDC (2008), "Where Will We Get the Water? Assessing Southern California's Future Water Strategies."

Cost Curve Analysis of Various Water Efficient Technologies and Appliances

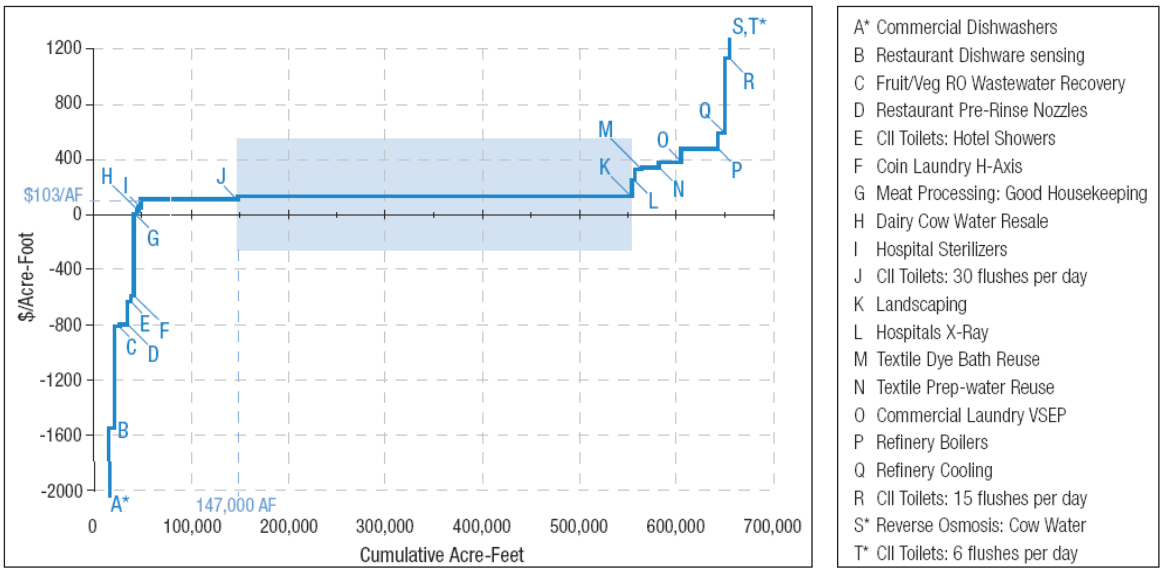


Figure 10: Graph from Waste Not Want Not, (Pacific Institute, 2003) identifies and assesses the comparitive costs of conservation and efficiency improvements achievable in California's residential, commercial, industrial, and institutional sectors using existing, effective technologies and options. Each water conservation measure is considered an alternative to new or expanded physical water supply; thus measures are considered cost-effective when their unit cost – which we call "the cost of conserved water" – is less than the unit cost of the lowest-cost option for new or expanded water supply.

Figure 10 (above) above presents these "cost curves" for conserved water in the residential, commercial, industrial, and institutional sectors of California, some of which have negative cost (due to water and energy savings associated with lower water use).

Significant work has been done to foster the adoption of water conservation and efficiency planning, programs and legislation. Since the early 1990s, when many urban areas adopted the California Urban Water Conservation Council's best practices guide, urban conservation has been gaining momentum. Recently, the Governor's 20X2020 Letter to the Legislature, the Climate Adaptation Strategy, and the California Water Plan Update 2009 all emphasize the importance of conservation and efficiency while recommending ways to accomplish it. These plans contributed to the the recent Senate Bill 7x7 Statewide Water Conservation that mandates a 20% reduction in per capita use for all urban areas by 2020. However, given the anticipated supply demand gap as a result of climate change and population expansion, more aggressive conservation mandates are likely to be required beyond 2020.

a. Achieve current conservation targets and align incentives to push beyond

- The Department of Water Resources should track the implementation of SB 7x7 to ensure that state and local agencies are accountable for, and are making sufficient progress toward, achieving the stated goals. Economic incentives should be provided to speed adoption of water efficient technologies and practices, including: establishing or increasing rebates, low-interest loan programs, and/or tax exemptions for installation of efficient appliances, fixtures, xeriscaping[41] or new plumbing systems; installation of drip irrigation systems, microsprinklers and other efficient water use technologies for agricultural production; and in urban, residential and commercial areas.

- Align incentives to encourage efficiency beyond 20X2020[42]. The strains of the supply-demand imbalances outlined above will likely necessitate efficiency well beyond 20% in the future. Therefore, in addition to supporting communities to reach the initial goal, incentives should be created for communities to go beyond the initial goal. The effect will not only achieve additional water use savings but will also encourage innovation and development of best practices to be shared throughout the state. Incentives could come in the form of grants or awards for communities that achieve 20% per capita reduction earlier than 2020 or greater than 20% per capita reduction by 2020.

- Institutionalize greater efficiency through development of new codes and standards. Another important factor in aligning incentives is revising the codes and standards of the built environment. Building and plumbing codes should be adjusted to facilitate low-impact development (LID) and enable implementation of water efficient technologies such as dual-plumbing, grey water systems, and storm water capture.[43] Additionally, water efficiency standards for appliances should be increased. Finally, fees and fines should be created to discrouage waste such as tiered pricing for water and fines for restricted practices such as hard surface clearing and over irrigation.

- Support agricultural water conservation and efficiency measures in order to make California's $37 billion agriculture sector more resilient. Practices that conserve agricultural water use and potentially reduce energy consumption and GHG emissions range from irrigation efficiency to cover cropping. Supporting efficiency in the agricultural sector will require investment in research for integrated farming

[41] Xeriscaping is landscaping that reduces or eliminates the need for supplemental irrigation

[42] This assumes the bond measures are accepted and Bill No. 7 is successful implemented. The task force supports the passage of the water package.

[43] In the summer of 2009, California revised its gray water code, allowing small residential gray water systems to be installed without going through a permitting process, and adopted a dual plumbing code, setting standards for installing recycled water systems for indoor uses. These changes are a step in the right direction, but have been challenged by some municipalities. Education and tools should be provided to help regulators and the public understand how to safely implement these technologies. In many areas, city planning codes still do not allow innovative design solutions to capture storm water runoff, such as curb cuts and retention basins.

systems approaches for on-farm water conservation practices, technical assistance for producers to translate research findings into on-the-ground farm and ranch management practices, and financial incentives for producers to overcome potential economic barriers to the use of on-farm water conservation practices.

b. Develop contingency plans for significant supply gap scenarios beyond 2020

While 20% per capita reduction of use in urban areas is a laudible goal, significantly more efficiency is needed in all sectors and regions if we are to accommodate the population expansion and absorb the expected shocks to supply in the coming decades. Robust scenario analysis should be conducted at both state and local levels to better understand potential impacts and possible measures to be implemented to deal with them.

3. Expand water sources

Even under the most optimistic efficiency scenarios, investment in developing new sources and expanding storage capacity will be necessary. It is not advisable – and most likely impossible – to try to overcome the expected supply demand gap by efficiency alone. Additionally, the projected loss of about a quarter of our current storage capacity due to reductions in the Sierra snowpack will drive the need for investment in replacement storage capacity.

a. Expand waste water and storm and flood water capture and storage and recycling

Waste water, storm water, and flood water represent a potential untapped supply of water, particularly in coastal urban areas of the state. Current practice for storm water management is intended to avoid flooding by allowing it to flow out to the ocean. Storm and flood waters managed in order to capture and filter for use could add valuable supplies, but they must be effectively recycled to high standards of quality. Water recycling must be conducted consistent with existing state and federal public health and water quality laws. It will require integrating flood and storm water management with water planning to ensure capture, storage, and recycling. The goal can also be achieved through adoption of, and reduce barriers to, low-impact development techniques for local and municipal storm and waste water capture and reuse. Farm use of recycled water must be complemented by water quality management practrice to reduce and avoid point-source pollution as well as public awareness campaigns for the safety of recycled water for agricultural use.

b. Expand surface and groundwater storage and recharge programs

The projection of losing as much as 80% of the Sierra snowpack by 2100 as a result of climate change requires that we invest significantly in replacement storage of both surface and groundwater throughout the state. Fortunately, California has

an extensive network of healthy aquifers that can provide significant underground storage capacity. Increased reliance on groundwater makes the protection of groundwater from contamination all the more important. To accomplish this, investment in conveyance and a reduction in barriers to water transfers will be needed. In addition, we will need to more actively manage development on the floodplains, in some cases restricting developing and in others reducing existing development. While the taskforce is committed to sustainable, local, low-energy water development as the state's top priority, in view of the extent of the anticipated loss of the Sierra snowpack, strategic surface storage will likely be needed as well. In addition, to optimize conjunctive use opportunities through the utilization of expanded surface and groundwater storage, new Delta conveyance is critical.

Important Issues For Further Study

Invest in development of more capital and energy efficient desalination Technology

Even with 20% per capita conservation goal, decontamination of Southern California aquifers will likely be required to meet the extensive needs of a growing Southern California population living in a warmer climate. Currently, desalination is both capital and energy intensive. However, investment in developing a more efficient technology will make these valueable resources available when they are needed.

Case Study: Groundwater Banking in the Central Valley

Introduction

Groundwater banking offers a valuable response to climate change impacts on water resources in California. As surface runoff is concentrated in the winter and early spring due to earlier snowmelt, supply will be increasingly out of phase with demand. In addition, rising temperatures will lead to rising evaporation rates. Given that the annual yield of all proposed surface storage projects in the state is less than four million acre-feet and that many of these projects have been declared unfeasible by the Bureau of Reclamation, the approximately ten million acre-feet of storage available in just Central Valley aquifers alone represents a large storage capacity with low evaporative rates as compared to surface storage.

In the last decade, groundwater banks have increased throughout the Central Valley as individual water districts seek to take advantage of groundwater storage options and improve the management and reliability of often scarce surface water supplies. Yet, there are still some concerns around groundwater banking programs. A program's ability to transport water out of a basin raises issues related to water transfers and water rights. Two to one banking is one way to decrease local impacts and to ensure that water remains within the basin. In addition, appropriate monitoring of groundwater levels and accurate accounting of traded water are critical to maintaining good relations with overlying and surrounding landowners and the credibility of groundwater banking strategies.

Groundwater banking, like any conjunctive use strategy, cuts to the heart of links between surface and groundwater and basin impacts such as water quality, recharge, and groundwater levels. Thus, banking programs are best implemented as part of a larger, integrated planning effort. The state's recent focus on Integrated Regional Watershed Management Planning should include groundwater management particularly in areas considering groundwater banking. Specifically, plans should require consistent monitoring of groundwater levels and quality and coordinate banking programs with other surface and groundwater uses. Groundwater banking programs can provide a valuable management tool to help better coordinate groundwater and surface water management to improve basin conditions and to adapt to climate change impacts.

Background

Groundwater banking has come to refer to the practice of recharging specific amounts of water into a groundwater basin that can later be withdrawn and used by the entity that deposited the water. Groundwater banking is an example of "conjunctive use" or the integrated management of surface and groundwater supplies. For example, when surface water supplies are plentiful, they can be used to recharge groundwater, which is then used during dry periods when surface water is scarce. Surface water can recharge groundwater basins through both natural and artificial means. Natural or incidental recharge results from percolation into the basin from natural waterways fed by rainfall or snowmelt and from excess water applied for crop irrigation. Artificial recharge replicates and promotes natural processes by capturing and retaining water in surface impoundments (dams, dikes, and infiltration areas) to allow water to percolate into the underlying basin. Another form of artificial recharge is direct injection of water into groundwater basins through injection wells. An additional form of recharge is "in-lieu," which refers to the groundwater that remains in basin when groundwater users switch to surface water instead of pumping from aquifers. Whether physical or in-lieu recharge methods are used, groundwater is stored in the basin for later use.

Groundwater banking differs from the more general description of conjunctive use because the water deposited in the bank is attributed to a specific entity and may be imported from non-local sources. Likewise, withdrawals must be in amounts specific to the amount deposited

and available and can be used outside of the basin in which the deposits were made. In effect, groundwater banking uses aquifers for storage purposes and offers water to other water users, including those who do not overlie a groundwater basin to store water there. It also allows flexibility to respond to seasonal and inter-annual variability, as water can be stored in wet periods for use in dry ones. This will be increasingly important as climate change is projected to increase the frequency and intensity of extreme weather events, including floods and droughts.

As a storage alternative, water banking has several advantages over surface reservoirs. Groundwater storage is generally considered less environmentally damaging than dam or reservoir construction, and significant evaporative losses occur with surface storage. Rising temperatures associated with climate change will increase this unproductive evaporation. Water stored underground does not evaporate, though losses can still occur as the water is being transferred to underground storage. In general, water banking has lower capital costs than dam and reservoir construction, though banking projects can require extensive distribution networks, infiltration areas, and injection wells. Infiltration areas can be complex, requiring specific soil types and sometimes changes in land use. Annual operation and maintenance costs may also be higher than conventional surface storage, particularly when considering the recovery costs of pumping water for withdrawal during dry years. This case study reviews two innovative and successful water banking programs that have led to better coordination and use of limited water supplies.

Water banking requires certain physical characteristics in terms of the groundwater basin, surface water availability, and access to transport as well as the institutional factors related to the management and use of the basin. Ideal natural characteristics for conjunctive use and water banking include the following:

- Aquifers with accessible storage – unconfined, with adequate de-watered storage space at relatively shallow depth (decreased pumping costs);
- Aquifers that are easy to fill – overlying area has soils with high permeability;
- Aquifers that are easy to pump – high-yielding wells with minimal pumping drawdown; and
- Areas that minimize negative impacts – no risk of land subsidence, liquefaction, water quality degradation as water levels change; and lack of direct hydraulic connectivity with perennial streams that would induce recharge from other sources (Brown 1993).

Additionally, sources of surface water and transportation and distribution facilities to both receive and distribute banked water are needed. Banking requires that participants have access to surface water when it is available and the ability to transport it to the banking facility. Banking projects must also provide for a method of transporting extracted water to banking participants. Projects utilizing in-lieu recharge must have sufficient distribution systems to support conjunctive use. Beyond the physical infrastructure, these exchanges require institutional infrastructure, including agreements, monitoring, and accounting methods to guarantee a secure right to the banked water.

There are several concerns related to groundwater banking. Overlying landowners, for instance, have concerns about local impacts on groundwater. While recharge may have positive benefits, e.g., temporarily raising the water table, withdrawals have the opposite effect of drawing down the water table, possibly resulting in subsidence and water quality degradation. In addition, residents within the boundaries of the groundwater basin may object to using stored water outside of the basin; in some cases there are county ordinances prohibiting out-of-basin use. Participants in groundwater banks may also be concerned about the security of their deposits

since in some cases, stored groundwater may not be 100 percent recoverable or may not be recoverable at particular times.

Groundwater in the Central Valley

The groundwater basin that underlies that Central Valley contains one-fifth of all groundwater pumped in the nation and thus is, in effect, California's largest reservoir. In 2009, the United States Geological Service released a report on groundwater levels in California's Central Valley. Among the major findings of this study was that groundwater levels are declining in the southern Tulare Basin portion of the San Joaquin Valley as more water is pumped out than recharges naturally. But the southern valley also shows the most promise for large-scale artificial groundwater recharge, particularly along the eastern side with its coarse-grained soils from river and alluvial-fan sediments.

The report found severe aquifer overdraft between 1962 and 2003, when an average 9.1 million acre-ft of water went into storage annually, with an average removal from storage of about 10.5 million acre-feet/yr (Faunt et al.. 2009). Thus, in typical years the net loss in groundwater storage is about 1.4 million acre-feet. Over the last four decades, the entire Central Valley has lost about 60 million acre-feet of groundwater, driven by the declines in the Tulare Basin, which lost almost 70 million acre-feet over the time period. This drawdown has had numerous negative effects, including localized subsidence and increased well-drilling and pumping costs. However, it also provides an opportunity, as there is a vast amount of groundwater storage potential in the dewatered portions of the aquifer.

Water Banking in the Central Valley

Water banking in the Central Valley is primarily done through surface water impoundments in the southern part of the valley. Located at the southern end of the San Joaquin Valley, the county is the one of the most productive agricultural counties in the nation. With over 800,000 acres of irrigated farmland, the county relies on surface and groundwater sources to meet its water demand. Kern County offers an example of an area that has implemented water banking programs as an important water supply management tool to better meet local needs. A number of factors make Kern County a prime area for water

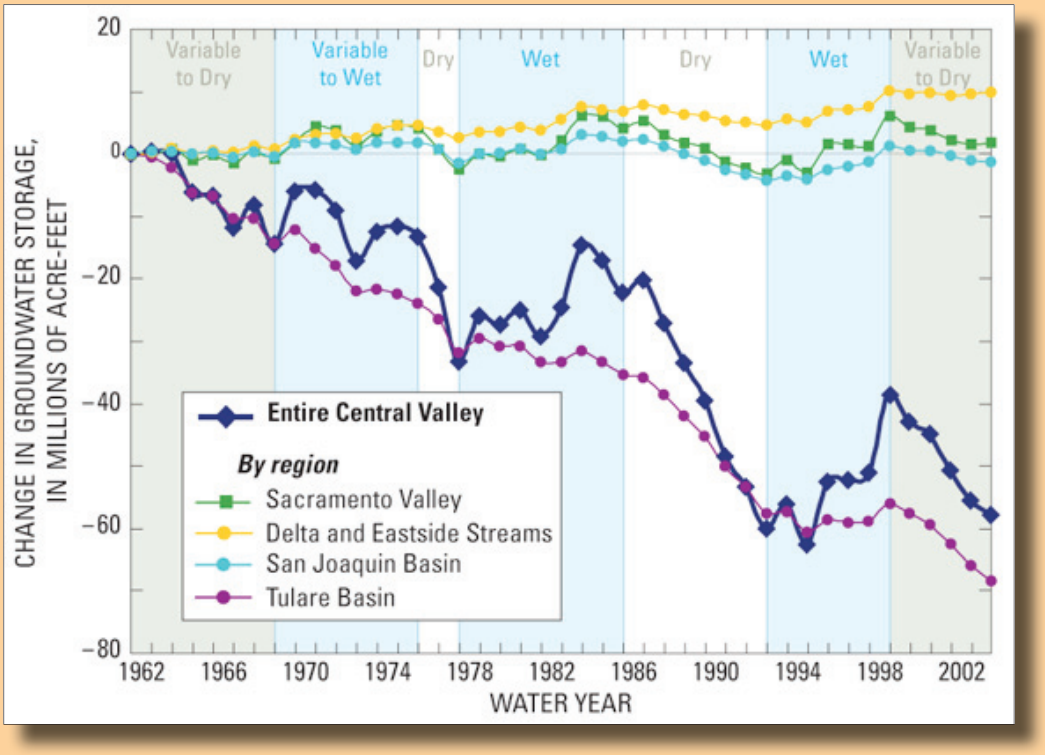


Figure x. Changes in groundwater storage in the entire Central Valley and by region in millions of acre-feet, 1962-2003 (originally published in Faunt, C.C., ed., 2009)

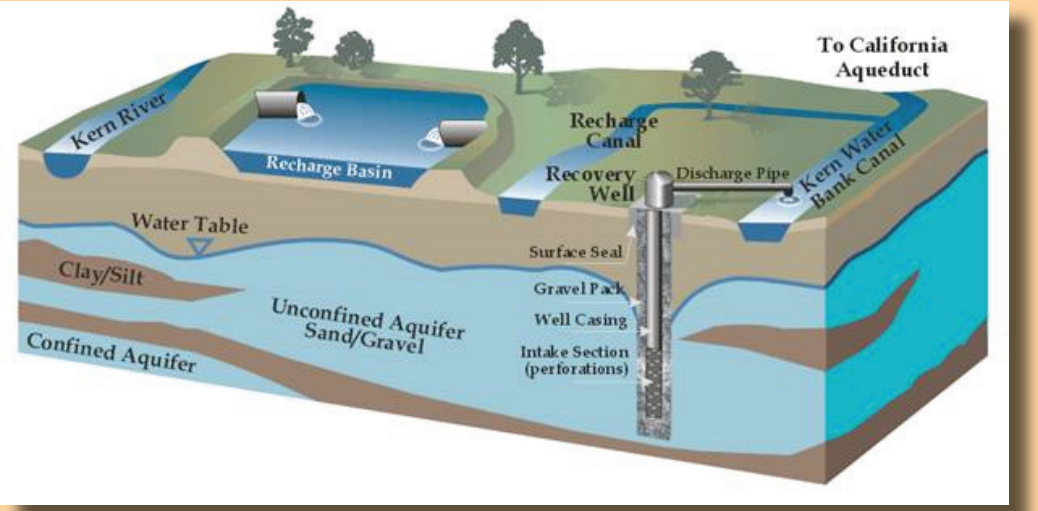


Figure x. Cross-section of the Kern Water Bank in Kern County (Kern Water Bank 2010).

banking. The area is conveniently situated in terms of geology and proximity to water-supply and delivery systems. Kern County banks water from local rivers, the State Water Project (SWP), and the Central Valley Project (CVP). Most of the water banks are located on alluvial fans consisting of sandy sediments on the valley floor, which are highly permeable and, therefore, well-suited for recharging underlying aquifers (Faunt et al.. 2009). The heavy reliance on groundwater pumping over the last several decades has resulted in substantial dewatered storage. The county also has several options for moving water around via the Kern River, the Friant-Kern Canal (CVP), the California Aqueduct (SWP), and the Cross Valley Canal. In addition, a distribution network of canals and pipelines serves much of the irrigated acreage.

The earliest groundwater programs began in this area in the late 1970s and early 1980s. The city of Bakersfield developed a series of recharge ponds within its 2800 Acre Recharge Facility; The Kern County Water Agency developed 240 acres of recharge ponds on lands along the Kern River for the Berrenda Mesa Water District, as well as recharge operations in a portion of the Kern River channel. The early 1990s saw the development of still more water banks, including the Kern Water Bank, Kern County Water Agency's "Pioneer Property," and programs in the Arvin-Edison and Semitropic Water Districts. These programs were motivated by the ability to provide greater water supply reliability through conjunctive use particularly in drought years when the CVP and SWP are not able to meet contracted water deliveries, and to fund the further development of groundwater banking facilities.

Today, the three major water banks (Arvin–Edison, Kern, and Semitropic water banks) have a combined storage capacity of about three million acre-feet (Kern Water Bank Authority, 2007; Semitropic Water Storage District, 2007). That is more than five times the amount of water in Millerton Lake, one of the larger reservoirs feeding the Central Valley surface-water system. In addition, several smaller banking programs have been launched by the Buena Vista Water Storage District, the Rosedale-Rio Bravo Water Storage District, and the Kern Delta Water District. Altogether, groundwater banks in Kern County can currently store just over 800,000 acre-feet a year and return 700,000 acre-feet annually. And several new water banks are being proposed.

Rosedale-Rio Bravo Water Storage District's Conjunctive Use Program

The Rosedale-Rio Bravo Water Storage District encompasses 44,150 acres in Kern County, with 28,500 acres developed as irrigated agriculture and about 6,000 acres developed for urban uses. The District was established in 1959 to develop a groundwater recharge program to offset overdraft conditions in the regional Kern County aquifer. To

Water Bank	Acres	Maximum Annual Recharge (acre-feet/year)	Maximum Annual Recovery (acre-feet/year)
Berrenda Mesa	369	58,000	46,000
Bakersfield 2,800 Acres	2,760	168,000	46,000
Kern Water Bank	19,900	450,000	314,000
Pioneer Property	2,273	146,000	98,000
West Kern/Buena Vista	2,000	77,000	45,000
Arvin-Edison	130,000	150,000	150,000
Semitropic	221,000	430,000	423,000
Rosedale-Rio Bravo	40,000	234,000	45,000
Kern Delta	125,000	50,000	50,000
Buena Vista	50,000	110,00	32,000
Total	*566,000*	*864,000*	*700,000*

Figure x. Updated information about various groundwater banking projects in Kern County, California (originally published in KCWA n.d..).

meet the long-term needs of its landowners, Rosedale developed the Groundwater Storage, Banking, Exchange, Extraction and Conjunctive Use Program in the late 1990s.

From the beginning, Rosedale took a unique approach to groundwater banking. Typically, the first step of a groundwater banking project is to secure partners that will provide capital for the development of infrastructure and then to divide the banking capacity between those partners. Most of the banks in Kern County are actually banking water for wealthier out-of-basin interests, most notably the Metropolitan Water District, a large urban supplier. Rosedale decided to finance the construction of banking infrastructure itself through a variety of local financing mechanisms, including revenue bonds. Then they set a 2:1 banking requirement, which means that for every 2 AF of water banked, only 1 AF is available for return.

Essentially, the contribution from the banking partner comes to Rosedale in the form of water rather than initial capital. Rosedale General Manager, Eric Averett, explains: "We thought that there was a greater value in the water than the capital…This year is a great example, you could have $5 million in the bank, but if there is no water available, that money does no good. Early on the board recognized that water is the more valuable of the two commodities and has invested considerably to ensure we have an adequate supply of water to meet the district's needs."

The Conjunctive Use Program currently manages over 200,000 acre feet (AF) of stored groundwater in the underlying aquifer, which has an estimated total storage capacity in excess of 1.7 Million AF (ESA 2008). Water for the Conjunctive Use Program is supplied by the participating water agencies and includes high-flow Kern River water and water from the Central Valley Project (CVP) and State Water Project (SWP). Currently, the infrastructure for the Conjunctive Use Program includes over 1,000 acres of recharge basins and ten recovery wells**.** There are several participants in its Conjunctive Use Program: the Arvin-Edison Water Storage District, the Delano-Earlimart Irrigation District, the Kern-Tulare Water District, the Castaic Lake Water Agency, the Irvine Ranch Water District, and the Buena Vista Water Storage District (Averett, personal.communication). The program provides for maximum annual recharge of approximately 250,000 acre-feet/year and a maximum annual recovery of 45,000 acre-feet/year (Averett, personal. communication.).

General Task Force Recommendations Applied to Water

Problem Identification: Develop a baseline understanding of current status of water system resources – both natural and man made - and implement sustained monitoring of uses and changes

Comprehensive measurement and monitoring of groundwater levels must be implemented to establish a base line across regions and sustained monitoring of changes over time.[44] In addition, California has long failed to enforce diversion reporting requirements. Many users do not report at all, and there is little oversight of what is reported. Enforcement and expansion of surface diversion reporting requirements must be implemented, with serious consideration of modeling our system on Australia's real-time diversions measurement.[45]

Recent data on bond allocations in California demonstrates that over $3 billion of funding approved by California voters for improvements to our water quality and supply remain unallocated.

	Funds Remaining	Potential Uses
Proposition 1E	• $396 million for "Flood Control and Flood Prevention Projects,"	• Protection of Delta levees and expansion and protection of tidal wetlands of the Delta
	• $65 million for "Storm Water Flood Management"	• Accelerated adoption of low impact development strategies, including on-site storm water capture and filtration
Proposition 50 and 80	• $145 million for "Integrated Regional Watershed Management"	• Regional demand reduction and supple augmentation projects.
	• $27 million for "Statewide Water Planning and Design"	

[44] 2009 Water Package Bill No. 6 makes ground water monitoring mandatory and ties eligibility for state grant funds to compliance

[45] 2009 Water Package Bill No.8 improves accounting for diversions by further limiting exemptions from the reporting requirement, increasing penalties for failures to submit accurate reports and expanding resources at the State Water resources Control Board to enforce the statute

Application and Planning: Coordinated planning across various agencies, levels of government and sectors –pubic and private – in order to effectively manage its water resources

Water resources, ecosystems, and flood management must be integrated to reach the co-equal goals of water reliability and ecosystem health. Healthy ecosystems can assist in achieving both better flood management and protection of our water supplies if they are protected and preserved. Corrdinated planning at various levels of government and across sectors can help planners at all levels better understand the interrelationships and co-benefits of healthy eco-systems and water supply protection and improve decision making.

Funding and Implementation: Develop a stable and sustained funding source for integrated and coordinated water management on a state wide and regional basis.

Effectively resourced water management planning is a long-term need for California. It should not be treated a a series of one-time projects that will solve long-term problems. Bond funding should be just one tool in a resource funding strategy that mainly relies on user fees that adequately recover capital investments and sustain operating costs.

Forest/Range Wildfires

California has begun to shift its approach to forest and rangeland wilfire management from primarily reliance on fire suppression to suppression combined with a far greater emphasis on threat reduction.[46] This needs to be enhanced by developing zoning, building codes, and forest and vegetation management practices that make the state optimally resilient even in the face of increased fire threats due to climate change. If we fail to do so aggressively, we will be *compelled* to resist rather than to develop a resilience to the largely unstoppable forces of nature.

Focus

The Task Force focused primarily on areas of California where climate change related increased temperatures are projected to lead to increased wildfire risks (primarily in forested areas in the northern half of the state), and particularly in such areas of the state where there is currently, or could be in the future, homes and infrastructure at risk from increased wild and rangeland fires. This means our recommendations are most relevant for private and state-owned properties in rural areas and on the periphery of urbanized areas in the northern portion of the state. Nevertheless, though to a lesser degree, the projected effects of wildfires under a changing climate will impact Californians throughout the state.

The California Forest Ecosystem

California's Mediterranean climate makes much of the state vulnerable to fire. The extent of the threat varies by location, depending on the availability and flammability of fuels, how long-term climate and land management factors shape the type and quantity of vegetation, and the prevalence of human and natural ignitions. Because of the availability of plentiful fuels and the effects of temperature on the flammability of those fuels, climate change will have the most impact on wildfires in California's forests and rangeland. Forested areas of the Sierra Nevada Mountains and foothills and the Coast and Cascade ranges of northern California are expected to experience the greatest increases in the risk of large fires due to rising temperature.[47] These ecosystems have abundant live and dead vegetation to fuel large fires, the primary determinants of fire risks.

[46] State Board of Forestry and Fire Protection and the California Department of Forestry and Fire Protection,"2010 Strategic Fire Plan for California," Natural Resources Agency, May 14, 2010

[47] A. L. Westerling, B. P. Bryant, H. K. Preisler, T.P. Holmes, H. G. Hidalgo, T. Das, and S.R. Shrestha (2009), "Climate Change, Growth and California Wildfire," Public Interest Energy Research, California Energy Commission, Sacramento, CA. http://www.energy.ca.gov/2009publications/CEC-500-2009-046/CEC-500-2009-046-F.PDF

Over the past century, much of this area has already seen fire severity increase as a result of fire suppression techniques and land use changes. The suppression of fires – while protecting life, property, and natural resources - has led over time to increased biomass and changes in the mix of trees and vegetation in many areas of the state (e.g., in Douglas-fir, Ponderosa Pine, Mixed Conifer, and Eastside Pine forests[48]), resulting in increased fuel loading. As a result, in forests that had adapted to frequent low severity surface fires, the risk of large severe fires in the forest canopy has greatly increased. This alone has become a serious threat. The cost and difficulty of fire suppression in these forests has increased, while the effectiveness of fire suppression technologies and strategies has decreased. Climate change is exacerbating the risk of large fires occurring in these forests and the danger to private property in, and adjacent to, forests.

Priorities for air pollution management, on the one hand, and fire, fuels, and ecosystem management, on the other hand, need to be balanced to produce complimentary strategies capable of achieving objectives in both areas.

Finally, fire suppression-related expenditures in California are a growing cost to state and federal taxpayers, at the same time that property losses due to wildfire are increasing. Reaching well downwind, the frequency of exposure to severe air pollution due to wildfires has increased for the state's growing populations. Priorities for air pollution management, on the one hand, and fire, fuels, and ecosystem management, on the other hand, need to be balanced to produce complimentary strategies capable of achieving objectives in both areas.

Somewhat in contrast, in arid ecosystems (e.g., in desert shrub ecosystems in the Mojave Desert), the most important climatic effect on fire risks from year to year is based on precipitation in previous seasons. Years that allow the growth of fine vegetation (grasses, etc.) that subsequently dries out provide fuel that can carry a large fire.[49] Projections for precipitation under future climate change scenarios are less certain than for temperature, with the result that projections of fire risks in these areas are also less certain. Nevertheless, the most recently available modeling guidance for California climate indicates a tendency toward less precipitation on average for these areas of the state.[50] This means that not only are future fire risks uncertain in these arid ecosystems, but it is plausible that they might even decrease.

In coastal southern California (Santa Barbara, Ventura, Los Angeles, Orange, and San Diego Counties), the most significant fire risks are for coastal sagebrush

[48] Scott L. Stephens and Lawrence W. Ruth (2005), FEDERAL FOREST-FIRE POLICY IN THE UNITED STATES. Ecological Applications: Vol. 15, No. 2, pp. 532-542.

[49] A.L. Westerling, T.J. Brown, A. Gershunov, D.R. Cayan, and M.D. Dettinger (2003), "Climate and Wildfire in the Western United States," Bulletin of the American Meteorological Society, 84(5) 595-604. DOI: 10.1175/BAMS-84-5-595

[50] D.R. Cayan,, M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick (2009), CLIMATE CHANGE SCENARIOS AND SEA LEVEL RISE ESTIMATES FOR THE CALIFORNIA 2009 CLIMATE CHANGE SCENARIOS ASSESSMENT. Public Interest Energy Research, California Energy Commision, Sacramento, CA. http://www.energy.ca.gov/2009publications/CEC-500-2009-014/CEC-500-2009-014-F.PDF

ecosystems. Rather than variations in precipitation or temperature,[51] high winds that affect large portions of the southern coast simultaneously are a dominant influence on fire in these communities. While risks in this area are not yet as clearly linked to climate change as in the northern forested areas of the state,[52] some of our recommendations would also help to limit vulnerability to fire in coastal southern California communities in the wildland–urban interface, enhancing the public and private capacity to cope with climate change impacts in this region and elsewhere as well.

Current Policies and Practices

Many of the state's traditional land use policies have allowed development in fire-prone regions. While construction standards and vegetation regulations have been developed to prevent fires and in order to reduce impacts to life and property, fire suppression has been and continues to be the primary fire protection strategy. As now recognized in the 2010 Strategic Fire Plan for California, without additional vegetation management and prevention measures, fire suppression alone cannot keep up with the increasing wildfire risks of climate change, development, and fuel build-up. Climate change will make fires even more likely and harder to put out and will add additional stress on firefighting resources, resulting in increased costs to California.

Responsibility for managing fire on privately owned wildland lies primarily with the California Department of Forestry and Fire Protection (CAL FIRE). The State Responsibility Area includes a significant amount of the wild and rangeland urban interface (WUI), where development is fragmented and structures are adjacent to, or intermixed with, forest and brushland vegetation. These are the areas most likely to be exposed to high severity fuel hazards. Consequently, policies that influence investment decisions by private property owners and public entities and policies that influence how CAL FIRE is able to operate in the future are likely to have a substantial effect on the state's vulnerability to wildfire. Many of the land owners today lack the capacity (financial or technical) to effectively manage fuels in order to reduce the impacts of fire to the structures and ecosystems on their property. Furthermore, risks are often shared, especially among smaller parcels; i.e., land management on one parcel affects risks on neighboring land. In order to effectively reduce the impacts of fire to the structures and ecosystems in these areas, landscape level activities are needed to manage fuels. The state currently has limited resources and authority to address these issues at the level needed.

[51] Max A. Moritz (2003), SPATIOTEMPORAL ANALYSIS OF CONTROLS ON SHRUBLAND FIRE REGIMES: AGE DEPENDENCY AND FIRE HAZARD. Ecology: Vol. 84, No. 2, pp. 351-361.

[52] N.L. Miller and N. J. Schlegel (2006), "Climate change projected fire weather sensitivity: California Santa Ana wind occurrence," Geophysical Research Letters 33, L15711.

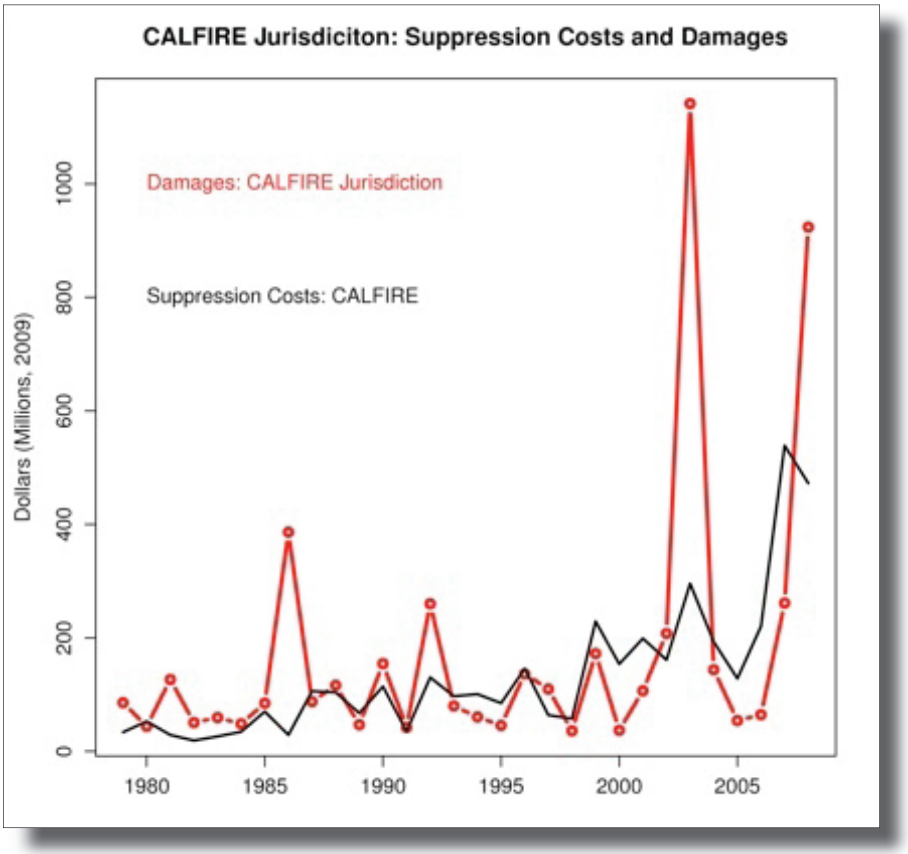
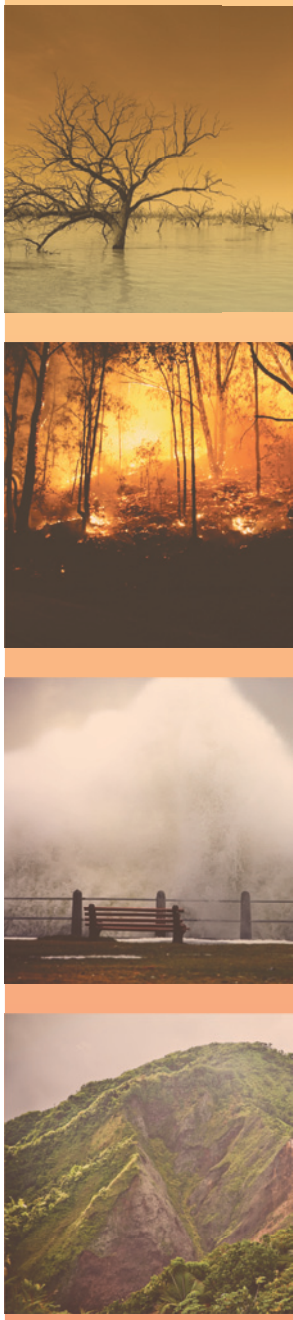


Figure 11: Suppression costs and damages due to wildfires within CALFIRE jurisdiction only, since 1979. Annual totals by fiscal year, adjusted for inflation (2009 dollars). Federal costs for fire suppression in California show a similar increase in recent decades.

Equally important, substantial wildland areas faced with wildfire risks are federally owned and managed (e.g., by the Forest Service, the Park Service, and the Defense Department). Federal land management policies are focused on vegetation management as a major strategy for reducing severe fire risk to both federal lands and adjacent communities. However, federal measures cannot overcome uneven vegetation management efforts on neighboring private lands that fall within CAL FIRE's protection responsibility. Therefore, while our recommendations are relevant to federally managed lands, they are directed primarily at the need for greater state and private management practices. These, in turn, need to be implemented in close coordination and cooperation with federal agencies.

The increased threat of major forest fires poses both a challenge and an opportunity for the state of California. Policies and practices that reverse the historic build-up of fuels and restore a more natural role for fire in the state's forest and other ecosystems, can at the same time, reduce the state's economic vulnerability to wildfire risks, leaving those fires more manageable when they occur. Implementation of such practices can also improve the health of California's forest ecosystems overall, enhancing their resilience to climate change.[53] Similarly, policies that limit the

[53] B.P. Bryant and A. L. Westerling (2009), "Potential Effects of Climate Change on Residential Wildfire Risk in California," Public Interest Energy Research, California Energy Commision, Sacramento, CA.



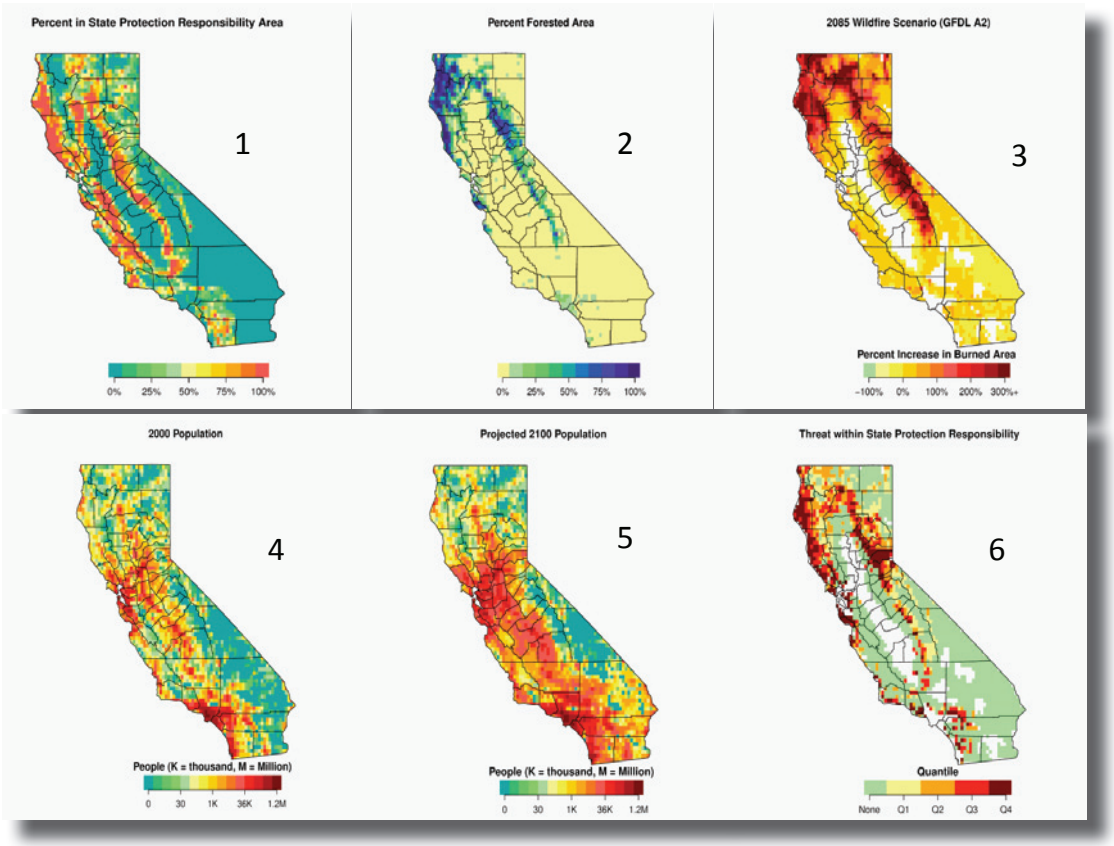


Figure 1 2: A graphical example of the potential threat from future increases in wildfire and development, using the intersection between the state protection responsibility area (i.e., CALFIRE jurisdiction (panel 1)), the currently forested areas of California (panel 2), a scenario for future wildfire (average increase in burned area for 2070-2099 compared to 1961-1990 for a high emissions pathway using the GFDL climate model, and assuming forest ecosystems remain in their current extent (panel 3)), and scenarios for current (year 2000) and future population (the U.S. Environmental Protection Agencies mid, or base case, growth and sprawl projection for California in 2100 (panels 4 and 5)). The intersection of these factors is shown in panel 6 as quantiles of a threat index. The darker red areas show the locations with the greatest combination of population, forest, and increased fire risks within the state protection responsibility area.

expansion of existing and development of new communities *into highly vulnerable fire areas* where fire is difficult to manage will reduce future property losses and fire suppression measures.

Overall Recommendations Specific to Wildfires

Recommendations for Immediate Action

Resilience as the cornerstone of wildfire management

California needs to shift its basic approach to forest fire management from fire suppression to threat reduction through developing zoning, building codes, and forest management practices that make the state more resilient even in the face of increased fire threats due to clime change.

We therefore recommend a three part resilience-based approach that requires: (1) more widely and effectively employing vegetation and ecosystem management to reduce fuels and fire severity; (2) adopting building codes that reduce the risk of loss to property exposed to fire threats; and (3) adopting zoning ordinances that result in communities being less exposed to wildfire risks, and in combination, reducing the complexity and scale of the fire management challenge.

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The shift in approach will involve near-term increased costs through significantly increasing vegetation management while continuing to provide fire suppression to protect existing structures and disturbed ecosystems. Over time, a combination of mechanical treatments and prescribed fires can be used to reduce surface and ladder fuels, increase mean tree size, and favor the cultivation of more fire-resilient tree species.

In the long term, the forest ecosystems allowed to develop over the past two centuries can be made less prone to severe fire by reducing biomass and altering fuel structures. Reduced fire severity will reduce the impact of climate change on wildfire and ecosystems. Reduced fire severity will also allow greater use of wildfire to maintain these more natural fuel conditions, facilitating vegetation and fire management.

Integrating fire and fuels management plans with land use, air pollution, and ecosystem management planning

Our recommended approach to land use, building standards, fire, and vegetation management strategies complements other public policy goals such as reducing exposure to air pollution and improving ecosystem health and sustainability. Moreover, these policy goals cannot be successfully pursued separately. For example, the effectiveness of various options for fuels management in reducing the risk of severe fire is dependent on ecosystem type and history. Similarly, ecosystem health is closely linked to human activities and development that have resulted in increased fuels and fire severity. Likewise, habitat for endangered species has been affected both by the legacy of past management and land use and by any new disturbances related to either climate change or implementing fuels reductions and ecosystem restorations. Consequently, wildfire use for fuels management cannot be conducted on the required ecological scale without a careful assessment of the balance between priorities for reducing long-term climate change induced risks of wildfire, on the one hand, and for limiting the short-term effects of wildfire on habitat, human settlements, and air quality, on the other.

The required local and regional planning efforts necessary to change the approach to forest management will need to include communities and private landholders in the wildland-urban interface, state and federal land management agencies, and relevant regulatory agencies. Planning should have the scope and capacity to evaluate multiple competing objectives and methodologies related to land use, building standards, fire management, vegetation and ecosystem management, and air pollution management. The result should be an integrated strategy on which public support for implementation can be built.

General Task Force Recommendations Applied to Wildfires

Risk Assessment: Specific risk assessment for wildfire prone areas

The Climate Risk Council will need to conduct specific risk assessments for wildfire prone areas susceptible to accelerating climate change. It willl need to periodically review how this is likely to affect forest management practices. It will need to assess their implications for wildfire risks to communities, infrastructure, and ecosystems, and provide accessible, location-specific risk assessment products at appropriate scales relevant to decision making processes.

Public Engagement: Develop realistic understanding of the true risks among forest and fire managers and support for new practices among the public

The shift from the historically predominant suppression approaches to adaptation management will not come about by itself, nor will policy changes alone suffice. Forest and fire managers at all levels must understand and accept this, and the public must come to support and actively engage in its implementation. This requires a better understanding of the very demonstrable risks that Californians already face and how climate change – together with continued development and forest management practices – could very well produce a "perfect storm" of increasing wildfire risks across the state. Property owners should understand the risks and also the practical and feasible actions they can take to reduce the risks to their own properties. To design an effective outreach, education, and active engagement process, state and local agencies must understand how their stakeholders think about fire risks, climate change, the range of response options, and related values of living near the wildland/urban interface.

Adaptive Management: Invest in long-term monitoring and evaluation and timely feedback on adaptive actions taken

Vulnerability to fire is a complex problem where the actions of humans interact with a changing climate. When we set about building resilience to fire, there will be large uncertainties about whether our chosen actions will result in the desired outcomes. An essential feature of any management approach will be the need to provide for adaptive management, or "learning by doing." Successful adaptive management requires long-term, consistent commitments to monitoring, evaluation, feedback, course corrections, and open communication on each of these fronts. This may require policies and procedures for ensuring that organizational cultures promote and reward these actions.

Important Issues for Further Study

Funding: Further study is required on financing mechanisms that align incentives toward adaptive actions among property owners

Significant public and private investments are needed to reduce vulnerability to wildfire risks and to support planning and capacity building for adaptation. This can be accomplished through modifications to insurance policies to reward adaptation, rebates for adaptation measures, fees and surcharges, public and private mandates, and investment funds providing grants and low-interest loans.

Built environment: The majority of structures that will be in place as fire risks increase in future decades is already built. Moreover, it has been shown that individuals tend to underestimate their exposure to such hazards. Property owners tend to use a high discount rate when assessing the costs and benefits of retrofitting existing structures to conform to current building codes designed to reduce vulnerability to loss from hazards. Homeowners may have relatively short residency times in a given location. While adaptation costs in this situation will be borne up front, benefits from retrofitting homes to reduce vulnerability to hazards such as fire accrue over a long time period. It is for these reasons that the we think that incentives strategies are the preferred way to bring about the optimal level of private investments to reduce long-term wildfire risks.

New development: New development: should not be permitted to increase vulnerability to wildfire risks.

Building codes: Although building codes are regularly updated to reduce the vulnerability of structures to fire, financial and regulatory incentives may need to be introduced to encourage faster development and adoption of new fire resistance strategies. The state should commission a study to assess the feasibility of policies to accelerate the development of new fire-resilient technologies, especially for retrofitting existing structures.

Funding support: Property owners should generally be responsible for costs of vegetation management on their property. However, in places where the legacy of long-term fire exclusion has produced extremely challenging fuel conditions, additional sources of support for implementing needed vegetation management may be justified.

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Fire and Range Wildfires Case Study: El Dorado County, California

El Dorado is a rural California county readily accessible by highway from the Sacramento metropolitan area and Lake Tahoe. Its population was estimated by the US Census Bureau to be 178,447 in 2009, a 14.2% increase over the year 2000 census. The county has averaged population growth of thirty-eight percent per decade since 1960. Population density (91/sq mi) is less than half that of California as a whole.

Pollock Pines, located near the center of the county, is a good example of the issues that Sierra foothills communities face in managing wildfire risks. It sits near the boundary between the California state fire protection responsibility area managed by the Amador–El Dorado unit of CAL FIRE and the western border of the El Dorado National Forest. The USDA Forest Service manages fire risks on a mosaic of federal lands surrounding the community, while the population and private property at risk lie primarily within the state responsibility area managed by CAL FIRE. Large fires have occurred regularly in the surrounding state and federally managed areas throughout the last century (Figure 1).

Fire risks in the Pollock Pines area are anticipated to increase substantially in coming decades due to climate change, with increases in wildfire burned area expected to increase by one hundred percent or more by the end of the 21st century across a conservative range of climate projections according to impact assessments for California wildfire.

Management of fire risks in and around Pollock Pines is governed by a multitude of planning processes, including the National Fire Plan and the Healthy Forests Initiative, the California Fire Plan, the El Dorado County Wildland Fire Hazard Mitigation Plan of the El Dorado Fire Safe Council and the Amador-El Dorado Unit of CAL FIRE, the El Dorado County Community Wildfire Protection Plan, the CAL FIRE Amador-El Dorado Unit Fire Management Plan, and the Eldorado Forest Land and Resource Management Plan.

Fire hazards are a well-recognized danger to communities throughout El Dorado County, and fire hazards mitigation is a high priority activity of federal, state and local community planners and resource managers. The state fire protection agency, CAL FIRE, protects 566,000 acres in El Dorado County, including 311,000 acres classified as "very high" fire severity hazard (which includes all of Pollock Pines). Building

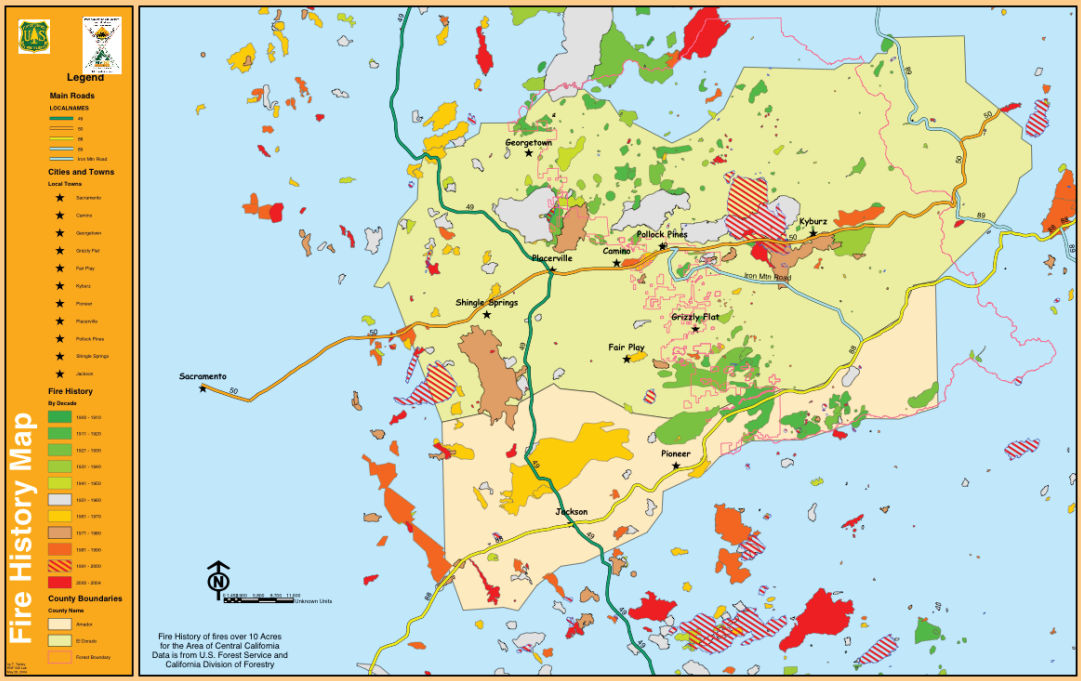


Figure 1. Fire history for fires over 10 acres in and around El Dorado and Amador counties.

permits for new construction in high to very high fire severity hazard zones require compliance with new ignition-resistant building codes implemented on January 1, 2008 after severe property losses due to wildfires were experienced in the state during the last decade.

Another approach taken by the state to reduce fire hazards is to require defensible space around structures at risk. State law requires one hundred feet of defensible space around buildings, unless the defensive perimeter would extend beyond property lines. Homeowner's insurance companies are allowed to require larger defensive perimeters (though still within an owner's property line) with the approval of a designated authority. Assembly Bill 2301 would authorize insurance companies to require defensive perimeters beyond a property line if the adjacent land is publicly-owned, require state public lands management agencies to grant right of entry for this purpose, and provide for an exemption from the California Environmental Quality Act. While planning for growth has led to improved building standards in recent years, most buildings predate the new building standards and their risks are typically not reduced by these measures. Decisions on development in fire-prone landscapes have not been determined by fire safety issues.

Fuels reduction programs are a consistent need throughout the county to reduce fire hazards — both because fire suppression and land use changes have increased fuels on the landscape in many places and because vegetation can regenerate rapidly after thinning treatments. Increased fuel loads can lead to increased fire severity, increasing the danger from wildfires to property, public health and safety, and ecosystems. The potential for interactions between these two human-caused sources of increased fire risks (climate change and increased fuels due to fire suppression and land use changes) is both a concern going forward and an opportunity. High fuel loads increase vulnerability to increased wildfire due to climate change, but successful efforts to reduce fuel loads can reduce vulnerability to climate change.

Projects to reduce significant fuel accumulations on private lands can qualify for state assistance through a variety of mechanisms, including Community Assistance Grants, the Vegetation Management Program, and the California Forest Improvement Program. However, the last funding for these efforts was authorized through Proposition 40 in 2002, and available resources are well below current needs to maintain or reduce the current fire hazard. The Eldorado National Forest has more resources for vegetation management to reduce fuels and fire risks than the local CAL FIRE unit, but funding has still been too low on average and uneven from year to year. Recent reductions in the price of fiber products have reduced revenues from timber sales and Stewardship Contracts. Since these are sources of revenue for vegetation management, this has exacerbated ongoing shortfalls. Both state and federal efforts prioritize community protection, implying that funds for restoring fire and fuels to more natural, sustainable conditions in areas remote from direct threats to communities, may be lagging as well.

Time horizons for planning in the local CAL FIRE and Forest Service units typically range from two to five years. Given the reality of sustained, long-term accelerating risks from climate change, a planning process with a longer view may be required to prioritize effectively vegetation treatments on the landscape and deal with long-term issues such as climate-resilient replanting strategies to enhance carbon storage on burned-over public and private lands.

An effective comprehensive approach to reducing vulnerability to current and future fire risks in communities like Pollack Pines requires longer planning time horizons, active monitoring of conditions, continued coordination among multiple public agencies and private landowners, and adequate resources over an extended period to make progress on managing vegetation to restore fuels to safer, more sustainable levels and reduce the risk of large severe fires.

Water Supply Case Study: Drought in Australia's Murray Darling Basin

Introduction

Twelve years ago, the rain stopped falling in southeast Australia. The average temperature has climbed 1.6 degrees Fahrenheit since 1950, according to the Commonwealth Scientific and Industrial Research Organization, Australia's respected science agency. So much less rain is falling that surface flows across the region's river valleys have been cut 40 percent. Over the past decade there has been so little water left in the lower sections of the Murray-Darling river system that for every four out of ten days, the Murray River doesn't even have enough flow to reach its mouth in the Great Southern Ocean south of Adelaide.

This on-going drought is not only a result of climate change: it is a test of an industrial society's ability to cope with new and dangerous conditions that threaten its ability to survive. Outside the country's borders, the crisis was hardly known until Australia's one-million-ton rice crop failed two years ago. The crop disaster wrecked the economies of rice-producing towns and caused world food prices to rise, prompting food riots in poor nations. But in the aftermath, the area is re-tooling itself to become one of the most water-efficient regions in the world. This is a story of a resilient people who have learned the value of water and have found new and better ways to manage their increasingly scarce supplies.

Background

The Murray-Darling River basin is home to Australia's fifth largest city, Adelaide, and accounts for 65 percent of irrigated agriculture in Australia. The basin is commonly referred to as the nation's "food bowl," producing over one-third of Australia's food supply (Craik and Cleaver 2008). The Murray-Darling basin occupies one million square kilometers in the southeastern corner of Australia. Originally a predominately dry-farming region, the Basin became a center of irrigated agricultural production in the post World War II era when soldier resettlement schemes promised free or cheap land and later, expanded availability of water for irrigation uses.

Irrigated agriculture in the southern Murray-Darling Basin is supported by large reservoirs in the Snowy Mountains and, to a lesser degree, groundwater aquifers across much of the region.

Construction of the Snowy Mountains Scheme began in the 1940s to supply more water to the region and culminated in the early 1970s with the completion of sixteen major dams, 145 km of tunnels, 80 km. of aqueducts, and seven major power stations. The American Society of Civil Engineering recognized the project as "one of seven civilian engineering wonders of the modern world." The project and supporting government policies successfully encouraged agricultural development and water use, diverting 86 percent of the natural flow of the Murray-Darling Basin by 1995 (Australia's Chief Hydrologist, personal communication,. 2/17/09). Rising water diversions, however, were accompanied by emerging environmental problems in the region, including toxic algal blooms, decreased water quality, loss of wetlands, and high soil and water salinity. Over the last decade, these issues have been exacerbated by prolonged drought and emerging climate change impacts.

Impacts of the Drought

Between 2006 and 2008, much of the Basin received extremely low annual precipitation; in fact, the 2006 water year had the lowest runoff on record in the Murray-Darling Basin (Figures x and y). During this period, many farmers with general security allocations received zero percent of their annual water allocations, while those with high security entitlements received severely reduced allocations, with catastrophic impacts on the agricultural sector in both social and economic terms. Impacts on irrigated agricultural production are best illustrated by rice production, which declined from more than one million tons in 2006 to fewer than 20,000

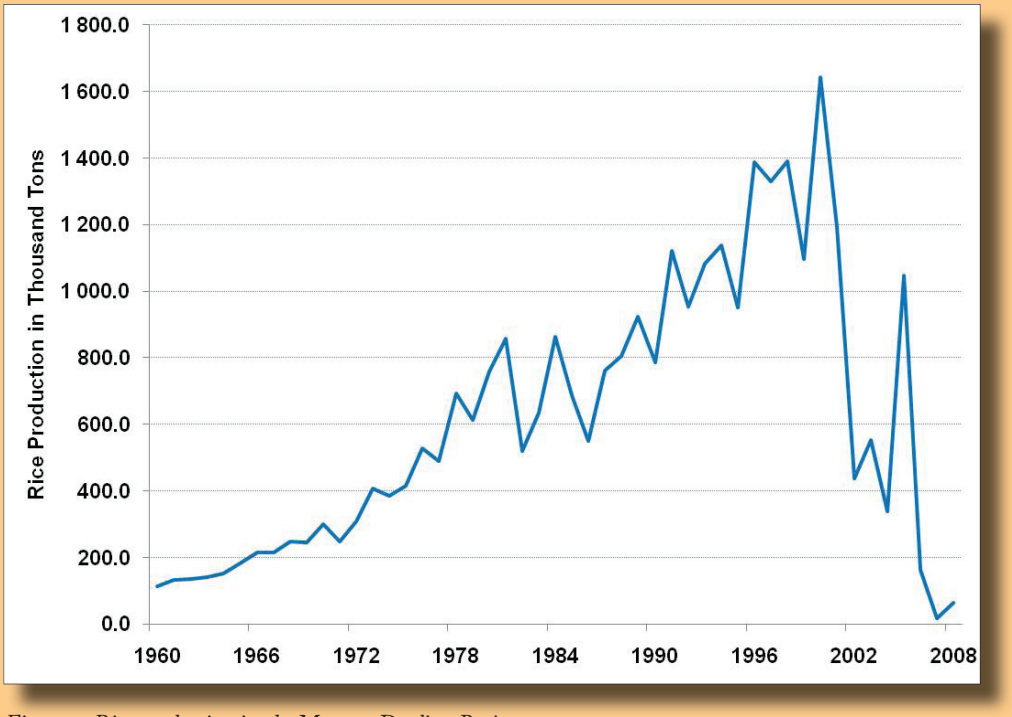


Figure z. Rice production in the Murray-Darling Basin
Source: Annual crop reports from 1960-2008 from the Australian Bureau of Agricultural and Resource Economics (ABARE 2009).

tons in 2008, a 98 percent reduction (Figure z). Production of other commodities such as wine grapes, citrus, vegetables, irrigated pastures for the diary industry, and cereals production were also severely affected (ABARE 2009).

In addition, the city of Adelaide has been hard hit by the increasing salinity of the Murray River. "It's a city of more than one million people that gets 70 percent of its water on average from the River Murray, but the Murray-Darling basin has been in decline for decades," said James Pittock of the Australian National University (cited in Hart 10/12/09). The *Guardian* recently reported that salinity levels have reached 1,200 EC in the Murray River, which is 400 EC above the World Health Organization's acceptable drinking level (O'Loughlin and Vidal 09/28/09).

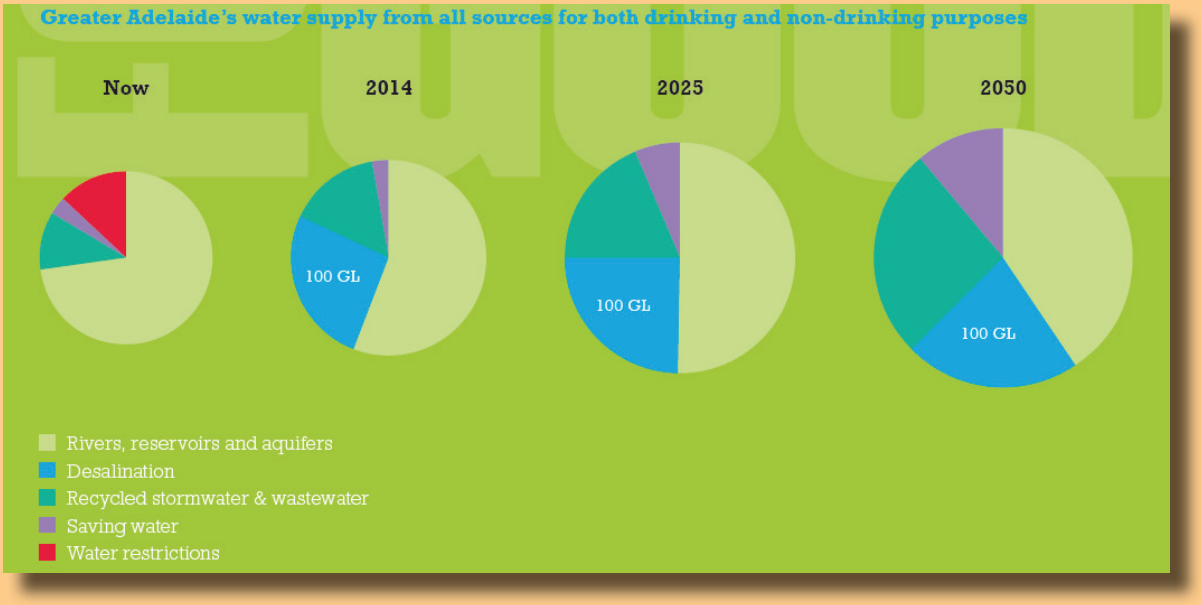
Initially the drought was considered simply one of many in a region that is prone to these events. Today scientists believe that these recent events in Australia are a harbinger of long-term climate change. Indeed, Australia's Bureau of Meteorology predicts that within two to three decades, drought will occur twice as frequently and be twice as severe (Circle of Blue 2009).

Increases in the frequency and intensity of droughts are consistent with recent projections for the western United States, including California.

Water Policy Reform

There have been a variety of water policy reforms from the local to national scale. At the regional level, the government of South Australia has developed a comprehensive plan to diversify the water supply. Over the next few decades, Adelaide's water supply will shift away from surface water, reservoirs, and groundwater extraction to greater conservation and efficiency, recycled wastewater, stormwater capture, and desalination (Water for Good 2009).

These changes are being bolstered by a variety of regional efforts, including a new billing system that aligns incentives for more efficient water use and provides better information to water customers about their water use. For instance, a tiered water rate structure was developed that charges more as more water is used, and a new format for the bills was created to clearly delineate the amount of water consumed over a particular



time period and to separate water supply charges from wastewater charges. In addition, the South Australian government created a public education program called WaterWise Communities. People can register online to receive a freeWaterWise kit. The kit for households includes a checklist of tips on how to use water wisely in the home and garden, a four minute shower timer, a personal water saving plan, a fridge magnet with water saving ideas, a bookmark, a gardening calendar, a letterbox sticker, and a H2OME rebate booklet detailing water saving rebates. There is also a kit for businesses and community groups that includes a checklist of tips on how to use water wisely throughout the workplace, a reception window sticker, a fridge magnet with water saving ideas, plus bathroom mirror and shower stickers encouraging wise water use.

At the national scale, in 2007 Australia commenced reform of its water management system to incorporate this new, water-scarce reality, passing the Commonwealth Water Act. The Act and accompanying intergovernmental agreements have seen constitutional rights over water resources in the Murray-Darling Basin assigned by the states to the Commonwealth and investment of approximately $13 billion Australian dollars (~$US 10.5 billion) in water reform measures, including:

- federalizing water data collection,
- requiring greater regulatory reporting (e.g. water balances and a National Water Account),
- moving to full cost recovery for all water infrastructure and services,
- creating a market for water trading (based on tradable property rights and in combination with a review of existing caps on water extractions),
- increasing on-farm efficiencies (e.g. canal lining, drip irrigation, shifting to more water-efficient crops), and
- purchasing water entitlements from willing sellers to restore aquatic ecosystems.

In retrospect, the Snowy Mountains Scheme did not protect the agricultural sector from severe and prolonged drought and emerging climate change impacts best reflected in reduced snowmelt, precipitation, and runoff. Instead, Australia's Chief Hydrologist has argued that the project may have actually increased the vulnerability of the basin's farmers to water scarcity by creating an artificially inexpensive source of water that was perceived as a secure supply.

Today, farmers in the Murray-Darling Basin are leaders in implementing innovative, on-farm water conservation and water-efficient production and management practices.

Unfortunately, the focus on increased agricultural water conservation and efficiency came too late for many. While some have suggested that the fate of the Murray-Darling Basin could be California's future, we have the advantage of learning several important lessons from the management mistakes that contributed to severe agricultural decline there. Key among these lessons is that massive storage capacity in a basin is no guarantee of a reliable or predictable water supply, especially when total precipitation and runoff decline. Another is that the most innovative and efficient farmers are better able to withstand periods of shortage.

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Sea Rise Level Case Study: Monterey, California

In 2009, the city of Monterey was home to just over 29,000 permanent residents (doubling or even tripling during the high tourist season and popular weekends). With just eight square miles of land area, the city is densely populated (3,516 people/sq. mile). The predominantly white, well-educated city population has a higher-than-state-average median household income of over $49,000, half the State's poverty rate, and one of the lower unemployment rates in Monterey County.[1] Located on the southern end of Monterey Bay, the city is considered one of the jewels along Northern California's outer coast where residents enjoy sweeping views of the Bay and the federally protected Monterey Bay National Marine Sanctuary, plus access to beaches to the North and the wild coast and steep cliffs of Big Sur to the south. Monterey is also no stranger to the relentless onslaught of storms and wind-driven waves that erode its shoreline, particularly during El Niño winters, when sea level is higher than usual and storms hit the coast with increased frequency (see Figure).[2,3]

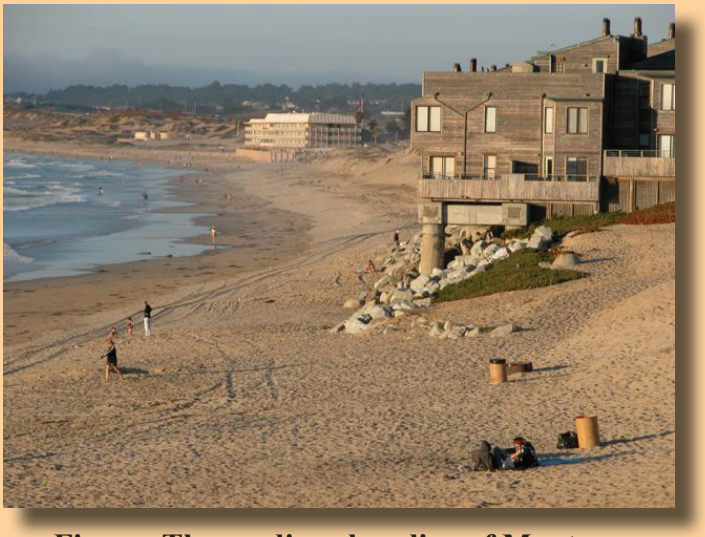

Figure: The eroding shoreline of Monterey
Source: David Revell

Monterey's erosion problems are common along California's coast. Eighty-six percent of the state's 1,100 miles of open ocean coast is eroding,[4] resulting in coastal cliffs retreating at an average rate of 10 to 30 centimeters (up to one foot) per year, although erosion rates can be as high as 4.5 meters (~15 feet) per year.[5,6] Historically, the most popular option to manage shoreline retreat in California has been the construction of coastal armoring. A loophole in the state's Coastal Act has hindered strict implementation of the law's explicit restriction of armoring for all structures built since the late 1970s. As a result, more than 10% of California's coastline is now armored. By 1998, at least 15 miles of the National Marine Sanctuary's 276-mile shoreline were armored by seawalls and

[1] US Census Bureau data for Monterey City: http://quickfacts.census.gov/qfd/states/06/0648872.html

[2] D. Smith, K. Gref, A. Hoffmann, and L. Turrini-Smith. (2005),. Are "Stable Shorelines" and "Broad Beaches" Mutually Exclusive Management Goals Along Southern Monterey Bay? Report WI-2005-09. Monterey, CA: The Watershed Institute, California State University Monterey Bay.

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[5] G.B. Griggs and K. Patsch (2004a), "Cliff erosion and bluff retreat along the California coast." Sea Technology September: 36-40.

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riprap, including areas along some of the most severely eroding portions of Monterey's city shoreline.[7],[8] Typical impacts of such armoring along retreating shorelines include aesthetic depreciation, beach loss due to placement of the armor on public beaches (often resulting in access restrictions), loss of sand supply from previously eroding (now armored) cliffs, resulting passive and active erosion, and thus reduction of habitat for various beach and dune-dependent species.[9]

Over the last few years, a remarkable shift has begun in how the city, other local jurisdictions along the Bay, the state, and the National Marine Sanctuary are thinking about managing regional erosion problems. In fact, to address them effectively, all will need to work together. The Monterey Bay National Marine Sanctuary (MBNMS) has been addressing the issues through its Sanctuary's Management Plan, the goal of which is to reduce expansion of armoring in coastal areas through proactive regional planning, project tracking, and comprehensive permit analysis and compliance.[10] In 2005, the Sanctuary, in collaboration with state and local partners, initiated the Southern Monterey Bay Coastal Erosion Work group to facilitate the development of such a regional approach to coastal erosion. The twenty member workgroup is made up of scientists, federal and state agencies, local governmental representatives, conservation interests, and other local experts. The Workgroup's goals are: to compile and analyze existing information on erosion rates; identify critical erosion areas; identify and assess the complete range of options available for responding to erosion; and develop a proactive and comprehensive regional shoreline preservation, restoration, and management plan with selected site-specific and broader area-wide recommendations that minimize environmental and socioeconomic impacts to the maximum extent feasible.[11]

The city's initial goal – in conjunction with the regional workgroup – was to end the piecemeal approach that typically led to more armoring and more loss of beach area, and instead develop a shoreline management program. By 2009, however, it became clear to city planners that Monterey needed to develop a longer-term adaptation strategy for sea level rise. "Dealing with sea level rise goes considerably beyond our local expertise," according to senior city planner, Kimberly Cole. "Our local budget is insufficient, and we lack the local technical resources." While the regional approach helped to develop a common long-term vision and bring relevant stakeholders to the table, finding near- and long-term solutions requires solving conflicts among local, state, and federal rules and regulations in overlapping jurisdictions. "In some important instances the three jurisdictions have conflicting management plans, different directives that hinder moving forward. For example, the National Marine Sanctuary has rules that prevent us from using dredge material on the beach in front of eroding properties." Some interim solutions will be needed, though what they might be is not yet clear in light of immanent erosion threats to shoreline development. "We'd like to avoid further armoring of our coastline."

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[7] G.B. Griggs., K.B. Patsch, and L. Savoy, Eds. (2005), Living with the Changing California Coast. Berkeley, CA: University of California Press.

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[9] R. Stamski (2005), The Impacts of Coastal Protection Structures in California's Monterey Bay National Marine Sanctuary. Silver Spring, MD: NOAA, National Ocean Service, Marine Sanctuaries Division.

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