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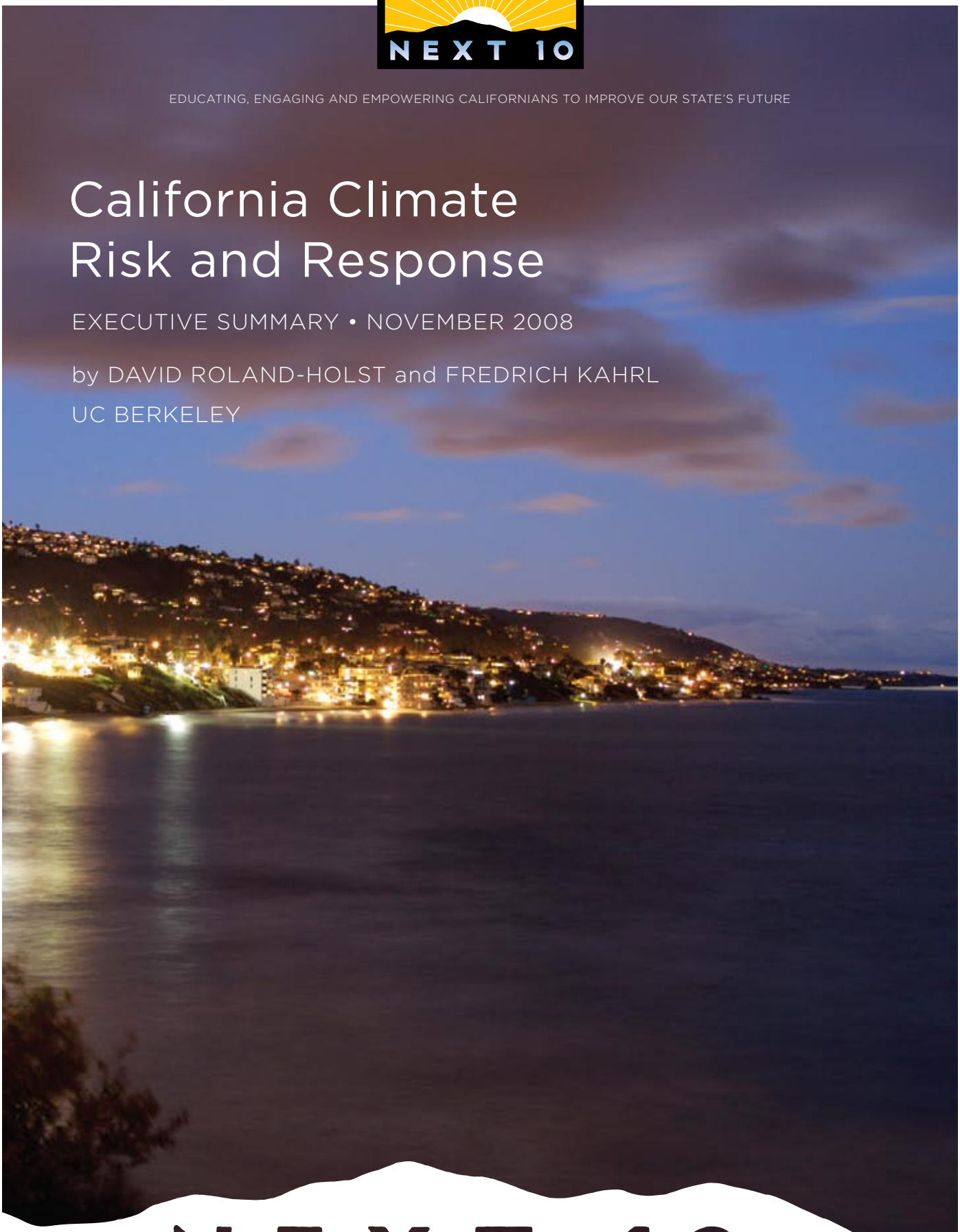
EDUCATING, ENGAGING AND EMPOWERING CALIFORNIANS TO IMPROVE OUR STATE'S FUTURE

California Climate Risk and Response

EXECUTIVE SUMMARY • NOVEMBER 2008

by DAVID ROLAND-HOLST and FREDRICH KAHRL

UC BERKELEY



NEXT 10

At this moment in history a financial crisis of global proportions is unfolding. The impacts of this disaster will be felt for years to come, and its cost borne by future generations. A universal lesson also comes from this crisis: Markets can deliver profits, but they may not deliver sustainability. For this reason, the public interest must be secured at all times by policy foresight and responsible leadership.

The serial market failures sparked by the collapse of the housing industry and credit markets have profound consequences for California's budget. Given the current fiscal uncertainty, it is reasonable to challenge government priorities, assessing the long-term economic and social performance of every dollar of government spending and every regulation. Chief among the state's priorities is Governor Schwarzenegger's Executive Order #S–3–05 (Schwarzenegger 2005) which calls for a 30 percent reduction below business-as-usual of greenhouse gas emissions by 2020 and 80 percent below 1990 levels by 2050. The Global Warming Solutions Act (AB 32), which was signed into law September 2006 and mandates a first-in-the-nation limit on emissions that cause global warming, requires that the California Air Resources Board (CARB) put an implementation plan (Scoping Plan) in place by January 2009. This December, CARB will vote on this policy roadmap to meet the emissions reduction target of 169 Million Metric Tons of Carbon (MMTCO2) equivalent by 2020 to stabilize at 427 MMTCO2 overall.

It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.

— Charles Darwin

This policy is a hallmark example of the proactive initiatives needed to sustain California's prosperity, overcoming short-term challenges to put the state on a long-term path of lower carbon emissions and higher economic growth.

Multiple studies have been conducted assessing the economic impacts of CARB's Scoping Plan. CARB's own economic analysis using the Environmental Dynamic Revenue Assessment (E-DRAM) model projects that the state's proposed package of policies will increase overall personal income by $14 billion, overall gross state product by $4 billion and result in the creation of 100,000 additional jobs. Using the Berkeley Energy and Resources (BEAR) Model, we find that if California improves energy efficiency by just 1 percent per year, proposed state climate policies will increase the Gross State Product (GSP) by approximately $76 billion, increase real household incomes by up to $48 billion and create as many as 403,000 new jobs. To document the economic potential of energy efficiency, we examined historical data and found that over the past thirty-five years, innovative energy efficiency policies created 1.5 million additional fulltime jobs with a total payroll of over $45 billion.

While multiple studies have been conducted assessing the economic impacts of CARB's Scoping Plan, to date, there has been limited economic analysis of California's climate risk—the impact of climate change if the state continues business-as-usual—or of the adaptation needed to cope with unavoidable climate change.

This report provides for the first time a comprehensive examination of the economic impacts of climate change and adaptation in California. In conducting this multi-sector assessment, we compile the most recent available science on climate damage, assess its economic implications, and examine alternative strategies for adaptation.

Core Findings

From the most general perspective, our review of the evidence on climate risk and response supports four overarching findings:

1. Our estimates indicate that climate risk—damages if no action is taken—would include tens of billions per year in direct costs, even higher indirect costs, and expose trillions of dollars of assets to collateral risk. Table ES1 below illustrates these costs.

2. Climate response—mitigation to prevent the worst impacts and adaptation to climate change that is unavoidable—on the other hand, can be executed for a fraction of these net costs by strategic deployment of existing resources for infrastructure renewal/ replacement and significant private investments that would enhance both employment and productivity.

3. At the sector level, there will be some very significant adjustment challenges, requiring as much foresight and policy discipline as the state can mobilize. In this context, the political challenges may be much greater than the economic ones. The state's adaptation capacity depends upon flexibility, but divergence between public and private interests may limit this flexibility. As in the current financial dilemma, resolving this will require determined leadership.

4. Despite the extent and high quality of existing climate research reviewed in this document, the degree of uncertainty regarding many important adjustment challenges remains very high. This uncertainly is costly, increasing the risk of both public and private mistakes and the deferral of necessary adaptation decisions. The process of improving research and understanding of climate effects may itself be costly and difficult, but policymakers must have better visibility regarding climate risk and response options.

TABLE ES1
ECONOMIC DAMAGE AND ASSET RISK ESTIMATES FOR CALIFORNIA (2006 USD billions)

	Damage Cost/Year		Assets at Risk
	Low	High	
Water	NA	0.6	5
Energy	2.7	6.3	21
Tourism and Recreation	0.2	7.5	98
Real Estate	0.2	1.4	900 Water
	0.1	2.5	1,600 Fire
Agriculture, Forestry, Fisheries	0.3	4.3	113
Transportation	NA	NA	500
Public Health	3.8	24.0	NA
TOTAL	**7.3**	**46.6**	

Note: These costs and assets at risk values are intended to be indicative. Annual averages do not represent the actual adjustment process, which will probably be nonlinear and dependent on timing of adaptation measures. The absence of a value in this table does not imply that its expected value is zero, but rather that its value might be negative (water in a B1 scenario) or we are not confident of available data needed to estimate it (e.g. costs for transportation). All of the values in this table are drawn from tables and text in the sections on individual sectors in full report. Finally, the total for assets at risk is omitted to avoid double counting.

Like most natural disasters, the detailed processes of climate change and ensuing damages are difficult to predict. For this reason, adaptation investments like levies are built against 100 or even 300 year inundation risks, rather than targeting for the next decade. All such events present a trend, cycles, and random variation. Sea level has a strong trend, but tidal cycles and random storms are less predictable. Temperature also has a strong trend, but fires are seasonal and subject to random outbreaks. From a strategic perspective, adaptation decisions should be informed by trends and decisions regarding sequencing of investments.

This study discusses trends over several decades and even to the end of the century. Strategic responses will depend on more detailed analysis of the adaptation in question. For example, bridges and overpasses have useful lives of 50-100 years, so climate adaptation based on the best available science should be incorporated in this kind of planning immediately. Other adaptation decisions must be deferred until we better understand the scope of risk, like seawater intrusion into farmland or drought tolerance. Decisions like insurance for coastal real estate lie somewhere in between, and in any case should be significantly guided by private market information and participation. What is most needed right now is capacity at the state and local level for better assessment and incorporation of this information into strategic planning.

Sector Findings

Seven strategic sectors are focal points for "California Climate Risk and Response." Our general findings for each are summarized below:

WATER

Water scarcity in California will increase sharply because of climate change, at least on a seasonal basis. Even in the most optimistic scenario, Sierra snowpack, a major source of water storage in California, is projected to shrink by 30 percent by 2070-2099. Drier higher warming scenarios put that number at 80 percent. All scenarios show significantly increased water flow in the winter, and decreased flow in the spring and summer, when water demand is highest. Combined with significant expected population growth, this will lead to considerable stress on the state's physical and institutional capacity for water storage and allocation. Higher water flow variability will also lead to increased risks of flooding, levee failure, saline intrusion, and drought-induced habitat destruction.

In the absence of climate defense measures, the potential costs of these climate impacts remains very uncertain, with estimates ranging from the hundreds of millions to several billion per year. To a significant extent, the difference in estimates are due to assumptions about how

the state would adapt to scarcity imposed by population and unavoidable climate damage even if the earth's climate is stablized. Water conservation is the most cost-effective means of reducing these pressures, but it is unlikely to be sufficient to avert more intense rural-urban competition. The water economy is seriously distorted by legacy rights, allocation, and pricing policies. Urban water users pay over 50 times more than agriculture (the major user) pays, even when accounting for treatment costs. Effective climate response may require a complete re-appraisal of rules governing the state's water entitlements and private use.

All told, there are an estimated $5 billion in assets at risk in the water sector; damage costs for the high warming scenario are projected to reach $600 million a year. Adaptation will add hundreds of millions of dollars to existing renewal and replacement costs.

ENERGY

Energy conditions in California depend on the evolution of the electric power and transportation sectors. Storm damage to transmission lines causing power outages leads to lost revenues and repair costs on the supply side and lost productivity for commercial customers. Changes in the seasonal availability of water will lead to a reduction in the state's hydropower resources, which last year accounted for 14.5 percent of California's total system power. At the same time, projected inland migration and population growth combined with higher temperatures will increase residential electricity demand. If, as some predict, per capita consumption rises by up to 50 percent over this century in the low warming scenario and 75 percent in higher but not the highest warming scenario (still below 2005 levels for the greater United States), as a result of dramatically higher air conditioning use, the state must fundamentally rethink policies toward electricity production, distribution, and demand. The cost impact of the loss of hydropower and increased summer electricity demand will not be uniformly distributed across California's electricity sector, nor will changes in rates and expenses. In northern California, the residential electricity supply is more dependent on hydropower, while heat driven increases in residential electricity use will be

concentrated in the Central Valley and Southern California.

The annual economic impact of climate induced damage in the energy sector range from $2.7 billion in the low warming scenario to $6.3 billion in the high warming scenario. $21 billion in energy assets are at risk.

In the near-term, demand-side management (DSM) programs that encourage reductions in peak load could effectively reduce the economic and environmental implications of an increase in summer electricity demand. In the longer-term, projected demand growth could reverse the state's historic progress in energy efficiency and reduce household purchasing power by billions of dollars per year, unless much more aggressive DSM policies are implemented. But demand side strategy alone will prove to be insufficient for the higher warmer scenarios in the long-term. To the extent that electricity supply growth would cause even greater climate damage, more aggressive commitments to renewable energy must be considered, particularly distributed technologies such as photovoltaic. Considering the public health, greenhouse gas and economic implications of peak electricity demand in California, the state is in urgent need of innovations that address the timing of electricity demand and the severity of social, environmental and economic impacts. Both climate mitigation (AB 32) and

adaptation imperatives suggest the need for a radical rethinking of electricity production and distribution in California. Without this kind of guidance, induced innovation and technology adoption will fall short of California's climate innovation potential.

TRANSPORTATION

Transportation is vital to the state's diverse but integrated economy, and especially to its national and international economic linkages. California's seaports (Los Angeles, Long Beach and Oakland) accounted for more than 40 percent of U.S. container shipping by volume and more than 23 percent ($425.5 billion) of the total foreign trade through the nation's top 50 international freight gateways in 2004. Within the state, air, rail, water and truck transportation accounted for $19.1 billion (1 percent) of California's GSP in 2006.

California transportation will confront critical challenges from climate change. Extreme weather (frequency and intensity of Pacific storms, extreme heat days) and sea level rise are the two largest climate induced impacts on the state's transportation infrastructure. Unfortunately, there has been very little research on this issue, so policy guidance at the present time is very limited. What we do know is that California's port infrastructure has several hundred billion dollars of real asset exposure to changes in sea level, tidal amplitude, and weather induced wave action. This includes many of the state's major airports,

which will require fortification or, at dramatically higher cost, relocation. Road systems around the state are also vulnerable to temperature increases in ways that are only beginning to be understood. In addition to asset exposure, the spillover effects of disabling this infrastructure would multiply economic damages significantly.

Much of California's transportation infrastructure is in disrepair. Nearly 30 percent of the state's roads and bridges are structurally deficient or functionally obsolete. The American Society of Civil Engineers gives the state a below average rating in both aviation and surface transportation infrastructure, and estimates that nearly $20 billion per year would be required to bring it up to a "B" rating. Given the longevity of transportation infrastructure, investment decisions being made now will have a dramatic impact on the state's ability to cope with climate change impacts. To date, there has been no assessment of the transportation sector's climate change vulnerability and potential risks, possible responses and costs, or evaluation of tradeoffs at either the state or federal level.

As in many other sectors reviewed in this report, California's transportation infrastructure will be strained by population growth over the next century. Climate change should be integrated in a broader discussion of how transportation infrastructure is designed, where and whether it is built, retrofitted or rebuilt, and how it is financed in California. Less development in high-risk areas could limit damage. We estimate $500 billion of transportation sector assets are at risk.

TOURISM AND RECREATION

Tourism and recreation are important sources of state income and employment and a large category of services to state residents and visitors. The California Travel and Tourism Commission estimated that travel spending alone in California was $96.7 billion or five percent of GSP, supporting nearly 925,000 jobs in 2007. Travel spending is also a significant source of local and state revenues.

44 percent of total travel dollars were spent in three coastal destinations: Los Angeles ($22 billion), Orange ($8 billion) and San Diego ($10.5 billion).

Climate change impacts on this sector overall will be negative, though there may be some winners and losers. In the highest warming scenario, California's ski industry collapses, taking with it $500 million in annual revenues and 15,000 jobs (not including supporting service industries). If climate is stabilized, a more likely scenario is a ski season shortened by half, with similar cuts in revenue. But warmer water and air temperatures will open new and expand existing recreation opportunities like golf, though weather variability, extreme heat, and drought may reduce the benefits. Of all tourism and recreation, beaches will suffer the greatest cost-related climate impact primarily through inundation as a result of sea level rise and accelerated erosion through an increase in Pacific storm activity and attendant changes in wave patterns. As an example, a detailed beach model for Los Angeles and Orange Counties projects that a one meter rise (lowest warming scenario) in sea levels would lead to an average 33 foot reduction in beach width. Overall, the model forecasts a 26 percent reduction of Los Angeles and Orange County beaches,

ranging from five percent at Humboldt State Beach to 100 percent reduction at Las Tunas. Extreme weather events could have a much more significant economic impact on beaches, dramatically increasing beach nourishment costs. Thus overall damage and adaptation costs suffered by this sector will mask substantial transfer effects, and total economic adjustments will be much larger than net benefits or costs.

We estimate that there are $98 billion in tourism and recreation assets at risk, with a projected annual price tag of $200 million to $7.5 billion in climate damage costs depending on the warming scenario.

As the state adapts to changing patterns of use in this sector, important opportunities and challenges will arise for public and private investment in environmental assets and services. Population growth has historically and will continue to have the largest impact on ecosystems. Going forward, the state should give greater recognition to linkages between environmental asset quality (e.g. coastal ecology, forest cover, parks) and willingness to pay for environmental services.

REAL ESTATE AND INSURANCE

Taken together these two sectors represent the largest economic climate risk for the state, although they are among the least studied to date. California has $4 trillion in real estate assets, of which $2.5 trillion are exposed, deeply implicating the insurance industry.

Three major climate change impacts have direct consequences for real estate:

1. Increases in the frequency and severity of wildfires, which burn property. The number of large wildfires in California is projected to increase by 12-53 percent, depending on the climate scenario.
2. Sea level rise and coastal erosion, which permanently inundate property.
3. Increases in the frequency and severity of Pacific storms, which destroy or temporarily inundate property through high winds, coastal flooding or other storm related activity.

The magnitude and scope of these impacts are not static; they are conditioned by demographics, economics and policy. Put simply, more people living in more high-risk areas means more damage.

A relatively small percent of the state's residential and commercial property faces direct climate damage, but it is concentrated in the most valuable markets. In addition to structures directly threatened, there is significant depreciation risk across all markets linked to forested, coastal, estuarial, or riverine real estate markets. Such linkages far outweigh direct damages.

Private insurers pay three-fourths of all weather related losses in the U.S., with the federal government paying the rest. Munich Re estimates that direct insured losses account for approximately 40 percent of all economic losses in catastrophic weather events. Using this estimate, the insurance exposure for near shore property in California could be on the order of $400 billion. Climate change will substantially increase risks faced by the insurance industry and insurers have begun to better assess their exposure. Insurers have historically played and could again play a leading role in loss prevention. But insurance is only possible when risks are quantifiable. The industry has historically looked to the past to price risk, but this approach will not be practical in evaluating climate risk, when both the potential for stabilization and local impacts are uncertain. The federal government's role of insurer of the last resort has historically created huge distortions in insurance markets by effectively depressing insurance premiums in high risk areas, thereby encouraging people to live there.
Combined estimates show that Californians could face from $200 million to $1.4 billion in additional annual water damage costs from climate change and from $100 million to $2.5 billion in additional annual fire damage costs. The state has over $900 billion of assets at risk because of water and $1.6 trillion in assets at risk because of fire.

Efficient adaptation to this challenge will depend critically on how the cost is allocated between private and public interests. If the government assumes the costs of climate defense and risk management, this represents a massive transfer of wealth from taxpayers to selected property owners, as well as a moral hazard in insurance and property markets that may drive prices far above more realistic risk-adjusted valuations, further inflating the public's climate liability. Unfortunately there is very little research to support policy guidance on this important climate issue.

AGRICULTURE, FORESTS AND FISHERIES

Agriculture plays an important role in California politics, society and economy. California is the largest farm producer in the U.S. and has been since 1948. California produces nearly half of all U.S. fruit, nuts and vegetables, many of which are only produced in California. With $15.1 billion in value added, agriculture accounted for only 1.2 percent of California's $1.74 trillion GSP in 2006. However, including its direct, indirect, and induced linkages, agriculture accounts for an estimated 6.5 percent of California's value added or more than $113 billion of 2006 GSP.

Climate change will have significant impacts on the agriculture sector, and while important politically, its economic significance will be challenged to keep pace with the scarcity value of its underlying land and water resources. Long-term economic and population growth will increase land prices all over the state, and climate change will raise the scarcity value of agriculture's second most important input, water, to unprecedented levels. For these reasons, we expect dramatic changes in agriculture over the next century.
To remain viable, California will have to improve the productivity of diminishing land and water resources available to this sector, at the same time upgrading

average product quality to pay much higher prices for those resources. Generally, we expect significant agricultural consolidation around high value and more technology-intensive crops.

Forestry accounts for an even smaller part (.1 percent of 2000 GSP) of the state's economy than agriculture.

But while it is a small income source, forests cover 39.7 million acres and 40 percent of California's total land area, playing an important role in our ecosystem. Fisheries, primarily squid and salmon, are worth a total of $100 million annually.

Both higher and lower warming scenarios will lead to a gradual but substantial change in the composition and location of agricultural, forest and fish production. Gradual warming might be beneficial for agriculture and forestry, but once temperatures exceed a certain level, the benefits of higher CO2 levels and warmer temperatures are negated by deterioration of basic plant functioning. While longer growing seasons may sometimes be good, earlier flowering poses a potential problem if plants become desynchronized with life cycles of pollinators. A reduction of the number of chill hours poses a significant problem for fruit and nuts, the largest primary agriculture revenue generator in the state. And warmer temperatures increase the growth rates of pests, weeds and pathogens. Rising temperatures may increase forest productivity around the world, but reduce their range. The largest impact on the forestry sector will be driven by the global market, as are many of the economic impacts of climate change, with timber supply increases causing prices to fall in the near-term. Reduced revenues from timber harvested on public land reduces funds used to manage forests, potentially forcing forest agencies to scale back on activities with implications for wildfire and pest management.

Extreme events such as heat waves and floods pose significant challenges to this sector including early flowering, reduced effectiveness of pollination, decreased ability for photosynthesis, decreased yield and demise of plants requiring long periods of growth. At higher temperatures, there is a marked decrease in feed intake in livestock, with more of their energy used for cooling. California dairy cows are particularly vulnerable because higher temperatures mean less milk. Of the top ten dairy counties in the state, a climate stabilization scenario shows a 7-10 percent reduction in dairy production, and 11-22 percent for the highest warming scenario.

We estimate that the agriculture, forestry and fisheries combined have $113 billion in assets exposed to climate damage, with an annual price tag of $300 million if climate is stabilized, to over $4.3 billion in the highest warming scenario.

PUBLIC HEALTH

Public health effects of climate change are overwhelmingly negative, with rising risks of heat-induced morbidity and mortality adding hundreds of millions of dollars per year to the human cost of climate change.

California has the worst air quality in the United States, with the number of deaths attributed to air pollution equal to traffic fatalities. There are two public health impacts of climate change that are both significant and relatively certain: an increase in ozone concentration and a rise in the frequency, intensity and length of heat waves. Changes in other air pollutants may also have important implications for human health. An increase in wildfire frequency increases the pollutant PM2.5—which

accounts for most of the pollution related mortality in California, and has a potential link to increased risk of lung cancer. The cost related impacts are hard to assess because it depends on fire specific characteristics and proximity to population.

Ozone formation in the atmosphere is dependent on meteorological conditions, including temperature, and higher temperatures in the troposphere increase the frequency of meteorological conditions conducive to ozone formation. Higher temperatures also increase biogenic emissions of VOCs, which leads to significantly higher ozone concentrations in some parts of California. Additional factors, such as the positive relationship between higher temperatures and the amount of NO emitted by power plants, could amplify these effects. A final concern is that the "background" rate of ozone in the troposphere, which is directly influenced by methane

emissions, has rapidly increased over the past three decades, and background ozone levels may soon exceed state standards.

An analysis of traditionally high ozone areas of Los Angeles (Riverside) and the San Joaquin Valley (Visalia) projects that the number of days with conditions conducive to ozone formation could increase by 25-80 percent by 2100, depending on warming scenarios.

Finally, left unchecked, rising average surface temperatures could lead to substantial increases in the number, length and severity of heat waves which dramatically increase the risk of heat stroke, heart attack, and severe dehydration, particularly among elderly, children, ethnic minority and farm worker populations.

The California Air Resources Board (CARB) estimates that air pollution—primarily ozone and fine particulate matter pollution—currently costs the state $71 billion per year as a result of 8,800 premature deaths ($69 billion) and hospital visits ($2.2 billion). Not included in the costs of pollution are the lost productivity associated with 4.7 million school absences and 2.8 million lost work days.

We estimate that the additional annual costs associated with an increase in ozone resulting from climate change ranges from $.5 billion to $10.2 billion, depending on the warming scenario. Heat related impacts results in additional annual costs ranging from $3.3 billion to $13.9 billion.

Public policy can play a significant role in adaptation, mainly through health education and targeted assistance to vulnerable (elderly and low income) groups who will need improved access to mitigating technologies (e.g. air conditioning, refrigeration). Controlling criteria pollutant emissions is the most powerful option for reducing the pollution-related impacts of climate change. AB 32 will undoubtedly play a role in pollution control efforts in California. Importantly, greenhouse gas abatement efforts through AB 32 may be a sufficient but not necessary condition for reducing air pollution.

The public health sector faces from $3.8 billion to $24 billion in additional annual costs associated with climate change impacts.

RECOMMENDATIONS

Taken together, these sector impacts portend direct losses of up to tens of billions of dollars per year if no action is taken, far greater indirect costs, and assets exposed to risk valued in trillions of dollars. In the absence of state action, private agency would combine limited defensive investment with long-term asset depreciation, as threatened real estate and other economic interests are abandoned or converted to lower value activities. Some of this is inevitable and perhaps desirable, as the alternative would be state intervention that promotes unsustainable resource use and/or transfers wealth from taxpayers to inefficient private investment. However, public policy still needs to play a prominent role in the adaptation process and, by a combination of forward-looking fiscal and regulatory determination, the state can promote more sustainable growth at lower private cost.

A wide array of adaptation policies, supported by more intensive and extensive research of the kind reported here can overcome market failures and provide the support and guidance needed for private agency to effectively share this adjustment burden. These would include, but are by no means limited to:

- Facilitation of more efficient water allocation within the state, including a comprehensive re-examination of regulatory approaches to efficient water and energy use, including systems of legacy entitlement and public/private cost sharing.
- More extensive and, where appropriate, intensive promotion of renewable energy technology, including innovation, diffusion, and adoption.
- Investments for climate defense of strategic state infrastructure.
- Investments in state natural landscape and recreational assets, and promotion of public-private partnerships for a new generation of tourism and recreation based on high quality, sustainable environmental services.
- Reassessment of state agricultural policy, with emphasis on knowledge-intensive agricultural innovation, higher value crops, water and land use efficiency, and environmental services.
- An integrated climate action plan for public health, including targeted policies to mitigate risk for the elderly and low-income groups.

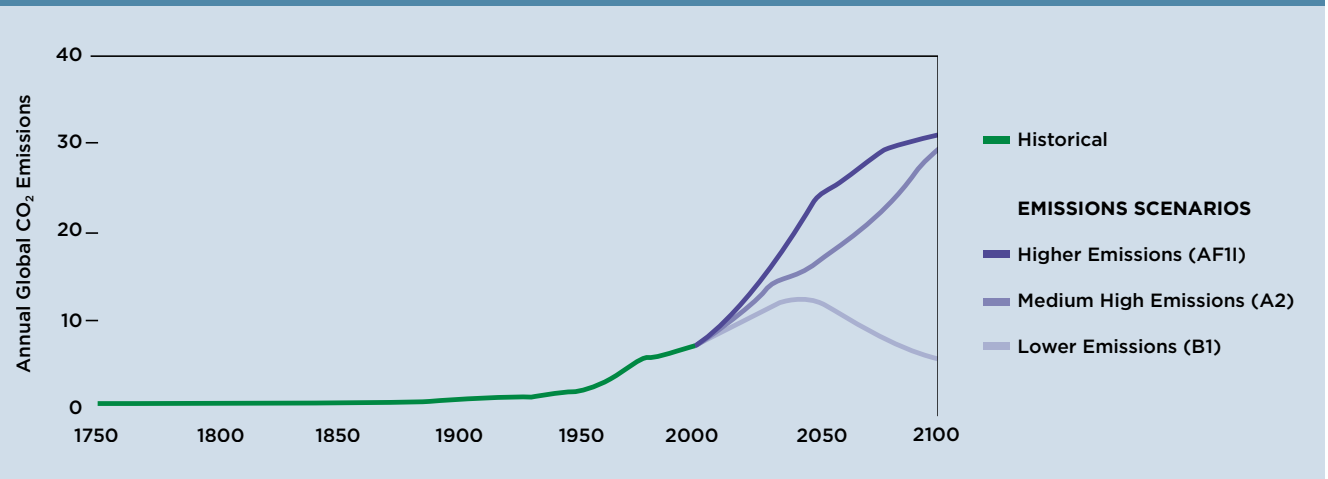
All these measures and more will help the state make its transition to a more climate resilient future, and continue California's legacy of innovative policy solutions that deliver sustained prosperity. Some will be very difficult to achieve politically, but all are necessary to avert higher long-term climate costs. Meanwhile, the present level of uncertainty regarding expected California climate damage is so high that returns on investment in more research could be quite substantial. For the time being, we must emphasize that the estimated annual cost ranges in Table ES1 only indicate an average adjustment burden. In reality, year-to-year costs will fluctuate very significantly, and the state must be prepared for the peaks of this variance. Until more detailed and precise guidance emerges, however, the best strategic option for the state must be: Hope for the best, but prepare for the worst.

METHODOLOGY

To compile data on climate damage, we rely on the most timely and authoritative climate science and analysis available, drawn from the top academic and other research institutions pursuing this important work. Most of today's climate models assess a family of four scenarios (A1, A2, B1, B2) defined by the Intergovernmental Panel on Climate Change (IPCC). Our work follows most of the climate modeling work in California and focuses on three of these scenarios: a fossil fuel-intensive, high emissions scenario where emissions rise rapidly and slow over time (A1fi); a medium-high scenario where emissions grow steadily over time (A2); and a lower emissions scenario where emissions rise until almost mid-century and then begin to fall (B1) (Figure ES1). A1fi and A2 represent a tripling, and B1 a doubling, of atmospheric CO2 concentrations relative to pre-industrial levels by 2100. The IPCC predicts that the A1fi and A2 scenarios will lead to substantial warming. Although the B2 scenario might be a climate-stabilizing scenario, it is still accompanied with a significant amount of warming and sea level rise.

After compiling the climate damage data, we then translate the physical impacts into seven economic sectors of greatest significance in this context: water, energy, transportation, tourism and recreation, real estate and insurance, agriculture, and public health. While the science on climate damage is now advancing rapidly, there has been less work done on the economic impacts of climate change. The science tells us definitively that climate change is occurring and will have significant adverse effects, but uncertainties remain about magnitudes. For example, polar ice melting appears to be accelerating faster than expected only a year ago. Because of this variance, we have estimated ranges for economic impacts and valued assets at risk in each category of climate damage. Impact estimates are driven by direct damages and collateral losses linked to these through markets. For example, damage to coastal residential property will induce an adverse contagion on nearby commercial activities assets.

FIGURE ES1
GLOBAL EMISSIONS TO 2100 UNDER AF1I, A2, AND B1 SCENARIOS



Source: Luers et al., 2006

CONCLUSION

The rise in global carbon dioxide emissions last year outpaced the IPCC's highest warming scenario and could translate into a global temperature rise of more than 11 degrees Fahrenheit by the end of the century, according to the panel's estimate.

California can respond to climate risk by developing effective strategies for climate response that include mitigation and adaptation. A real commitment to this would begin immediately by establishing and extending capacity for technical assessment and policy analysis, followed by timely and sustained policy activism. California's historic AB 32 initiative is a positive model for this, but only a beginning. The scope of long-term climate issues is much wider, and could sustain a longer-term agenda for economic stimulus based on mitigation and adaptation. Proactive measures, such as directing new and renewed public expenditures to more climate-secure infrastructure (e.g. the new Bay Bridge as a response to real but unpredictable earthquake risk, rapid rail, etc.), can stimulate local job creation and complementary private investments. Private sector growth can be further accelerated with investment incentives and other promotion for energy efficiency, technologies for climate adaptation, including renewable, carbon capture and storage, home insulation, etc. Again and again in our history, we have seen policy initiative transform adversity into progress. Just as the Depression inspired the New Deal, World War II induced unprecedented economic mobilization, and satellite envy launched the space program and the IT revolution, California can turn the threat of climate change into a growth opportunity with the right policy leadership.

About Next 10

NEXT 10 IS A NONPARTISAN, NONPROFIT ORGANIZATION THAT EDUCATES, ENGAGES AND EMPOWERS CALIFORNIANS TO IMPROVE THE STATE'S FUTURE.

Next 10 is focused on innovation and the intersection between the economy, environment, and quality of life issues. We create tools and provide information that fosters a deeper understanding of the critical issues affecting our state. Through education and civic engagement, we hope Californians will become empowered to affect change.

California Climate Risk and Response is authored by Professor David Roland-Holst and Fredrich Kahrl at the University of California Berkeley. Next 10 funds research from leading experts on complex state issues, providing critical data to help inform the state's efforts to grow the economy and reduce global warming emissions.

PREPARED BY
UC Berkeley
David Roland-Holst
Fredrich Kahrl

PRODUCED BY
Next 10
F. Noel Perry
Sarah Henry
Marcia E. Perry
Sonali Biddiah

Special thanks to Morrow Cater for providing the insight and guidance necessary to educate, engage, and empower Californians on these issues so critical to our future.

WWW.NEXT10.ORG

NEXT 10
650.321.5417
INFO@NEXT10.ORG
WWW.NEXT10.ORG

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