

Managing climate risks in California: the need to engage resource managers for successful adaptation to change

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Abstract In this paper we propose a framework for evaluating how prepared California resource managers are for risks of continued climate change. The framework presented suggests three critical dimensions of preparedness – *awareness* of climate-related risks, *analytic capacity* to translate such climate risks information into specific planning and management activities, and the extent of *actions* taken to address the risks. We illustrate the application of this framework in this paper through preliminary research of California coastal managers where we identify limited *awareness* of climate-change related risks, limited *analytic capacity*, and significant constraints on the abilities of institutions and individuals to take adaptation actions. Our analysis suggests that for California to realize its significant adaptive capacity and be able to manage the unavoidable impacts of climate change, resource managers need to be engaged more effectively in future discussions of managing climate risks in the state.

1 Introduction

It is now evident that the climate is changing in ways that pose risks to health, economy, and environments around the globe. Society's and the environment's ability to cope with climate impacts depends in important ways on the pace and magnitude of global climate change, thus continuing to require substantial mitigation efforts. However, because society is already facing risks associated with climate variability at present, the first signs of change are already being observed, and further impacts over the next 30 years are unavoidable due to the emissions already released into the atmosphere, adaptation is increasingly recognized

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as a complementary necessity to mitigation (e.g., Easterling et al. 2004; Jones 2003; Wilbanks et al. 2003).

While adaptation enjoys concerted attention in the international global environmental change research and policy communities, US political and public discourse on the need and options for, and possible constraints on, adapting to climate change, largely absent until very recently. Similar observations have been made for the situation in much of Europe (e.g., O'Brien et al. 2006). Many of the key players in the US climate policy debate are reluctant to highlight the important parallel role of adaptation to mitigation in managing climate change. Climate contrarians either deny the reality of climate change or promote a view that suggests Americans have the capacity to adapt should climate change materialize, and that therefore there is no need to take action now to prepare or to mitigate (see, e.g., the discussion in Kates 1997). Meanwhile, many environmental advocacy groups have avoided talking about adaptation because they feared it could distract from the need for mitigation, or because doing so would be perceived as defeatist (e.g., Burton 1994). Thus, adaptation is only now emerging as a legitimate and needed subject for public and policy debate, leaving Americans ill-prepared for the complex challenges already evident today and waiting ahead.

Even in California, which has been at the forefront in the US on both the science of climate change and on defining emission reductions strategies, there has been limited discussion on managing the impacts of climate change at the level where it ultimately must occur: that of resource managers at the state and local levels. Over the last five years the California Climate Change Center, a state-funded research program dedicated to conducting climate change research relevant to the state, has begun to characterize the expected impacts on key state resources. Executive Order S-3-05, signed in 2005 by Governor Arnold Schwarzenegger, moved the debate forward by calling for both mitigation plans and adaptation strategies to manage these impacts. This public request opened up a critical opportunity to expand the much-needed discussion in California and elsewhere in the US on how society should manage future changes. However, as explored in this paper, the information coming out of the Climate Change Center and other studies do not yet sufficiently connect with regional and local planning and management programs. This situation may well be a specific case of a more general problem, which is characterized by (1) much academic research not being conducted to meet specific decision-makers' information needs (e.g., Cash et al. 2006; Cortner 2000; Steel et al. 2004; Jones et al. 1999), and (2) decision-makers demonstrating considerable reluctance in many instances of using such information in their day-to-day decision-making (e.g., Cash et al. 2006; Rayner et al. 2005; Mitchell et al. 2006). To facilitate and realize adaptation to global change risks at the level of resource managers, however, it is critical to understand their decision contexts, identify their information needs, understand managers' opportunities and constraints for taking long-term global change risks into account in their decisions, and considering their individual attitudes and capacities toward addressing climate change risks. In this paper, we report on preliminary results from surveys and interviews with coastal managers, which examine the level of awareness, analytic capacity, and actions taken to address risks associated with climate change.

In Section 2 we define key concepts and suggest a framework through which we can examine the extent to which selected California resource managers are engaged in the adaptation discussion to date. Sections 3 first summarizes the major threats expected from climate change in coastal areas and sketches the management structure through which planned (public sector) adaptation will take place. The remainder of Section 3 and 4 then illustrate the proposed framework with empirical research focused on coastal management. We close in Section 5 with suggestions for future research and supportive actions by government and civic society to help connect the state's political leadership on climate

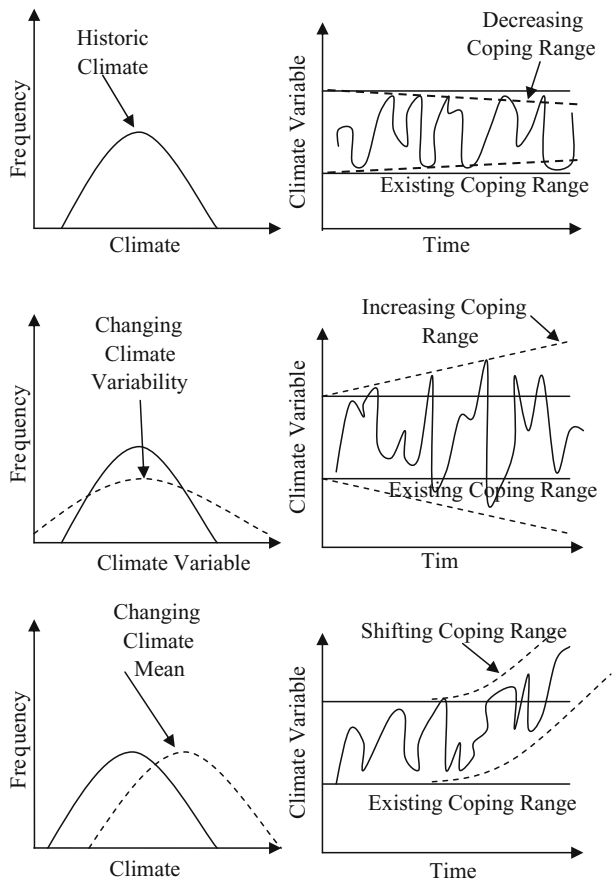
change impacts and adaptation more effectively with regional and local resource managers, thereby realizing the state’s significant adaptive capacity.

2 Capacity for coping with and adapting to climate variability and change

2.1 Current and future coping ranges

California society and state economy have evolved over time to live with and take advantage of the state’s diverse climatic zones and environmental conditions. The economies of the warm coastal regions of Southern California thrive on beach-going residents and tourists. In the moderate climatic region of the Napa Valley, the climate-sensitive wine industry has grown as the foundation of the local economy. And in the snow-rich Sierra Nevada, an important part of the economy has evolved around the climate-sensitive ski industry. Each of these regions has developed strategies to cope with climatic conditions that deviate from the mean, such as weather that is unusually hot, cold, wet, or dry. However, each sector’s ability to cope is often confined within a certain range of climatic conditions. This range is referred to as the “coping range” (e.g., Jones and Boer 2005; Smit and Pilifosova 2003), as illustrated in Fig. 1.

Fig. 1 Coping ranges under current and changing conditions. The panels on the left illustrate the frequency distribution of a given climate variable such as temperature, precipitation, or drought. The panels on the right represent the coping range and variability of the climate variable over time. Solid lines represent existing conditions and dashed lines represent changing conditions



To cope with its historical climate and climate variability, California has – among other things – constructed reservoirs, built levees, and developed information networks, hazard warning and emergency response systems. These structural, institutional, financial, and legal mechanisms along with social capital and cultural norms all contribute to and can either increase or diminish a society’s “coping capacity” reflected in its coping range (e.g., Adger 2003; Brooks et al 2005; Haddad 2005; Pelling and High 2005; Tompkins and Adger 2005).

Many of these customary coping strategies could be enhanced to widen the range of climate conditions that Californians can deal with without major harm. For example, increased use of insurance mechanisms in coastal areas may help spread and buffer against the growing risk of property damage from higher sea levels and storm-related flooding. However, a number of the coping strategies historically employed are coming under increasing pressure from multiple non-climatic stresses that may make them less effective over time. For example, levees in the Sacramento–San Joaquin region – already thought to be limited in their ability to protect development behind them against extreme flooding events now – will become even less effective in the face of future coastal storms as average sea level rises (Cayan et al., this volume). This means that certain regions, sectors, and populations are becoming more vulnerable to climate variability and change, even at present.

2.2 Building and realizing adaptive capacity: awareness – analysis – action

Building the capacity to adapt refers to a broadening of the range of options for proactively or reactively reducing society’s vulnerability and increasing resilience to climate variability and change (e.g., Brooks et al. 2005; Brooks et al. 2004; Pelling and High 2005; Yohe and Tol 2002). Importantly, however, building adaptive capacity will not guarantee that adaptation will actually occur, or occur efficiently and effectively (Adger and Vincent 2005). The substantial impacts from weather and climate extremes on society today, even in countries with substantial coping capacity, suggest that the capacity to cope with climate stresses is not always fully realized (e.g., Kasperson et al. 1995; Glantz 2001). Here we focus solely on the decision-maker’s side (as opposed to the science side) and argue that building and realizing capacity among decision-makers to cope with climate variability and adapt to climate changes requires strengthening three critical dimensions of adaptation: *awareness – analytic capacity – action*. In the context of planned adaptation to climate variability and change, decision-makers in the private and public sectors first need to become aware of the potential impacts and risks, and how these risks may affect them or their specific business and management responsibilities. This *awareness* needs to be coupled with a fuller understanding and *capacity to analyze* such information in order to develop policy initiatives, strategies and plans. This ability and resulting understanding can but may not suffice to provide the necessary motivation and willingness to act (e.g., Rayner et al. 2005; UKCIP 2003). Moreover, decision-makers need to have the willingness, incentives, and ability to use this understanding in decision-making, i.e., to translate their awareness and concern into concrete *actions*. Typically, the latter step involves removing a range of barriers that can prevent realization of well-intended policies and plans at every level of decision-making involved in the management of a particular resource (e.g., Cash 2001; Cash et al. 2006; Gunderson et al. 1995; Healy and Ascher 1995; Pulwarty and Melis 2001; Pulwarty 2003; Steel et al. 2004; Jones et al. 1999). Our goal in this initial research was to examine the extent to which selected California resource managers are aware of the potential risks from climate change, what capacity they have to assess local threats, and what barriers to action they may face. The results are suggestive of the degree of

preparedness for climate change and existing adaptive capacity, as well as of the barriers to fully realizing it.

3 Awareness, analytic capacity and action among California resource managers

California's leadership in climate science has led to significant awareness and analytic capacity in institutions of higher learning and state agencies, yet is not always matched by similar degrees of awareness, analysis, or action at the level of resource managers where incorporating climate risks might be most important. This has become evident in a preliminary study of coastal resource managers in the state.

3.1 Coastal impacts of climate change

Coastal California has witnessed persistent sea-level rise of about 10–20 cm over the past century (comparable to the global average rate) along its southern and central open ocean coastal sections and in San Francisco Bay and adjacent estuaries over at least the past century (e.g., California Coastal Commission 2001; Cayan et al. 2006; Thieler and Hammar-Klose 2000). Episodically, the state also witnesses severe flooding, coastal erosion, beach loss, and cliff retreat from winter storms, especially during El Niño events (Flick and Cayan 1984; Flick 1998; Ryan et al. 1999; Storlazzi and Griggs 2000; Moore and Griggs 2002; Sallenger et al. 2002).

The historic sea-level trends are expected to persist if not accelerate over coming decades and centuries (Church et al. 2001; Meehl et al. 2005; Wigley 2005). For California, Cayan et al. (2006, ix) suggest that “by the 2070–2099 period, sea level rise projections range from 11–54 cm (4.3–21 in.) for simulations following the lower (SRES) (B1) greenhouse gas (GHG) emissions scenario, from 14–61 cm (5.5–24 in.) for the middle-upper (A2) emissions scenario, and from 17–72 cm (6.7–28 in.) for the highest (A1fi) scenario” (for further discussion see Cayan, Bromirski et al., this volume). Concern is growing that global sea level could rise much faster as a result of rapid decay of the Greenland and West Antarctic ice sheets (e.g. Conway et al. 1999; Dahl-Jensen 2000; Paterson and Reeh 2001; Rignot and Thomas 2002; Krabill et al. 2004; Shepherd et al. 2004; Alley et al. 2005; Bindschadler 2006; Dowdeswell 2006; Rignot and Kanagaratnam 2006).

Apart from unknowable synergies and surprises, expected impacts from climate variability and change are essentially aggravated forms of existing problems (e.g., Galbraith et al. 2005; Griggs 2005; Mount and Twiss 2005; Neumann et al. 2002; Mageean et al. 2001). These impacts – faster sea-level rise, flooding, erosion, and changes in run-off, water temperature and quality – are and will be managed primarily through existing coastal management institutions. The approaches fall broadly in the common categories discussed in the literature – protect, accommodate, and retreat (e.g., McLean et al. 2001), and are implemented through the coastal management structure.

3.2 Coastal management in California and case study focus

In California, as in other US states, coastal management is based on a multi-level governance structure, involving federal and state agencies, state commissions, and local governments, with a growing emphasis on regional (i.e., supra-local) cooperation through cooperative councils, planning boards, and other coordinating entities. While also anchored at common governance levels, federal flood and other private-sector insurance also play a role in coping with hazard-related coastal challenges; and finally, private business and individual actors can

take action within the limits of given legal frameworks (these mechanisms were not part of this study and are not discussed further). This complex governance structure evolved out of several federal and state laws which address the many, and sometimes conflicting goals of coastal zone management in the USA and California (e.g., economic growth, species and habitat protection, public safety, private property rights, conservation of essential natural resources, and so on). In the research reported here, we focused on coastal managers in relevant state agencies (and to a lesser extent on federal and regional entities).

We interviewed 17 federal, state, and regional governmental decision-makers involved in California coastal management to qualitatively explore the state's coastal adaptive capacity. Interviewees were selected based on a review of state agency responsibilities and identification of key agency personnel carrying out agency missions. The particular focus of these lengthy (on average 70 min), semi-structured interviews included managers' current coastal management responsibilities, attitudes and knowledge about global warming, any efforts undertaken by their agencies to prepare for climate change impacts in coastal areas, and specifically, their climate change-related information needs if they were to take climate change impacts into account in their management efforts.¹

3.3 Awareness and analytic capacity among coastal managers

The interviews revealed that California coastal managers currently are not required to consider future climate in their planning or management decisions. Most do not use weather-, climate-, or sea level-related information in their decision-making today. They typically lack the time, staff, or financial resources to examine potential impacts of climate change on their management responsibilities. Few are deeply knowledgeable about climate change while others are unaware or only marginally knowledgeable about the potential for harm that climate change could bring to coastal California.

As we suggested above, awareness or the availability of information about climate change impacts alone will not solve the management challenges faced in coastal California.² Based on interviewees' views, considerable effort will need to be made to make scientific information relevant to, and fitting seamlessly into, existing decision-making procedures. Agency personnel will also need top-level leadership and incentives to direct their attention to climate change matters. To the extent that information and awareness are limiting factors, however, science could play a critical role in filling such information gaps and raising managers' awareness and understanding of climate change risks. Interviewees varied considerably, for example, in their knowledge of local or state-based researchers who could help them understand their climate change risks. Table 1 lists some of the major information needs revealed through the interviews (see also Tribbia and Moser 2008).

The overarching message emerging from the information needs identified by coastal managers is that climate change science still needs to be translated into types of information that are *salient to the manager* (for elaborate discussion on the importance of salience, among other information attributes, see Cash 2001; Cash et al. 2003, Moser 2006). For example, while sea-level rise projections are valuable as a general indicator to raise awareness of future coastal risks in a general sense, permitting officers who determine setback distances

¹ The coastal study also involved a complementary survey of nearly 300 local-level coastal managers. Results of that survey, also using the A–A–A framework are reported in Moser and Tribbia (2006, 2007) and Tribbia and Moser (2008).

² Similar findings have been made in other regions and sectors; see, e.g., Changnon et al. (1995), Pulwarty and Redmond (1997), Callahan et al. (1999), Ray (2003), Cash (2001), Rayner et al. (2005), Jacobs 2002.

Table 1 California coastal managers' information needs on climate change impacts

Specific management-related information needs
<p>Translation of projected sea-level rise, changes in coastal ocean, coastal storm frequency, and wave climate into shoreline retreat, beach erosion, and bluff retreat rates over various planning- or project-relevant timeframes (20–25, 50, 75 years)</p> <p>More reliable forecasting of El Niño events, and any changes in the frequency or severity of such events, and impacts on shoreline retreat rates</p> <p>Remapping of flood zones under different sea-level rise projections^a</p> <p>Information about potential changes in runoff and near-shore coastal and estuarine water temperatures, and exploration of the implications of such changes for water quality, water availability, and aquatic ecology</p>
Information management and accessibility needs
<p>Inventory and integration of existing (and additionally developed) information into common formats, e.g., geographic information systems</p> <p>Accessibility of integrated databases at various spatial aggregation/resolutions and for different temporal resolutions</p> <p>Adequate funding of ongoing monitoring of critical, management-relevant variables</p> <p>Exchange of information among coastal states and communities about their responses to climate change-related impacts and risks</p> <p>Better collaboration and exchange of relevant information among all involved agencies within California</p>
Information needs regarding uncertainty
<p>Uncertainty ranges around climate change impact projections to indicate scientific confidence</p> <p>Distinction between more and less likely impacts (e.g., “at-least” sea-level rise vs “maybe-as-much-as” sea-level rise)</p> <p>Scientific basis for uncertainty buffers (e.g., additional setbacks, extra capacity for storm water runoff)</p>
Trusted sources of information (in no particular order of preference)
<p>Federal Emergency Management Agency (FEMA)</p> <p>National Oceanic and Atmospheric Administration (NOAA)</p> <p>United States Geological Survey (USGS)</p> <p>Scripps Institution of Oceanography (SIO)</p> <p>California's Ocean Protection Council</p>

^a Improvements of California floodplain maps is already underway under the auspices of the American Technology Council and could be enhanced through consideration of climate change-related changes

to site new buildings need to know how these projections translate – together with possible changes in storm activity – into future coastal erosion rates.

Interestingly, interviews revealed that scientific uncertainty in climate impacts projections is not an unusual challenge in determining possible responses, and agencies differ in their approaches to dealing with uncertainty. Instead, several expressed a desire for a broader debate about the acceptability of individual vs public risks and how the

responsibility in case of impact should be shared. Interviewees suggested that climate change-related information must come from trusted sources, but differed in their preferences regarding who should produce it (see Table 1). They expressed underlying concerns over which institution would be most trusted, scientifically credible, and least “political” from the perspective of the information users and the coastal communities in which decisions would be implemented.

Finally, several interviewees expressed a desire that the needed information would not just be “made available” – even in a timely fashion and accessible language and formats – but be conveyed in frequently repeated training sessions to coastal managers who are not yet knowledgeable about climate change. These trainings would help make abstract climate change and generic impacts more “imaginable” through local or regional examples and case studies, and examine the technical, legal, economic, and social aspects of potential management options.

3.4 Action constraints: Realizing adaptive capacity in California

The interviews further revealed that resource managers face countless pressing ongoing and near-term concerns, which absorb most if not all of their available time, attention, and resources. However, enhancing their ability to manage climate variability today can assist in building resilience for future climatic changes (Berkes et al. 2002; Chambers 1989; Few 2003; Folke et al. 2002; Tompkins 2005; Tompkins and Adger 2004).

Among the key constraints to addressing adaptation that our study identified are: lack of financial resources; technical or technological constraints; institutional constraints and inflexibilities; cultural norms that predispose managers and the communities they manage to short-sighted and maladaptive responses; constraints arising from imbalances in political power or other positioning and delaying tactics; and – importantly – lack of social acceptability of different adaptation options. While these are commonly heard complaints already affecting resource management today and scientifically well-established constraints that limit adaptation to change, our studies suggest that policy-makers should be highly skeptical and carefully aware of the practical limitations that decision-makers at all levels face in preparing for the impacts of climate change. Coastal zone managers interviewed for this study repeatedly mentioned harsh and persistent, and frequently litigious, struggles between interest groups over questions of shoreline protection and development – struggles that absorb crucial financial and staff resources, create political stalemates, and produce a climate of conflict in which long-term visions for the coast would be very difficult to discuss. Moreover, even if coastal communities could resolve legal, technological, and related aesthetic and social acceptability challenges, the question would still remain who – at the federal, state, and local level – could or should pay for shoreline protection and its long-term maintenance.

Likewise, large-scale economic and demographic forces drive sprawl, development patterns and the demand for coastal protection structures that create challenges and legacies for coastal managers which are beyond the ability of local governments alone to control. Resource managers repeatedly spoke of being able to focus only on “putting the next fire out” rather than taking the long-term view.

4 Discussion

As the preliminary findings from this study of California coastal managers suggest, many of those who would be in charge of developing adaptation policies (at top agency levels) and

implementing adaptation decisions (within agencies at all levels of governance) are currently unaware of, or unconcerned about, climate change risks, do not feel that it is their responsibility or in their power (with the resources at hand) to address potential climate change impacts in their spheres of influence. While the level of understanding of climate change varied among interviewees, the motivation to address climate change was quite low among many of the managers interviewed.

This finding has to be viewed in the context of a generally still rather low level of sophisticated understanding of climate change in the USA (FrameWorks Institute 2001), and the common “cognitive illusions” or biases against absorbing and understanding uncertain information (Nicholls 1999). These biases tend to make people misjudge the accurate levels of risk, dismiss unfamiliar and insufficiently communicated risks, and believe overconfidently that they are not vulnerable to them. Moreover, while numerous climate change experts give public talks, few engage in sustained, personal interactions with resource managers to build mutual rapport, understanding, and trust which opens the doors to information being influential (Cash et al. 2003; Mitchell et al. 2006; Tribbia and Moser 2008). Thus, there is currently little specific effort underway in California to develop the scientific information that could usefully inform, and be used, in on-the-ground preparation for climate change impacts.

This study suggests further that a significant educational effort is needed along with incentives, staff, and financial resources to motivate resource managers to engage the topic in their day-to-day lives. Because the science of climate change impacts changes rapidly and the problem is long term in nature, it will be difficult to maintain staff knowledge and capacity at high levels. This is made even more difficult by competing and distracting demands on managers’ attention, the difficulty of maintaining motivation to act on any long-term problem, high staff turnover, the expected wave of retirements in the near future from many state agencies (McIntosh 2005) which eliminates significant stores of institutional memory, and budget-imposed constraints on hiring, retaining, and training new staff to replace retiring personnel. Thus enhancing resource managers’ ability to analyze and use climate-relevant information in their decision-making requires long-term commitment to training and institutional capacity building, including building sustained or even institutionally formalized science–decision-maker interactions or positioning well-trained experts in state and regional agencies.

In summary, these preliminary findings begin to shed light on the “on-the-ground” constraints of implementing adaptation strategies in California. Strong leadership and dedicated commitment at the federal, state, and local levels as well as focused assistance from California’s substantial academic sector will be necessary to realize California’s capacity to cope with and adapt to the changes ahead.

5 Conclusions

Developing and implementing a plan to effectively manage climate change impacts will require a broad discussion on the needed societal response that involves all levels of government, the private sector, and civic society. Such a discussion has only begun at the highest levels in California state government, but, in order to affect actions on the ground, must be broadened to resource managers and the wider public. It should – at a minimum – address the following questions:

- What level of climate change (or risk of change) is society willing to accept (thus also raising questions about the extent of greenhouse gas mitigation)?

- What goals should adaptation achieve, e.g., preserving the status quo, actively managing change toward new conditions, promoting deeper societal changes required for sustainability?
- What is an acceptable level of individual vs. public risk and how should the responsibility be shared?
- What are the social justice, environmental, economic, and other trade-offs associated with allocation of scarce resources as more systems come under growing pressure from climate and other stresses?

In addition, to fulfill the mandate contained in Executive Order S-3-05 to report on California's preparedness for climate change, it is necessary to improve understanding of the fundamental social processes that enhance or constrain the state's ability to adapt to climate change, including factors external to the state and not under its control, and those that affect local capacity to deal with the unavoidable impacts and to assess opportunities and constraints in preparing for potential future impacts of climate change. As an economically vibrant, technologically innovative, and frequently courageous political pioneer state, California may have a greater capacity than some to face the challenges from climate change. A concerted focus on further researching, quantifying, and addressing the state's vulnerabilities and adaptation constraints is clearly needed. More specifically, actions are recommended at three levels, each discussed below.

5.1 Government and policy actions

Government at both the state and federal levels can play a crucial role in stimulating and facilitating lower levels of government (regional and local institutions, which often are the implementing arms of government) and the private sector by providing incentives to begin exploring the growing risks from climate change, the response options, and ways to implement them. While higher levels of government can stimulate action elsewhere, the challenge of seamlessly coordinating and integrating federal, state, and local policies across scales cannot be overstated and needs to be carefully and consciously addressed.

Toward these ends, our research suggests benefits from the following actions:

- Establish mechanisms that increase lower-level governmental accountability vis-à-vis state-set climate-related and other environmental goals (e.g., no net loss of particular habitats, implementation of planning goals or building standards)
- Initiate (and provide adequate funding and staff to arrange) public forums to discuss climate change risks and response options; forums could be agency-specific or location-specific, for the private sector, public officials, or the general public
- Promote integrated resource and hazard management plans that promote or require incorporating climate risks among other multiple and interacting stressors.

5.2 Future research directions

State and federal agencies can also enhance adaptive capacity by building the necessary knowledge base for adaptation. The state could draw and build on this existing understanding, support research that applies the insights from elsewhere to the state, and fill gaps in understanding. Importantly, however, research relevant to practical adaptation decisions must be conducted in sustained consultation with pertinent decision-makers to increase the

information's relevance and legitimacy and to build the necessary mutual understanding and trust. Specifically, our study revealed research needs in the following areas:

- Collaborative and participatory research that expands resource managers' knowledge of climate and weather risks, and of adaptation options
- Research into the feasibility of and constraints on adaptation options in the context of multiple stressors
- Sector-specific empirical research of resource managers' specific information needs and response to these identified information needs by providing information that is directly relevant and easily accessible to different stakeholders' decisions.

5.3 Fostering public dialogue on adaptation

Civil society has a significant role to play in preparing for change through informed discussions of how to respond to climate change risks. While many adaptation actions will need to be planned and carried out through governmental programs and institutions, the public is a stakeholder, whether it is aware of that fact yet or not. An expanded discussion of societal response to climate change would raise awareness and understanding among stakeholders of the need for climate change mitigation and adaptation as complementary necessities. Without such an informed public conversation about adaptation, proactive steps and strategies are unlikely to be explored or politically supported, much less implemented. This would leave society to cope in inefficient and probably more costly ways as further impacts manifest in the future.

Civic actors could contribute to this dialogue in the following specific ways:

- Scientists can play a bigger role in educating the interested public as well as local, regional, and state decision-makers about the need for adaptation, thus stimulating public discussion of the potential options and constraints on coping and adaptation
- Environmental groups, land trusts, conservancies and other advocates can begin examining how climate change may impact their interests and goals and help identify win-win solutions
- Private sector businesses can identify their exposure and risks in light of climate change, and begin identifying measures that help reduce their vulnerabilities over the short, medium, and longer term.

Preparing for and adapting to the impacts of climate change will take committed, ongoing, and collaborative effort from government, the private sector, the research community, and civil society. Here we have only shed preliminary light on the specific roles of governmental decision-makers, fully cognizant of the fact that a far more complex set of actors will ultimately be involved and shape public debate and response to climate change. While the challenges are large, California has a history of leading the nation in terms of policy and forward-looking management approaches. The state has an opportunity once again to advance the debate and lead by example.

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