

## 28. Adaptation

### 2 Convening Lead Authors

3 Rosina Bierbaum, University of Michigan  
4 Arthur Lee, Chevron Corporation  
5 Joel Smith, Stratus Consulting  
6

### 7 Lead Authors

8 Maria Blair, American Cancer Society  
9 Lynne M. Carter, Louisiana State University  
10 F. Stuart Chapin III, University of Alaska Fairbanks  
11 Paul Fleming, Seattle Public Utilities  
12 Susan Ruffo, The Nature Conservancy  
13

### 14 Contributing Authors

15 Shannon McNeeley, Colorado State University  
16 Missy Stults, University of Michigan  
17 Laura Verduzco, Chevron Corporation  
18 Emily Seyller, University Corporation for Atmospheric Research  
19

### 19 Key Messages

- 20 **1. Substantial adaptation planning is occurring in the public and private sectors and at**  
21 **all levels of government; however, few measures have been implemented and those**  
22 **that have appear to be incremental changes.**
- 23 **2. Barriers to implementation of adaptation action include lack of funding, policy and**  
24 **legal impediments, and difficulty in anticipating climate related changes at local**  
25 **scales.**
- 26 **3. There is no “one-size fits all” adaptation, but there are similarities in approaches**  
27 **across regions and sectors. Sharing best practices, learning by doing, and iterative**  
28 **and collaborative processes including stakeholder involvement, can help support**  
29 **progress.**
- 30 **4. Climate change adaptation actions often fulfill other societal goals, such as**  
31 **sustainable development, disaster risk reduction, or improvements in quality of life,**  
32 **and can therefore be incorporated into existing decision-making processes.**
- 33 **5. Vulnerability to climate change is exacerbated by other stresses such as pollution,**  
34 **habitat fragmentation, and poverty. Adaptation to multiple stresses requires**  
35 **assessment of the composite threats as well as trade-offs among costs, benefits, and**  
36 **risks of available options.**
- 37 **6. The effectiveness of climate change adaptation has seldom been evaluated, because**  
38 **actions have only recently been initiated and comprehensive evaluation metrics do**  
39 **not yet exist.**

## 1 Introduction

2 Over the past few years, the focus moved from the question “Is climate changing?” to the equally  
3 important question: “Can society manage unavoidable changes and avoid unmanageable  
4 changes?”<sup>1,2</sup> Research demonstrates that both mitigation (efforts to reduce future climate  
5 changes) and adaptation (efforts to reduce the vulnerability of society to climate change impacts)  
6 are needed in order to minimize the damages from human-caused climate change and to adapt to  
7 the pace and ultimate magnitude of changes that will occur.<sup>3,4,5</sup>

8 Adaptation and mitigation are closely linked; adaptation efforts will be more difficult, more  
9 costly, and less likely to succeed if significant mitigation actions are not taken.<sup>2,6</sup> The study and  
10 application of adaptation in the climate change realm is nascent compared to the many analyses  
11 of mitigation policies and practices to reduce emissions. Uncertainties about future  
12 socioeconomic conditions as well as future climate changes can make it difficult to arrive at  
13 adaptation decisions now. However, the pace and magnitude of projected change emphasize the  
14 need to be prepared for a wide range and intensity of climate impacts of future conditions.  
15 Planning and managing based on the climate of the last century means that tolerances of some  
16 infrastructure and species will be exceeded.<sup>5,7,8</sup> For example, building codes and landscaping  
17 ordinances will likely need to be updated not only for energy efficiency, but also to conserve  
18 water supplies, protect against disease vectors, reduce susceptibility to heat stress, and improve  
19 protection against extreme events.<sup>5,9</sup> Although there is uncertainty about future conditions,  
20 research indicates that intelligent adaptive actions can still be taken now.<sup>10,11</sup> Climate change  
21 projections have inherent uncertainties, but it is still important to develop, refine, and deploy  
22 tools and approaches that enable iterative decision-making and increase flexibility and  
23 robustness of climate change responses (Ch. 2: Our Changing Climate).<sup>12</sup>

24 Climate change affects human health, natural ecosystems, built environments, and existing  
25 social, institutional, and legal arrangements. Adaptation considerations include local, state,  
26 regional, national, and international issues. For example, the implications of international  
27 arrangements need to be considered in the context of managing the Great Lakes, the Columbia  
28 River, and the Colorado River to deal with drought.<sup>13,14</sup> Both “bottom up” community planning  
29 and “top down” national strategies<sup>11</sup> may help regions deal with impacts such as increases in  
30 electrical brownouts, heat stress, floods, and wildfires. Such a mix of approaches will require  
31 cross-boundary coordination at multiple levels as operational agencies integrate adaptation  
32 planning into their programs.

33 Adaptation actions can be implemented reactively, after changes in climate occur, or proactively,  
34 to prepare for projected changes.<sup>11</sup> Proactively preparing can reduce the harm from certain  
35 climate change impacts, such as increasingly intense extreme events, shifting zones for  
36 agricultural crops, and rising sea levels, while also facilitating a more rapid and efficient  
37 response to changes as they happen. This chapter highlights efforts at the federal, regional, state,  
38 tribal, and local levels, as well as initiatives in the corporate and non-governmental sectors to  
39 build adaptive capacity and resilience in response to climate change. While societal adaptation to  
40 *climate variability* is as old as civilization itself,<sup>15</sup> the focus of this chapter is on preparing for  
41 unprecedented human-induced *climate change* through adaptation. A map of illustrative  
42 adaptation activities and four-detailed case examples that highlight ongoing adaptation activity  
43 across the U.S. are provided in Section IV of this chapter.

## Adaptation Key Terms Definition Box\*

**Adapt, Adaptation:** Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.

**Adaptive Capacity:** The potential of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, take advantage of opportunities, and cope with the consequences.

**Mitigation:** Technological change and substitutions that reduce resource inputs and emissions per unit of output. Although several social, economic, and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce greenhouse gas emissions and increase the amount of carbon dioxide absorbed and stored by natural and man-made carbon sinks. (see Ch. 27: Mitigation).

**Multiple Stressors:** Stress that originates from different sources that affect natural, managed, and socioeconomic systems and can cause impacts that are compounded and sometimes unexpected. An example would be when economic or market stress combines with drought to negatively impact farmers.

**Resilience:** A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

**Risk:** A combination of the magnitude of the potential consequence(s) of climate change impact(s) and the likelihood that the consequence(s) will occur.

**Vulnerability:** The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

\*Definitions adapted from (IPCC 2007; NRC 2007, 2010a).<sup>11,16,17</sup>

## Adaptation Activities in the United States

### Federal Government

Federal leadership, guidance, information, and support are vital to planning for and implementing adaptation actions at all scales and in all affected sectors of society (Table 28.1).<sup>11,18,19,20</sup> Several new federal climate adaptation initiatives and strategies have been developed in recent years, including:

- Executive Order (EO) 13514, requiring federal agencies to develop recommendations for strengthening policies and programs to adapt to the impacts of climate change;<sup>21</sup>
- The creation of an Interagency Climate Change Adaptation Task Force (ICCATF) that led to the development of national principles for adaptation and is leading to crosscutting and government-wide adaptation policies;
- The development of three crosscutting national adaptation strategies focused on integrating federal, and often state, local, and tribal efforts on adaptation in key sectors:

1 1) the National Action Plan: Priorities for Managing Freshwater Resources in a Changing  
2 Climate;<sup>22</sup> 2) the National Fish, Wildlife and Plants Climate Adaptation Strategy;<sup>23</sup> and 3)  
3 a priority objective on resilience and adaptation in the National Ocean Policy  
4 Implementation Plan;<sup>24</sup>

- 5 • A new decadal National Global Change Research Plan (2012–2021) that includes  
6 elements related to climate adaptation such as improving basic science, informing  
7 decisions, improving assessments, and communicating with and educating the public;<sup>25</sup>  
8 and
- 9 • The development of several interagency and agency-specific groups focused on  
10 adaptation, including a “community of practice” for federal agencies that are developing  
11 and implementing adaptation plans, an Adaptation Science Workgroup inside the U.S.  
12 Global Change Research Program (USGCRP); and several agency specific climate  
13 change and adaptation task forces.
- 14 • A November 2013 Executive Order entitled “Preparing the United States for the Impacts  
15 of Climate Change” that, among other things, calls for the modernizing of federal  
16 programs to support climate resilient investments, managing lands and waters for climate  
17 preparedness and resilience, the creation of a Council on Climate Change Preparedness  
18 and Resilience, and the creation of a State, Local, and Tribal Leaders Task Force on  
19 Climate Preparedness and Resilience.<sup>26</sup>

20 Federal agencies are all required to plan for adaptation. Actions include coordinated efforts at the  
21 White House, regional and cross-sector efforts, agency-specific adaptation plans, as well as  
22 support for local-level adaptation planning and action. Table 28.1 lists examples, but is not  
23 intended as a comprehensive list.

24

Table 28.1: Examples of Individual Federal Agency Actions to Promote, Implement, and Support Adaptation at Multiple Scales\*

Agency	Component	Action	Description
<b>All Federal Agencies</b>		Developed Adaptation Plans as part of their annual Strategic Sustainability Performance Plans	The 2012 Strategic Sustainability Performance Plans for Federal agencies contain specific sections on adaptation. Agencies are required to evaluate climate risks and vulnerabilities to manage both short- and long-term effects on missions and operations.
<b>Department of Health and Human Services (HHS)</b>	Centers for Disease Control and Prevention (CDC)	Climate-Ready States and Cities Initiative	Through their first climate change cooperative agreements in 2010, CDC awarded \$5.25 million to ten state and local health departments to assess risks and develop programs to address climate change related challenges.
<b>Department of Agriculture (USDA)</b>		Integrating climate change objectives into plans and networks	USDA is using existing networks such as the Cooperative Extension Service, the Natural Resource Conservation Districts, and the Forest Service's Climate Change Resource Center to provide climate services to rural and agricultural stakeholders.
<b>USDA</b>	Forest Service	Developed a <i>National Roadmap for Responding to Climate Change</i> and a <i>Guidebook for Developing Adaptation Options</i> , among many resources	The <i>National Roadmap</i> was developed in 2010 to identify short- and long-term actions to reduce climate change risks to the nation's forests and grasslands. The <i>Guidebook</i> builds on this previous work and provides science-based strategic and tactical approaches to adaptation.
<b>Department of Commerce (DOC)</b>	NOAA	Supporting research teams and local communities on adaptation-related issues and develops tools and resources	Through the Regional Integrated Sciences and Assessments (RISAs) program, develop collaboration between researchers and managers to better manage climate risks. Through the Regional Climate Centers (RCCs) and the Digital Coast partnership, deliver science to support decision-making.
<b>Department of Defense (DoD)</b>		Developed a DoD Climate Change Adaptation Roadmap	DoD released its initial Department-level Climate Change Adaptation Roadmap in 2012. The Roadmap identifies four goals that serve as the foundation for guiding the Department's response to climate change that include using a robust decision making approach based on the best available science.
<b>DoD</b>	U.S. Army Corps of Engineers (USACE), Civil Works Program	Developed climate change adaptation plan; making progress in priority areas including vulnerability assessments and development of policy and guidance	The USACE Civil Works Program initial climate change adaptation plan in 2011 has a goal to reduce vulnerabilities and improve resilience of water resources infrastructure impacted by climate change. Vulnerability assessments and pilot projects are in progress. Other guidance is underway.
<b>DoD</b>	Department of the Navy	Developed road maps for adaptation in the Arctic and across the globe	The Navy Arctic Roadmap (November 2009) promotes maritime security and naval readiness in a changing Arctic. The Climate Change Roadmap (May 2010) examines broader issues of climate change impacts on Navy missions and capabilities globally.
<b>Department of Energy (DOE)</b>		Develop higher spatial and temporal scales of climate projections and integrate adaptation and climate considerations into integrated assessments	Develops community-based, high-resolution (temporal and spatial) models for climate projections and integrated assessment models that increasingly reflect multi-sectoral processes and interactions, multiple stressors, coupled impacts, and adaptation potential.

<b>Department of Energy (DOE)</b>		Developed climate change adaptation plan, and completed comprehensive study of vulnerabilities to the energy sector of climate change and extreme weather	The 2013 DOE Report "U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather" examines current and potential future impacts of climate trends and identifies activities underway and potential opportunities to enhance energy system climate preparedness and resilience.
<b>Department of the Interior (DOI)</b>	Fish and Wildlife Service (FWS)	Developed a FWS climate change strategic plan (2010) and established a network of Landscape Conservation Cooperatives (LCCs)	Established a framework to help ensure the sustainability of fish, wildlife, plants, and habitats in the face of climate change. Created a network of 22 LCCs to promote shared conservation goals, approaches, and resource management planning and implementation across the United States.
<b>DOI</b>	U.S. Geological Survey (USGS)	Established a network of Climate Science Centers (CSCs)	DOI operates a National Climate Change and Wildlife Center and eight regional CSCs, which provide scientific information and tools that land, water, wildlife, and cultural resource managers and other stakeholders can apply to anticipate, monitor, and adapt to climate change.
<b>DOI</b>	National Park Service (NPS)	Climate Change Response Strategy (2010), Climate Change Action Plan (2012), and Green Parks Plan (2012)	NPS actions span climate change science, adaptation, mitigation, and communication across national parks, including exhibits for park visitors, providing climate trend information for all national parks, risk screening and adaptation for coastal park units, and implementing scenario planning tools.
<b>DOI</b>	Bureau of Land Management (BLM)	Rapid Ecoregional Assessments (REAs)	REAs synthesize information about resource conditions and trends within an ecoregion; assess impacts of climate change and other stressor; map areas best-suited for future development; and establish baseline environmental conditions, against which to gauge management effectiveness.
<b>Department of Transportation (DOT)</b>	Federal Highway Administration (FHWA)	Developed Risk Assessment Model for transportation decisions	DOT worked with five local and state transportation authorities to develop a conceptual Risk Assessment Model to identify which assets are: a) most exposed to climate change threats and/or b) associated with the most serious potential consequences of climate change threats. Completed November 2011.
<b>DOT</b>		Comprehensive study of climate risks to Gulf Coast transportation infrastructure followed by in-depth study of Mobile, AL	Phase 1 of the 2008 study assessed transportation infrastructure vulnerability to climate change impacts across the Gulf. Phase 2, to be completed in 2013, focuses on Mobile, AL. This effort will develop transferable tools for transportation planners.
<b>Environmental Protection Agency (EPA)</b>		Established the Climate Ready Estuaries program, the Climate Ready Water Utilities initiative, and a tribal climate change adaptation planning training program	These selected EPA initiatives provide resources and tools to build the capacity of coastal managers, water utilities, and tribal environmental professionals to plan for and implement adaptation strategies
<b>National Aeronautics and Space Administration (NASA)</b>		Initiated NASA's Climate Adaptation Science Investigator (CASI) Workgroup to partner NASA scientists, engineers, and institutional stewards	The CASI team builds capacity to address climate change at NASA facilities by downscaling facility-specific climate hazard information and projections; conducting customized climate research for each location; and leading resilience and adaptation workshops that spur community-based responses.

1 \*Material provided in table is derived directly from Agency representatives and Agency websites.

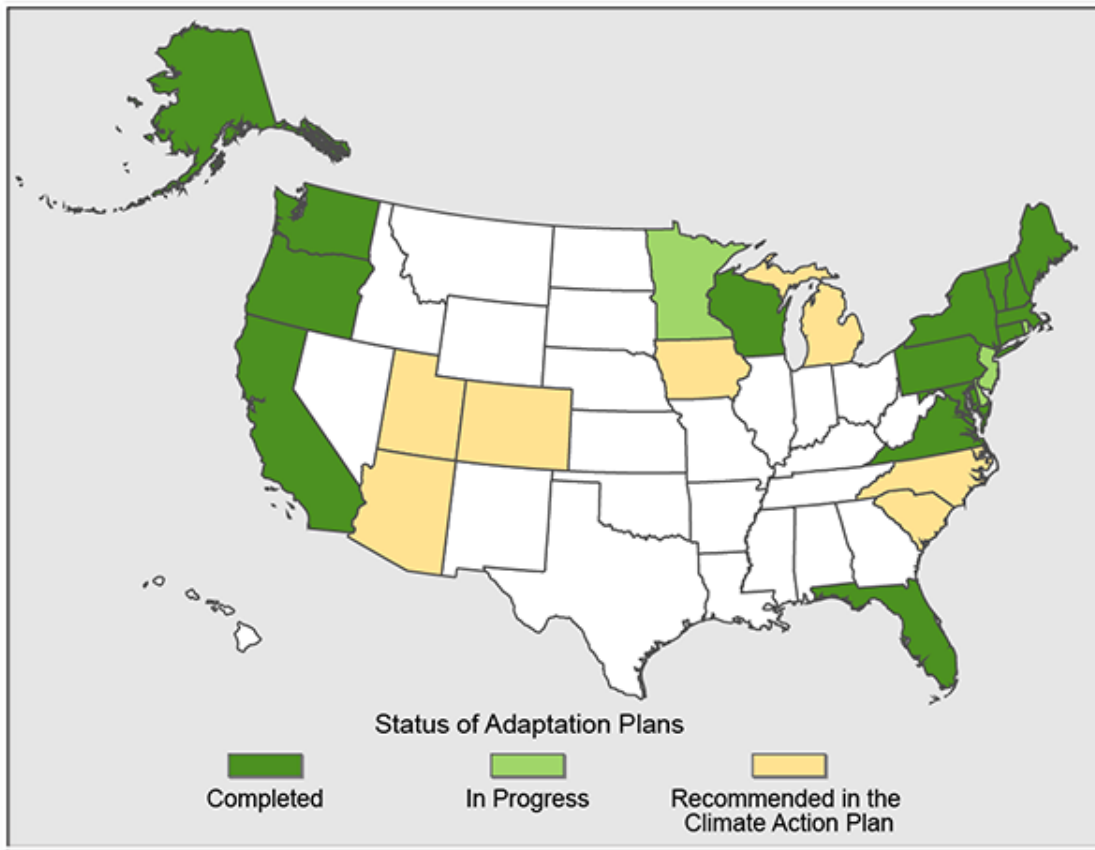
- 1 Federal agencies can be particularly helpful in facilitating climate adaptation by:
- 2 • Fostering the stewardship of public resources and maintenance of federal facilities,  
3 services, and operations such as defense, emergency management, transportation, and  
4 ecosystem conservation in the face of a changing climate;<sup>11,27,28,29</sup>
  - 5 • Providing usable information and financial support for adaptation;<sup>11,20,29</sup>
  - 6 • Facilitating the dissemination of best practices and supporting a clearinghouse to share  
7 data, resources, and lessons learned;<sup>11,20,30</sup>
  - 8 • Dealing with and anticipating impacts that cross geopolitical boundaries, assisting in  
9 disaster response, and supporting flexible regulatory frameworks;<sup>11,29</sup>
  - 10 • Ensuring the establishment of federal policies that allow for “flexible” adaptation efforts  
11 and take steps to avoid unintended consequences;<sup>29,31</sup> and
  - 12 • Building public awareness.<sup>32</sup>

### 13 States

14 States have become important actors in national climate change related efforts. State  
15 governments can create policies and programs that encourage or discourage adaptation at other  
16 governance scales (such as counties or regions)<sup>33</sup> through regulation and by serving as  
17 laboratories for innovation.<sup>34,35</sup> Although many of these actions are not specifically designed to  
18 address climate change, they often include climate adaptation components.

19 Many state level climate change-specific adaptation actions focus on planning. As of winter  
20 2012, at least 15 states had completed climate adaptation plans; four states are in the process of  
21 writing their plans; and seven states have made recommendations to create state-wide adaptation  
22 plans.<sup>36</sup>

### Status of State Climate Adaptation Plans



1

2 **Figure 28.1:** Status of State Climate Adaptation Plans. (Figure source: redrawn from  
3 C2ES 2012)<sup>36</sup>).

4 In addition to formal adaptation plans, numerous states have created sector-specific plans that  
5 consider long-term climate change (Figure 28.1). For example, at least 16 states have  
6 biodiversity conservation plans that focus on preparing for long-term changes in climate.<sup>37</sup> In  
7 addition to planning, some states have created legislation and/or programs that are either directly  
8 or indirectly targeted at reducing climate vulnerabilities (Table 28.2).

9



Table 28.2: Examples of State-Level Adaptation Activities\*

State	Adaptation Action
<b>Alaska</b>	Alaska Climate Change Impact Mitigation Program provides funds for hazard impact assessments to evaluate climate change related impacts, such as coastal erosion and thawing permafrost. <sup>38</sup>
<b>California</b>	Building standards mandating energy and water efficiency savings, advancing both adaptation and mitigation; State Adaptation Plan calls for 20% reduction in per capita water use. <sup>39</sup>
<b>Florida</b>	Law supporting low water use landscaping techniques. <sup>40</sup>
<b>Hawaii</b>	Water code that calls for integrated management, preservation, and enhancement of natural systems. <sup>41</sup>
<b>Kentucky</b>	<i>Action Plan to Respond to Climate Change in Kentucky: A Strategy of Resilience</i> , which identifies six goals to protect ecosystems and species in a changing climate. <sup>42</sup>
<b>Louisiana</b>	<i>Comprehensive Master Plan for a Sustainable Coast 2012</i> includes both protection and restoration activities addressing land loss from sea level rise, subsidence, and other factors over the next 50 years. <sup>43</sup>
<b>Maine</b>	The <i>Maine Sand Dune Rules</i> require that structures greater than 2,500 square feet be set back at a distance that is calculated based on the future shoreline position and considering two feet of sea level rise over the next 100 years. <sup>44</sup>
<b>Maryland</b>	Passed <i>Living Shorelines Act</i> to reduce hardened shorelines throughout the state; <sup>45</sup> passed “Building Resilience to Climate Change” policy which establishes practices and procedures related to facility siting and design, new land investments, habitat restoration, government operations, research and monitoring, resource planning, and advocacy.
<b>Montana</b>	Maintains a statewide climate change website to help stakeholders access relevant and timely climate information, tools, and resources.
<b>New Mexico</b>	The Active Water Resource Management program allows for temporary water rights changes in real time in case of drought. <sup>46</sup>
<b>Pennsylvania</b>	Enacted polices to encourage the use of green infrastructure and ecosystem based approaches for managing storm water and flooding. <sup>9</sup>
<b>Rhode Island</b>	Requires public agencies considering land-use applications to accommodate a 3- to 5-foot rise in sea level.
<b>Texas</b>	Coordinated response to drought through National Integrated Drought Information System (NIDIS); RISAs (Southern Climate Impacts Planning Program [SCIPP], Climate Assessment for the Southwest [CLIMAS]); and state and private sector partners through anticipatory planning and preparedness (for example, implemented in 2011 drought). <sup>47</sup>

1 \*This list contains selected examples of state-level adaptation activities and should not be  
 2 considered all-inclusive.  
 3

## 1 **Tribal Governments**

2 Tribal governments have been particularly active in assessing and preparing for the impacts of  
3 climate change (see Ch. 12: Indigenous Peoples). For example:

- 4 • Adaptation planning in Point Hope, Alaska, emphasizes strategies for community  
5 health.<sup>48</sup>
- 6 • In Newtok, Alaska, the village council is leading a land-acquisition and planning effort to  
7 relocate the community, because climate change induced coastal erosion has destroyed  
8 essential infrastructure, making the current village site unsafe.<sup>49</sup>
- 9 • The Tulalip Tribes in Washington State are using traditional knowledge gleaned from  
10 elders, stories, and songs and combining this knowledge with downscaled climate data to  
11 inform decision-making.<sup>50</sup> Also in Washington State, the Swinomish Indian Tribal  
12 Community integrated climate change into decision-making in major sectors of the  
13 Swinomish Community, such as education, fisheries, social services, and human health.<sup>51</sup>
- 14 • The Haudenosaunee Confederacy in the northeastern U.S. is addressing climate impacts  
15 by preserving a native food base through seed-banking (Ch. 12: Indigenous Peoples).<sup>50</sup>

## 16 **Local and Regional Governments**

17 Most adaptation efforts to date have occurred at local and regional levels.<sup>52,53,54,55,56</sup> Primary  
18 mechanisms that local governments are using to prepare for climate change include: land-use  
19 planning; provisions to protect infrastructure and ecosystems; regulations related to the design  
20 and construction of buildings, roads, and bridges; and emergency preparation, response, and  
21 recovery (Table 28.3).<sup>9,44,55,57</sup>

22 According to a recent survey of 298 U.S. local governments, 59% indicated they are engaged in  
23 some form of adaptation planning.<sup>58</sup> Local adaptation planning and actions are unfolding in  
24 municipalities of varying sizes and in diverse geographical areas. Communities such as Keene,  
25 New Hampshire; New York City, New York; King County, Washington; and Chicago, Illinois  
26 are vanguards in the creation of climate adaptation strategies.<sup>9,11,59</sup> In addition to local  
27 government action, regional agencies and regional aggregations of governments are becoming  
28 significant climate change adaptation actors.<sup>8,56</sup>

29

Table 28.3: Examples of Local and Regional Adaptation Activities\*

Local or Regional Government	Adaptation Action
<b>Satellite Beach, FL</b>	Collaboration with the Indian River Lagoon National Estuary Program led to efforts to try to incorporate sea level rise projections and policies into the city’s comprehensive growth management plan. <sup>53</sup>
<b>Portland, OR</b>	Updated the city code to require on-site stormwater management for new development and re-development. Provides a downspout disconnection program to help promote on-site stormwater management . <sup>60</sup>
<b>Lewes, DE</b>	In partnership with Delaware Sea Grant, ICLEI-Local Governments for Sustainability, the University of Delaware, and state and regional partners, the City of Lewes undertook a stakeholder-driven process to understand how climate adaptation could be integrated into the hazard mitigation planning process. Recommendations for integration and operational changes were adopted by the City Council and are currently being implemented. <sup>61</sup>
<b>Groton, CT</b>	Partnered with federal, state, regional, local, non-governmental, and academic partners through the EPA’s Climate Ready Estuaries program to assess vulnerability to and devise solutions for sea level rise. <sup>62</sup>
<b>San Diego Bay, CA</b>	Five municipalities partnered with the port, the airport, and more than 30 organizations with direct interests in the Bay’s future to develop the San Diego Bay Sea Level Rise Adaptation Strategy. The strategy identified key vulnerabilities for the Bay and adaptation actions that can be taken by individual agencies, as well as through regional collaboration. <sup>9</sup>
<b>Chicago, IL</b>	Through a number of development projects, the city has added 55 acres of permeable surfaces since 2008 and has more than four million square feet of green roofs planned or completed. <sup>63</sup>
<b>King County, WA</b>	Created King County Flood Control District in 2007 to address increased impacts from flooding through activities such as maintaining and repairing levees and revetments, acquiring repetitive loss properties, and improving countywide flood warnings. <sup>64</sup>
<b>New York City, NY</b>	Through a partnership with the Federal Emergency Management Agency (FEMA), the city is updating FEMA Flood Insurance Rate Maps based on more precise elevation data. The new maps will help stakeholders better understand their current flood risks and allow the city to more effectively plan for climate change. <sup>65</sup>
<b>Southeast Florida Climate Compact</b>	Joint commitment among Broward, Miami-Dade, Palm Beach, and Monroe Counties to partner in reducing heat-trapping gas emissions and adapting to climate impacts, including adaptation in transportation, water resources, natural resources, agriculture, and disaster risk reduction. Notable policies emerging from the Compact include regional collaboration to revise building codes and land development regulations to discourage new development or post-disaster redeveloping in vulnerable areas. <sup>66</sup>

<p><b>Phoenix, AZ; Boston, MA; Philadelphia, PA; and New York, NY</b></p>	<p><b>Climate change impacts are being integrated into public health planning and implementation activities that include creating more community cooling centers, neighborhood watch programs, and reductions in the urban heat island effect.</b><sup>9,67,68,69</sup></p>
<p><b>Boulder, CO; New York, NY; and Seattle, WA</b></p>	<p>Water utilities in these communities are using climate information to assess vulnerability and inform decision-making.<sup>60</sup></p>
<p><b>City of Philadelphia</b></p>	<p>In 2006, the Philadelphia Water Department began a program to develop a green stormwater infrastructure, intended to convert more than one-third of the city’s impervious land cover to “Greened Acres”: green facilities, green streets, green open spaces, green homes, etc., along with stream corridor restoration and preservation.<sup>5</sup></p>

1           \*This table includes select examples of local and regional adaptation activities and should not be  
2           considered all-inclusive.

3           There is no one-size-fits-all adaptation solution to the challenges of adapting to climate change  
4           impacts, as solutions will differ depending on context, local circumstance, and scale as well as on  
5           local culture and internal capacity.<sup>9,30</sup>

6           **Non-governmental and Private Sector**

7           Many non-governmental entities have been significant actors in the national effort to prepare for  
8           climate change by providing assistance that includes planning guidance, implementation tools,  
9           contextualized climate information, best practice exchange, and help with bridging the science-  
10          policy divide to a wide array of stakeholders (Figure 28.4).<sup>70,71</sup> The Nature Conservancy, for  
11          example, established the Canyonlands Research Center in Monticello, Utah to facilitate research  
12          and develop conservation applications for resource issues under the multi-stresses of climate  
13          change and land-use demands in the Colorado Plateau region.<sup>72</sup>

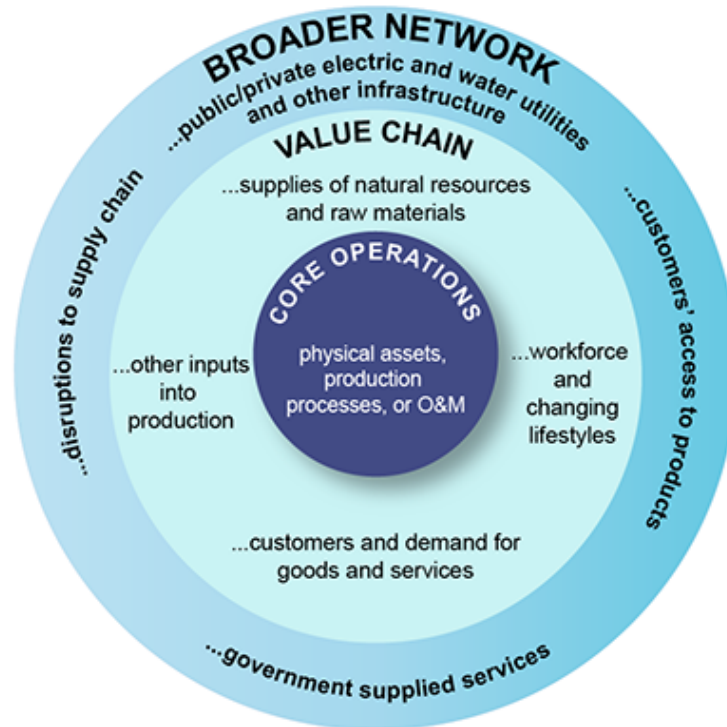
**Table 28.4: Examples of Non-governmental Adaptation Efforts and Services\***

Types of Adaptation Efforts and Services	Examples of Organizations Providing Services
<b>Adaptation planning assistance, including creation of guides, tools, and templates</b>	Center for Climate Strategies, ICLEI-Local Governments for Sustainability, International Institute for Sustainable Development, Natural Resources Defense Council, The Nature Conservancy, World Resources Institute, World Wildlife Fund
<b>Networking and best practice exchange</b>	C40 Cities Climate Leadership Group, Adaptation Network, Center for Clean Air Policy, Climate Adaptation Knowledge Exchange, ICLEI-Local Governments for Sustainability, Institute for Sustainable Communities, Urban Sustainability Directors Network, World Business Council for Sustainable Development
<b>Climate information providers</b>	Union of Concerned Scientists, Urban Climate Change Research Network, Stockholm Environment Institute, U.S. Center
<b>Policy, legal, and institutional support</b>	Center for Climate and Energy Solutions (formerly Pew Center on Global Climate Change), Georgetown Climate Center
<b>Aggregation of adaptation-pertinent information</b>	Carbon Disclosure Project, Climate Adaptation Knowledge Exchange, Georgetown Climate Center

1        \*This list contains examples of non-governmental organizations providing the identified services  
 2        and should not be considered all-inclusive or a validation of actions claimed by the organizations.

3        With regard to the private sector, evidence from organizations such as the Carbon Disclosure  
 4        Project (CDP) and the Securities and Exchange Commission’s (SEC) Climate Change 10-K  
 5        Disclosure indicate that a growing number of companies are beginning to actively address risks  
 6        from climate change (Table 28.5).<sup>73</sup> The World Business Council for Sustainable Development  
 7        (WBCSD) and the Center for Climate and Energy Solutions (C2ES) have identified three types  
 8        of risks driving private sector adaptation efforts, including risks to core operations, the value  
 9        chain, and broader changes in the economy and infrastructure (See Figure 28.2).<sup>74,75,76</sup>

### Effects of Climate Change on...



1  
2 **Figure 28.2:** “Risk Disk” depicts three pathways by which risks posed by climate change  
3 can affect business, such as through core operations, the value chain, and broader changes  
4 in the economy and infrastructure. (Figure source: redrawn from C2ES 2008<sup>74</sup>).

5 This analysis is supported by responses to the 2011 CDP, and suggests that companies are  
6 concerned about how changes in the climate will impact issues such as feedstock, water supply  
7 and quality, infrastructure, core operations, supply chains, and customers’ ability to use (and  
8 their need for) services.<sup>73</sup>

**Table 28.5: Examples of Private Sector Actions to Adapt to Climate Risks as Reported to the Carbon Disclosure Project\***

Company	Sector	Climate Risk	Examples of Actions Undertaken
<b>Coca-Cola Company</b>	Consumer Staples	Changes in physical climate parameters;  Changes in other climate-related developments	Coca-Cola is working around the world to replenish the water used in finished beverages by participating in locally relevant water projects that support communities and nature. Since 2005, the Coca-Cola system has engaged in more than 320 projects in 86 countries. The range of community projects includes watershed protection; expanding community drinking water and sanitation access; water for productive use, such as agricultural water efficiency; and education and awareness programs. ( <a href="http://www.thecoca-colacompany.com/citizenship/conservation_partnership.html">http://www.thecoca-colacompany.com/citizenship/conservation_partnership.html</a> )
<b>ConAgra Foods, Inc.</b>	Consumer Staples	Company experienced weather-related sourcing challenges, such as delayed tomato harvesting due to unseasonably cool weather, and difficulty sourcing other vegetables due to above normal precipitation.	As part of its business continuity planning, ConAgra Foods has analyzed its supply risk to develop strategic partnerships with suppliers, minimize sole-sourced ingredients, and identify alternate suppliers and contract manufacturers to minimize production disruptions in the instance of an unexpected disruption in supply. ( <a href="http://company.conagrafoods.com/phoenix.zhtml?c=202310&amp;p=Policies_Environment">http://company.conagrafoods.com/phoenix.zhtml?c=202310&amp;p=Policies_Environment</a> )
<b>Constellation Brands</b>	Consumer Staples	Changes in physical climate parameters;  Changes in other climate-related developments	Constellation has already taken adaptation actions, particularly in California where water availability is an issue, to manage or adapt to these risks. Constellation is working with numerous organizations to help fund industry-based research to determine potential climate change impacts on vineyard production.
<b>Munich Re</b>	Reinsurance	Changes in regulation; Changes in physical climate parameters;  Changes in other climate-related developments	Since 2007, a Group-wide climate change strategy covering all aspects of climate change – for example, weather-related impacts, regulatory impacts, litigation and health risks, etc. – has supported their core corporate strategy. The strategy is based on five pillars: mitigation, adaptation, research, in-house carbon dioxide reduction, and advocacy. ( <a href="http://www.munichre.com/en/group/focus/climate_change/default.aspx">http://www.munichre.com/en/group/focus/climate_change/default.aspx</a> )
<b>Pacific Gas and Electric Company (PG&amp;E)</b>	Utilities	Changes in regulation; changes in physical climate parameters;  Changes in other climate-related developments	PG&E's adaptation strategies for potential increased electricity demand include expanded customer energy efficiency and demand response programs and improvements to its electric grid. PG&E is proactively tracking and evaluating the potential impacts of reductions to Sierra Nevada snowpack on its hydroelectric system and has developed adaptation strategies to minimize them. Strategies include maintaining higher winter carryover reservoir storage levels, reducing conveyance flows in canals and flumes in response to an increased portion of precipitation falling as rain, and reducing discretionary reservoir water releases during the late spring and summer. PG&E is also working with both the U.S. Geological Survey (USGS) and the California Department of Water Resources to begin using the USGS Precipitation-Runoff Modeling System (PRMS) watershed model, to help manage reservoirs on watersheds experiencing mountain snowpack loss. ( <a href="http://www.pge.com/about/environment/commitment/">http://www.pge.com/about/environment/commitment/</a> )

<b>SC Johnson &amp; Son, Inc.</b>	<b>Household Products</b>	<b>Changes in physical climate parameters</b>	<b>SC Johnson is adjusting to the various physical risks that climate change imposes through a diversified supplier and global manufacturing base. In March 2009, SC Johnson announced a broad ingredient communication program. SC Johnson assesses risks along each ingredient’s supply chain to ensure that the company is sourcing from a geographically diverse supplier base. In addition to evaluating product ingredients, SC Johnson has also diversified its operations around the world, allowing it to maintain business continuity in the face of a regional climate change related disruption. (<a href="http://www.scjohnson.com/en/commitment/overview.aspx">http://www.scjohnson.com/en/commitment/overview.aspx</a>)</b>
<b>Spectra Energy, Inc.</b>	Energy	Changes in regulation; Changes in physical climate parameters;  Changes in other climate-related developments	Spectra Energy uses a corporate-wide risk analysis framework to ensure the oversight and management of its four major risk categories: financial, strategic, operational, and legal risks. Physical risks posed by climate change fall within these categories and the company uses risk management committees to ensure that all material risks are identified, evaluated and managed prior to financial approvals of major projects. ( <a href="http://www.spectraenergy.com/Sustainability/">http://www.spectraenergy.com/Sustainability/</a> )

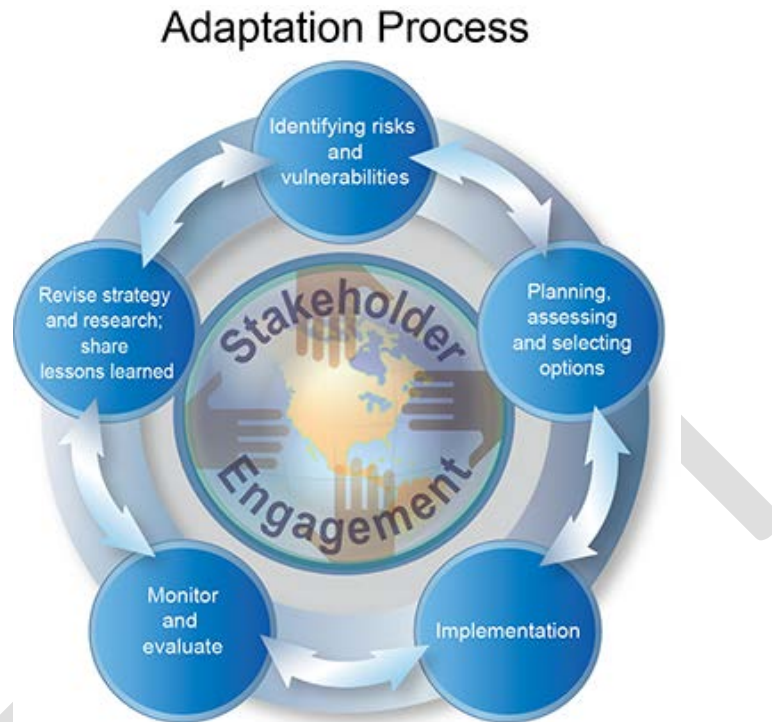
1 \* This list contains examples of private sector actions to adapt to climate risks as reported to the Carbon  
 2 Disclosure Project and should not be considered all-inclusive or a validation of actions claimed by the  
 3 organizations.

4 Some companies are taking action to not only avoid risk, but to explore potential opportunities  
 5 that may emerge in a changing climate, such as developing new products and services;  
 6 developing or expanding existing consulting services; expanding into new operational territories;  
 7 extending growing seasons and hours of operation; and responding to increased demand for  
 8 existing products and services.<sup>73,75,77,78</sup>



## 1 I. Adaptation Process

2 General patterns in adaptation processes are beginning to emerge, with similarities discernible  
3 across sectors, systems, and scales.<sup>52,78,79</sup>



4  
5 **Figure 28.3: Generalized Adaptation Process** (Figure source: adapted from NRC,  
6 2010<sup>11</sup>).

7 This is not a stepwise or linear process; various stages can be occurring simultaneously, in a  
8 different order, or be omitted completely. However, as shown clockwise in Figure 28.3, the  
9 process generally involves characterizing vulnerability, developing options, implementing  
10 actions, monitoring outcomes, and re-evaluating strategies. Each of these is described in more  
11 detail below.

### 12 **Identifying and Understanding Risk, Vulnerabilities, and Opportunities**

13 Most adaptation actions are currently in the initial phase, with many actors focusing on  
14 identifying the relevant climate risks and conducting current and future risk and vulnerability  
15 assessments of their assets and resources.<sup>8,11,58,80,81,82</sup> In 2011, only 13% of 298 U.S.  
16 municipalities surveyed had completed vulnerability or risk assessments, but 42% expected to  
17 complete an assessment in the future.<sup>58</sup> At least 21 state fish and wildlife agencies have  
18 undertaken climate vulnerability assessments or recently completed an assessment of a particular  
19 species, habitat, or both.<sup>37</sup> Multiple qualitative and quantitative methods are used to understand  
20 climate vulnerability and risk, including case studies and analogue analyses, scenario analyses,  
21 sensitivity analyses, monitoring of key species, and peer information sharing.<sup>8,27,67,83</sup>

22

## 1 **Planning, Assessing, and Selecting Options**

2 Once risks and vulnerabilities are understood, the next stage typically involves identifying,  
3 evaluating, and selecting options for responding to and managing existing and future changes in  
4 the climate.<sup>27</sup> Decision-support planning methods and associated tools help to identify flexible  
5 and context-relevant adaptation activities for implementation.<sup>11,79</sup> Participatory approaches  
6 support the integration of stakeholder perspectives and context-specific information into  
7 decision-making.<sup>84,85</sup> This approach can include having community members and governing  
8 institutions work collectively to define the problem and design adaptation strategies that are  
9 robust while being sensitive to stakeholder values.<sup>85,86</sup> Moreover, regional collaboration has  
10 emerged as an effective strategy for defining common approaches to reducing potential threats,  
11 selecting metrics for tracking purposes, and creating governance structures to help navigate  
12 political challenges.<sup>66,87</sup> As discussed above, a number of government and other organizations  
13 have developed plans with identified adaptation options.

14 Common approaches to adaptation planning include “mainstreaming” or integrating climate  
15 adaptation into existing management plans (for example, hazard mitigation, ecosystem  
16 conservation, water management, public health, risk contingency, and energy) or developing  
17 stand-alone adaptation plans.<sup>68,82,88,89</sup>

18 Many frameworks, tools, and approaches have emerged to help decision-makers make decisions  
19 in light of both uncertainty and the need to achieve multiple societal goals.<sup>7,79</sup> Some of these,  
20 however, are specific to particular localities or resources, are not easy to use by the intended  
21 audiences, do not adequately evaluate trade-offs, and require sophisticated knowledge of climate  
22 change.<sup>90</sup> In general, these approaches promote options that allow reversibility, preserve future  
23 options, can tolerate a variety of impacts, and are flexible, such that mid-course adjustments are  
24 possible.<sup>31,91</sup> Among these approaches are Robust Decision Making (RDM), Iterative Risk  
25 Management (IRM), Adaptive Management or Co-Management, Portfolio Management, and  
26 Scenario Planning (see Ch. 26: Decision Support for more on decision frameworks, processes,  
27 and tools).<sup>7,11,27,53,92,93,94,95,96</sup>

## 28 **Implementation**

29 There is little peer-reviewed literature on adaptation actions, or evaluations of their successes and  
30 failures.<sup>11,35,81,97</sup> Many of the documents submitted as part of this Third National Climate  
31 Assessment (NCA) process indicate that adaptation actions are being implemented for a variety  
32 of reasons. Often, these are undertaken an aim toward reducing current vulnerabilities to hazards  
33 or extreme weather events, such as forest thinning and fuel treatments that reduce fire hazards in  
34 national forests or through the diversification of supply chain sourcing in the private sector.<sup>72,73</sup>  
35 Additionally, an increasing movement toward mainstreaming climate adaptation concerns into  
36 existing processes means that discerning unique climate adaptation activities will be a  
37 challenge.<sup>82,98</sup>

## 38 **Monitoring and Evaluation**

39 There is little literature evaluating the effectiveness of adaptation actions.<sup>9,72,79,85</sup> Evaluation and  
40 monitoring efforts, to date, have focused on the creation of process-based rather than outcome-  
41 based indicators.<sup>85,89</sup> A number of efforts are underway to create indicators related to climate  
42 adaptation,<sup>25</sup> including work by the National Climate Assessment and Development Advisory

1 Committee Indicators Working Group<sup>99</sup> and the U.S. Environmental Protection Agency.<sup>100</sup> Part  
2 of monitoring should include accounting for costs of adaptation. To be sure, this may be difficult  
3 to account for because of challenges in attribution of climate events to climate change versus  
4 climate variability. A few studies summarize projected future costs of adaptation.<sup>101,102</sup>

5 **Revise Strategies/Processes and Information Sharing**

6 Uncertainty about future climate as well as population growth, economic development, response  
7 strategies, and other social and demographic issues can stymie climate adaptation activity.<sup>8,94,103</sup>  
8 Through iterative processes, however, stakeholders can regularly evaluate the appropriateness of  
9 planned and implemented activities and revise them as new information becomes available.<sup>11,27,67</sup>  
10 Additionally, the sharing of best practices and lessons learned can be pivotal means to advancing  
11 understanding and uptake of climate adaptation activity.<sup>82,85</sup> The use of established information-  
12 sharing networks, such as regional climate initiatives, are illustrations of the types of networks  
13 that have supported stakeholder adaptation activity to-date.<sup>9,76,79,85</sup>

## 11 **II. Barriers to Adaptation and Examples of Overcoming Barriers**

2 Despite emerging recognition of the necessity of climate change adaptation, many barriers still  
3 impede efforts to build local, regional, and national-level resilience. Barriers are obstacles that  
4 can delay, divert, or temporarily block the adaptation process,<sup>104</sup> and include difficulties in using  
5 climate change projections for decision-making; lack of resources to begin and sustain adaptation  
6 efforts; lack of coordination and collaboration within and across political and natural system  
7 boundaries as well as within organizations; institutional constraints; lack of leadership; and  
8 divergent risk perceptions/cultures and values (Table 28.7).<sup>11,20,105</sup> Barriers are distinguished  
9 from physical or ecological limits to adaptation, such as physiological tolerance of species to  
10 changing climatic conditions that cannot be overcome (except with technology or some other  
11 physical intervention).<sup>8,53,106</sup>

DRAFT

Barrier	Specific Examples
<b>Climate Change Information and Decision-Making</b> <small>7,8,10,11,14,17,30,31,41,58,68,69,72,82,89,92,103,107,108,109,110</small>	<ul style="list-style-type: none"> <li>• Uncertainty about future climate impacts and difficulty in interpreting the cause of individual weather events</li> <li>• Disconnect between information providers and information users</li> <li>• Fragmented, complex, and often confusing information</li> <li>• Lack of climate education for professionals and the public</li> <li>• Lack of usability and accessibility of existing information</li> <li>• Mismatch of decision-making timescales and future climate projections</li> </ul>
<b>Lack of Resources to Begin and Sustain Adaptation Efforts</b> <small>8,13,41,50,53,58,81,82,109,110,111,112</small>	<ul style="list-style-type: none"> <li>• Lack of financial resources / no dedicated funding</li> <li>• Limited staffing capacity</li> <li>• Underinvestment in human dimensions research</li> </ul>
<b>Fragmentation of Decision-Making</b> <small>8,14,30,31,50,68,113,114</small>	<ul style="list-style-type: none"> <li>• Lack of coordination within and across agencies, private companies, and non-governmental organizations</li> <li>• Uncoordinated and fragmented research efforts</li> <li>• Disjointed climate related information</li> <li>• Fragmented ecosystem and jurisdictional boundaries</li> </ul>
<b>Institutional Constraints</b> <small>8,13,41,50,53,96,111,115,116,117</small>	<ul style="list-style-type: none"> <li>• Lack of institutional flexibility</li> <li>• Rigid laws and regulations</li> <li>• No legal mandate to act</li> <li>• Use of historical data to inform future decisions</li> <li>• Restrictive management procedures</li> <li>• Lack of operational control or influence</li> </ul>
<b>Lack of Leadership</b> <small>29,95,110,111,117,118,119</small>	<ul style="list-style-type: none"> <li>• Lack of political leadership</li> <li>• Rigid and entrenched political structures</li> <li>• Polarization</li> </ul>
<b>Divergent Risk Perceptions, Cultures, and Values</b> <small>50,71,82,114,115,118,120</small>	<ul style="list-style-type: none"> <li>• Conflicting values/risk perceptions</li> <li>• Little integration of local knowledge, context, and needs with traditional scientific information</li> <li>• Cultural taboos and conflict with cultural beliefs</li> <li>• Resistance to change due to issues such as risk perception</li> </ul>

1

2 Despite barriers, individuals within and across sectors and regions are organizing to collectively

3 overcome barriers and adapt to climate change. In many cases, lessons learned from initial

4 programs help inform future adaptation strategies. Figure 28.4 highlights ongoing climate

5 adaptation activities that have overcome some of these barriers in different regions led by state,

6 local, and private actors in the United States. It is not a comprehensive compilation of national

1 adaptation activity, but is intended to identify some of the variety of adaptation efforts taking  
2 place across the country.

3 In addition, Part IV of this chapter provides four in-depth case studies of climate adaptation  
4 strategies at different scales, with multiple stakeholders, and tackling different challenges. Each  
5 of these case studies highlights the different ways stakeholders are approaching adaptation.

- 6 • Through the creation of the National Integrated Drought Information System (NIDIS),  
7 the federal government, in partnership with the National Drought Mitigation Center  
8 (NDMC), states, tribes, universities, and others, has improved capacity to proactively  
9 manage and respond to drought-related risks and impacts through: 1) the provision of  
10 drought early warning information systems with local/regional input on extent, onset, and  
11 severity; 2) a web-based drought portal featuring the U.S. Drought Monitor and other  
12 visualization tools; 3) coordination of research in support and use of these systems; and  
13 4) leveraging of existing partnerships, forecasting, and assessment programs.
- 14 • In the Colorado River Basin, water resource managers, government leaders, federal  
15 agencies, tribes, universities, non-governmental organizations (NGOs), and the private  
16 sector are collaborating on strategies for managing water under a changing climate  
17 through partnerships like the Western Governors’ Association (WGA) and WestFAST  
18 (Western Federal Agency Support Team).
- 19 • In Wisconsin, the Northern Institute of Applied Climate Science and the U.S. Forest  
20 Service, working with multiple partners, initiated a “Climate Change Response  
21 Framework” integrating climate-impacts science with forest management.
- 22 • In Cape Cod, Massachusetts, the U.S. Department of Transportation’s Volpe Center  
23 worked with federal, regional, state, and local stakeholders to integrate climate change  
24 mitigation and adaptation considerations into existing and future transportation, land-use,  
25 coastal, and hazard-mitigation processes.

26  
27  
28  
29



**Figure 28.4: Adaptation Activity**

1. The State of Hawai‘i, Office of Planning, in cooperation with university, private, state, and federal scientists and others, has drafted a framework for climate change adaptation that identifies sectors affected by climate change, and outlines a process for coordinated statewide adaptation planning.<sup>121</sup>
2. One of the priorities of the Hawai‘i State Plan is preserving water sources through forest conservation, as indicated in their “Rain Follows The Forest” report.<sup>122</sup>
3. New England Federal Partners is a multi-agency group formed to support the needs of the states, tribes, and communities of the New England Region and to facilitate and enable informed decision-making on issues pertaining to coastal and marine spatial planning, climate mitigation, and climate adaptation throughout the region.<sup>123</sup>
4. Philadelphia is greening their combined sewer infrastructure to protect rivers, reduce greenhouse gas emissions, improve air quality, and enhance adaptation to a changing climate.<sup>124</sup>
5. Keene, NH, developed a Comprehensive Master Plan that emphasizes fostering walkable, mixed-use neighborhoods by putting services, jobs, homes, arts and culture, and other community amenities within walking distance of each other. The plan also calls for sustainable site and building designs that use resources efficiently. These strategies were identified in the city’s 2007 Adaptation Plan as ways to build resilience while reducing

- 1 greenhouse gas emissions.<sup>125</sup>
- 2 6. New York City has created a Green Infrastructure Plan and is committed to goals that  
3 include the construction of enough green infrastructure throughout the city to manage  
4 10% of the runoff from impervious surfaces by 2030.<sup>126</sup>
- 5 7. Lewes, DE, undertook an intensive stakeholder process to integrate climate change into  
6 the city’s updated hazard mitigation plan.<sup>61</sup>
- 7 8. Local governments and tribes throughout Alaska, such as those in Homer, are planting  
8 native vegetation and changing the coastal surface, moving inland or away from rivers,  
9 and building riprap walls, seawalls or groins, which are shore-protection structures built  
10 perpendicular to the shoreline.<sup>127</sup>
- 11 9. Villages are physically being relocated because of climate impacts such as sea level rise  
12 and erosion; these include Newtok, Shishmaref, Kivalina, and dozens of other villages.<sup>128</sup>
- 13 • Cedar Falls passed legislation in 2009 that includes a new floodplain ordinance that  
14 expands zoning restrictions from the 100-year floodplain to the 500-year floodplain,  
15 because this expanded floodplain zone better reflects the flood risks experienced by the  
16 city during the 2008 floods.<sup>129</sup>
- 17 10. In January 2011, the Michigan Department of Community Health (MDCH) released the  
18 *Michigan Climate and Health Adaptation Plan*, which has a goal of “preparing the public  
19 health system in Michigan to address the public health consequences of climate change in  
20 a coordinated manner.” In September 2010, MDCH received three years’ funding to  
21 implement this plan as part of the Climate-Ready States and Cities Initiative of CDC.<sup>130</sup>
- 22 11. Chicago was one of the first cities to officially integrate climate adaptation into a  
23 citywide climate adaptation plan. Since its release, a number of strategies have been  
24 implemented to help the city manage heat, protect forests, and enhance green design,  
25 such as their work on green roofs.<sup>63</sup>
- 26 12. Grand Rapids, MI, recently released a sustainability plan that integrates future climate  
27 projections to ensure that the economic, environmental, and social strategies embraced  
28 are appropriate for today as well as the future.<sup>131</sup>
- 29 13. Tulsa, OK, has a three-pronged approach to reducing flooding and managing stormwater:  
30 a) prevent new problems by looking ahead and avoiding future downstream problems  
31 from new development (for example, requiring on-site stormwater detention); b) correct  
32 existing problems and learn from disasters to reduce future disasters (for example,  
33 through watershed management and the acquisition and relocation of buildings in flood-  
34 prone areas); and c) act to enhance the safety, environment, and quality of life of the  
35 community through public awareness, an increase in stormwater quality, and emergency  
36 management.<sup>132</sup>
- 37 14. Firewise Communities USA is a nationwide program of the National Fire Protection  
38 Association and is co-sponsored by USDA Forest Service, DOI, and the National



- 1 Association of State Foresters. According to the Texas Forest Service, there are more  
2 than 20 recognized Texas Firewise Communities. The Texas Forest Service works  
3 closely with communities to help them to reach Firewise Community status and offers a  
4 variety of awareness, educational, informational, and capacity-building efforts, such as  
5 *Texas Wildscapes*, a program that assists in choosing less fire-friendly plants.<sup>133</sup>
- 6 15. After the heavy rainfall events of 2004 that resulted in significant erosion on his farms,  
7 Dan Gillespie, a farmer with NRCS in Norfolk, NE, began experimenting with adding  
8 cover crops to the no-till process. It worked so well in reducing erosion and increasing  
9 crop yields that he is now sharing his experience with other farmers.  
10 (<http://www.lenrd.org/projects-programs/>; <http://www.notill.org/>)<sup>134</sup>
- 11 16. Point Reyes National Seashore is preparing for climate change by removing two dams  
12 that are barriers to water flow and fish migration. This change restores ecological  
13 continuity for anadromous fish (those that migrate from the sea to fresh water to spawn),  
14 creating a more resilient ecosystem.<sup>135</sup>
- 15 17. Western Adaptation Alliance is a group of 10 cities in four states in the Intermountain  
16 West that share lessons learned in adaptation planning, develop strategic thinking that can  
17 be applied to specific community plans, and join together to generate funds to support  
18 capacity building, adaptation planning, and vulnerability assessment.<sup>136</sup>
- 19 18. Navajo Nation used information on likely changes in future climate to help inform their  
20 drought contingency plan.<sup>137</sup>
- 21 19. California Department of Health and the Natural Resources Defense Council collaborated  
22 to create the *Public Health Impacts of Climate Change in California: Community*  
23 *Vulnerability Assessment and Adaptation Strategies* report, which is being used to inform  
24 public health preparedness activities in the state.<sup>138</sup>
- 25 20. State of Idaho successfully integrated climate adaptation into the state's Wildlife  
26 Management Plan. (<http://fishandgame.idaho.gov/public/wildlife/cwcs/>)<sup>8</sup>
- 27 21. The Rising Tides Competition was held in 2009 by the San Francisco Bay Conservation  
28 and Development Commission to elicit ideas for how the Bay could respond to sea level  
29 rise.<sup>139</sup>
- 30 22. Flagstaff, Arizona, created a resilience strategy and passed a resilience policy, as opposed  
31 to a formal adaptation plan, as a means to institutionalize adaptation efforts in city  
32 government operations.<sup>140</sup>
- 33 23. The Olympic National Forest and Olympic National Park were sites of case studies  
34 looking at how to adapt management of federal lands to climate change. Sensitivity  
35 assessments, review of management activities and constraints, and adaptation workshops  
36 in the areas of hydrology and roads, fish, vegetation, and wildlife were all components of  
37 the case study process.<sup>141</sup>
- 38 24. King County Flood Control District was reformed to merge multiple flood management

- 1 zones into a single county entity for funding and policy oversight for projects and  
2 programs – partly in anticipation of increased stormwater flows due to climate change.<sup>142</sup>
- 3 25. The Water Utilities Climate Alliance has been working with member water utilities to  
4 ensure that future weather and climate considerations are integrated into short- and long-  
5 term water management planning.(<http://www.wucaonline.org/html/>)<sup>89</sup>
- 6 26. Seattle’s RainWatch program uses an early warning precipitation forecasting tool to help  
7 inform decisions about issues such as drainage  
8 operations.(<http://www.atmos.washington.edu/SPU/>)<sup>19</sup>
- 9 27. City of Portland and Multnomah County created a Climate Action Plan that includes  
10 indicators to help them gauge progress in planning and implementing adaptation  
11 actions.<sup>143</sup>
- 12 28. In 2010, the state of Louisiana launched a \$10 million program to assist communities that  
13 had been affected by Hurricanes Gustav and Ike in becoming more resilient to future  
14 environmental problems. Twenty-nine communities from around the State were awarded  
15 resiliency development funds. The Coastal Sustainability Studio at Louisiana State  
16 University started working in 2012 with all 29 funded communities, as well as many that  
17 did not receive funds, to develop peer-learning networks, develop best practices, build  
18 capacity to implement plans, and develop planning tools and a user-inspired and useful  
19 website to increase community resiliency in the state.<sup>144</sup>
- 20 29. FWS and The Nature Conservancy are cooperating in a pilot adaptation project to address  
21 erosion and salt water intrusion, among other issues, in the Alligator River Refuge. This  
22 project incorporates multiple agencies, native knowledge, community involvement, local  
23 economics, and technical precision.<sup>145</sup>
- 24 30. North and South Carolina are actively working to revise their state wildlife strategies to  
25 include climate adaptation.<sup>82</sup>
- 26 31. The Southeast Florida Climate Compact is a collaboration of the four southernmost  
27 counties in Florida (Monroe, Broward, Palm Springs, and Miami-Dade) focusing on  
28 enhancing regional resilience to climate change and reducing regional greenhouse gas  
29 emissions.<sup>66</sup>

### 30 III. Next Steps

31 Adaptation to climate change is in a nascent stage. The federal government is beginning to  
32 develop institutions and practices necessary to cope with climate change, including efforts such  
33 as regional climate centers within the U.S. Department of Agriculture, the National Oceanic and  
34 Atmospheric Administration (a division of the Department of Commerce), and the Department  
35 of the Interior. While the federal government will remain the funder of emergency responses  
36 following extreme events for which communities were not adequately prepared, an emerging  
37 federal role is to enable and facilitate early adaptation within states, regions, local communities,  
38 and the public and private sectors.<sup>11</sup> The approaches include working to limit current institutional

1 constraints to effective adaptation, funding pilot projects, providing useful and usable adaptation  
2 information – including disseminating best practices, and helping develop tools and techniques  
3 to evaluate successful adaptation.

4 Despite emerging efforts, the pace and extent of adaptation activities are not proportional to the  
5 risks to people, property, infrastructure, and ecosystems from climate change; important  
6 opportunities available during the normal course of planning and management of resources are  
7 also being overlooked. A number of state and local governments are engaging in adaptation  
8 planning, but most have not taken action to implement the plans.<sup>105</sup> Some companies in the  
9 private sector and numerous non-governmental organizations have also taken early action,  
10 particularly in capitalizing on the opportunities associated with facilitating adaptive actions.  
11 Actions and collaborations have occurred across all scales. At the same time, barriers to effective  
12 implementation continue to exist (see Section II).

13 One of the overarching key areas of focus for global change research is enabling research and  
14 development to advance adaptation across scales, sectors, and disciplines. This includes social  
15 science research for overcoming the barriers identified in Section II, such as strategies that foster  
16 coordination, better communication, and knowledge sharing amongst fragmented governing  
17 structures and stakeholders. Research on the kinds of information that users desire and how to  
18 deliver that information in contextually appropriate ways, as well as research on decision-making  
19 in light of uncertainty about climate change and other considerations, will be equally important.  
20 In addition to these areas, emerging areas of emphasis include:

- 21 • Costs and Benefits of Adaptation: Methodologies to evaluate the relevant costs of  
22 adaptation options, as well as the costs of inaction, need to be developed.<sup>6,101</sup>
- 23 • A Compendium of Adaptation Practices: A central and streamlined database of  
24 adaptation options implemented at different scales in space and time is needed.  
25 Information on the adaptation actions, how effective they were, what they cost, and how  
26 monitoring and evaluation were conducted should be part of the aggregated  
27 information.<sup>11,20,30</sup>
- 28 • Adaptation and Mitigation Interactions: Research and analysis on the growing and  
29 competing demands for land, water, and energy and how mitigation actions could affect  
30 adaptation options, and vice versa.<sup>4,25,81,146</sup>
- 31 • Critical Adaptation Thresholds: Research to identify critical thresholds beyond which  
32 social and/or ecological systems are unable to adapt to climate change. This should  
33 include analyzing historical and geological records to develop models of  
34 “breakpoints”.<sup>2,30,147</sup>
- 35 • Adaptation to Extreme Events: Research on preparedness and response to extreme events  
36 such as droughts, floods, intense storms, and heat waves in order to protect people,  
37 ecosystems, and infrastructure. Increased attention must be paid to how extreme events  
38 and variability may change as climate change proceeds and how that affects adaptation  
39 actions.<sup>11,148</sup>

1 Effective adaptation will require ongoing, flexible, transparent, inclusive, and iterative decision-  
2 making processes, collaboration across scales of government and sectors, and the continual  
3 exchange of best practices and lessons learned. All stakeholders have a critical role to play in  
4 ensuring the preparedness of our society to extreme events and long-term changes in climate.

## 5 **IV. Case Studies**

### 6 **Illustrative Case One: National Integrated Drought Information System**

7 NIDIS (National Integrated Drought Information System), originally proposed by the Western  
8 Governors' Association (WGA) and established by Congress in 2006,<sup>149</sup> is a federally-created  
9 entity that improves the nation's capacity to proactively manage drought-related risks across  
10 sectors, regions, and jurisdictions. It was created by Congress to "enable the Nation to move  
11 from a reactive to a more proactive approach to managing drought risks and impacts." NIDIS has  
12 successfully brought together government partners and research organizations to advance a  
13 warning system for drought-sensitive areas.

14 The creation of NIDIS involved many years of development and coordination among federal,  
15 state, local, regional, and tribal partners with the help of Governors' associations and Senate and  
16 Congressional leaders. NIDIS provides: 1) drought early warning information systems with  
17 regional detail concerning onset and severity; 2) a web-based portal ([www.drought.gov](http://www.drought.gov)); 3)  
18 coordination of federal research in support of and use of these systems; and 4) leveraging of  
19 existing partnerships and of forecasting and assessment programs. NIDIS currently supports  
20 work on water supply and demand, wildfire risk assessment and management, and agriculture.  
21 Regional drought early warning system pilot projects have been established to illustrate the  
22 benefits of improved knowledge management, improved use of existing and new information  
23 products, and coordination and capacity development for early warning systems. These prototype  
24 systems are in the Upper Colorado Basin, the Apalachicola-Chattahoochee-Flint River Basin in  
25 the Southeast, the Four Corners region in the Southwest, and California. The NIDIS Outlook in  
26 the Upper Colorado Basin provides early warning information every week, for example, that is  
27 utilized by a variety of users from federal agencies, water resource management, and the  
28 recreation industry.

29 The Western Governors' Association, the U.S. Congress, and others have formally  
30 acknowledged that NIDIS provides a successful example of achieving effective federal-state  
31 partnerships by engaging both leadership and the public, and establishing an authoritative basis  
32 for integrating monitoring and research to support risk management. Some of NIDIS's keys to  
33 success include:

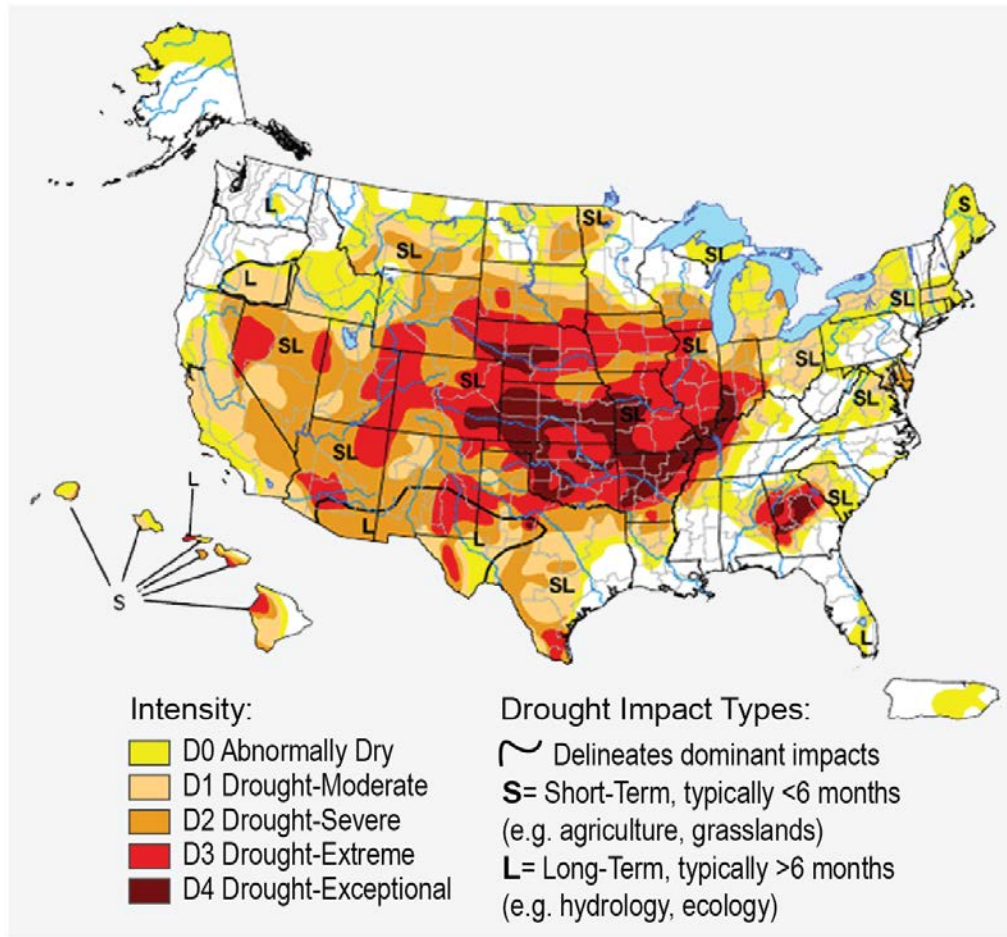
- 34 • Usable Technology and Information for Decision Support: The production of the U.S.  
35 Drought Monitor map, which integrates multiple indicators and indices from many data  
36 sources, was developed before NIDIS was established and has become a useful visual  
37 decision support tool for monitoring and characterizing drought onset, severity, and  
38 persistence. NIDIS has engaged regional and local experts in refining the regional details of  
39 this national product and in "ground truthing" maps via email discussions and webinars  
40 (Figure 28.5).

- 1 • Financial Assistance: Federal funding was allocated to NOAA specifically for NIDIS, but  
2 leveraged in kind by other agencies and partners.
  
- 3 • Institutional/Partnerships: Effective collaborations, partnerships, and coordination with  
4 NOAA, WGA, USDA, DOI, and USGS as well as local, regional, state, and tribal partners  
5 and with the National Drought Mitigation Center at the University of Nebraska, Lincoln,  
6 have led to multi-institutional “buy-in”.
  
- 7 • Institutional/Policy: The NIDIS Act was oriented toward the improvement of coordination  
8 across federal agencies and with regional organizations, universities, and states. It focused on  
9 the application of technology, including the Internet, and on impact assessments for decision  
10 support. A key aspect of NIDIS is the development of an ongoing regional outlook forum  
11 based on the above information to build awareness of the drought hazard and to embed  
12 information in planning and practice (in partnership with the National Drought Mitigation  
13 Center, the Regional Integrated Sciences and Assessments (RISA), and other research-based  
14 boundary organizations) to reduce risks and impacts associated with drought.

15

DRAFT

## U.S. Drought Monitor August 14, 2012



1

2 **Figure 28.5:** U.S. Drought Monitor Map accessed on August 20, 2012. The U.S. Drought  
 3 Monitor is produced in partnership between the national Drought Mitigation Center at the  
 4 University of Nebraska-Lincoln, the United States Department of Agriculture, and the  
 5 National Oceanic and Atmospheric Administration. Map courtesy of NDMC-UNL.

- 6
- 7 • Leadership and Champions: NIDIS supporters worked at all levels over more than two  
 8 decades (1990s and 2000s) to establish the NIDIS Act, including political (WGA,  
 9 Southern Governors’ Association, National Governors Association, and U.S. Senators  
 and Representatives); scientific leaders; and federal agencies (NOAA, USDA, DOI).
- 10
- 11 • Risk Perceptions: Whereas drought had been considered primarily a western issue in  
 12 previous decades, drought is now regularly affecting the southern, southeastern, and  
 13 northeastern parts of the country and response strategies are needed. Because of the 2012  
 14 drought, more than 63% of the contiguous U.S. by the end of July was classified as  
 15 experiencing moderate to exceptional drought and more than 3,200 heat records were  
 broken in June 2012 alone.<sup>150</sup>

## 1 **Illustrative Case Two: Adaptive Governance in the Colorado River Basin**

2 The Colorado River supplies water and valuable ecosystem services to 33 million people and is  
3 vulnerable to climate change because of decreases in mountain snowpack and water availability,  
4 increased competition among water users, fires, drought, invasive species, and extended extreme  
5 heat events, among other threats.<sup>13,151</sup> The 1922 Colorado River Compact, which allocates water  
6 among seven U.S. states and Mexico, was agreed upon in a particularly wet time period;<sup>152</sup> thus  
7 the river water is already over-allocated for current conditions. Given the likelihood of having  
8 less water because of climate change, resource managers and government leaders are  
9 increasingly recognizing that water must be managed with flexibility to respond to the projected  
10 impacts and the range of possible future climates (see Ch. 2: Our Changing Climate; Ch. 3:  
11 Water).<sup>13,153</sup> Multiple actors across multiple disciplines, scales of governance (including tribal,  
12 local, state, and federal), non-governmental organizations, and the private sector are organizing  
13 and working together to address these concerns and the relationship between climate and other  
14 stresses in the basin.

15 The Western Governors' Association (WGA) spearheaded adaptation efforts to enable federal,  
16 state, tribal, local, and private sector partners to address a range of issues, including climate  
17 change.<sup>13,153,154</sup> For example, the Western Federal Agency Support Team (WestFAST), which  
18 was established in 2008, created a partnership between the Western States Water Council  
19 (WSWC) and 11 federal agencies with water management responsibilities in the western United  
20 States. The agencies created a work plan in 2011 to address three key areas: 1) climate change;  
21 2) water availability, water use, and water reuse; and 3) water quality. To date they have  
22 produced the WestFAST Water-Climate Change Program Inventory, the Federal Agency  
23 Summary, and a Water Availability Studies Inventory  
24 (<http://www.westgov.org/wswc/WestFAST.htm>).

25 The WSWC and the USACE produced the Western States Watershed Study (WSWS), which  
26 demonstrated how federal agencies could work collaboratively with western states on planning  
27 activities.<sup>155</sup> In 2009, the WGA also adopted a policy resolution titled "Supporting the  
28 Integration of Climate Change Adaptation Science in the West" that created a Climate  
29 Adaptation Work Group composed of western state experts in air quality, forest management,  
30 water resources, and wildlife management. Other important adaptation actions were the  
31 SECURE Water Act in 2009, the Reclamation Colorado River Basin water supply and demand  
32 study, and the creation of NIDIS to support stakeholders in coping with drought.<sup>149,156</sup>

33

## 1 Illustrative Case Three: Climate Change Adaptation in Forests



2  
3 **Figure 28.6:** Northwoods Climate Change Response Framework Region (Figure Source:  
4 USDA Forest Service 2012<sup>157</sup>).

5 Northern Wisconsin's climate has warmed over the past 50 years, and windstorms, wildfires,  
6 insect outbreaks, and floods are projected to become more frequent in this century.<sup>158</sup> The  
7 resulting impacts on forests, combined with fragmented and complex forest ownership, create  
8 management challenges that extend across ownership boundaries, creating the need for a multi-  
9 stakeholder planning process.<sup>159</sup>

10 To address these concerns, the Northern Institute of Applied Climate Science, the USDA's  
11 Forest Service, and many other partners initiated the Climate Change Response Framework to  
12 incorporate scientific research on climate change impacts into on-the-ground management.  
13 Originally developed as a pilot project for all-lands conservation in northern Wisconsin, it has  
14 expanded to cover three ecological regions (Northwoods [Figure 28.6], Central Hardwoods, and  
15 Central Appalachians) across eight states in the Midwest and Northeast. The Framework uses a  
16 collaborative and iterative approach to provide information and resources to forest owners and  
17 managers across a variety of private and public organizations. Several products were developed  
18 through the Framework in northern Wisconsin:

- 19 1. Vulnerability and mitigation assessments summarized the observed and projected  
20 changes in the northern Wisconsin climate; projected changes in forest composition and  
21 carbon stocks across a range of potential climates; and assessed related vulnerabilities of  
22 forest ecosystems in northern Wisconsin.<sup>158</sup>
- 23 2. *Forest Adaptation Resources: Climate Change Tools and Approaches for Land*  
24 *Managers*<sup>160</sup> was developed to help managers identify management tactics that facilitate  
25 adaptation. A "menu" of adaptation strategies and approaches for planning,  
26 implementing, and monitoring adaptation activities was synthesized into an adaptation  
27 workbook from a broad set of literature and refined based on feedback from regional  
28 scientists and managers.<sup>161</sup>
- 29 3. A series of adaptation demonstrations was initiated to showcase ground-level  
30 implementation. The Framework and adaptation workbook provide a common process  
31 shared by diverse landowners and a formal network that supports cross-boundary  
32 discussion about different management objectives, ecosystems, and associated adaptation  
33 tactics.



1 From the beginning, the Framework has taken an adaptive management approach in its  
2 adaptation planning and projects. Lessons learned include:

- 3 • Define the purpose and scope of the Framework and its components early, but allow for  
4 refinement to take advantage of new opportunities;
- 5 • Begin projects with a synthesis of existing information to avoid duplicating efforts;
- 6 • Plan for the extra time necessary to implement true collaboration;
- 7 • Carefully match the skills, commitment, and capacity of people and organizations to  
8 project tasks;
- 9 • Maintain an atmosphere of trust, positivity, and sense of adventure, rather than  
10 dwelling on failures;
- 11 • Acknowledge and work with uncertainty, rather than submit to “uncertainty paralysis”;
- 12 • Recognize the necessity of effective communication among people with different goals,  
13 disciplinary backgrounds, vocabulary, and perspectives on uncertainty;
- 14 • Integrate the ecological and socioeconomic dimensions early by emphasizing the many  
15 ways that communities value and depend on forests; and
- 16 • Use technology to increase efficiency of internal communication and collaboration, as  
17 well as outreach.

18 The Framework brings scientists and land managers together to assess the vulnerability of  
19 ecosystems based on scientific information and experience in order to plan adaptation actions  
20 that meet management goals. On-the-ground implementation has just begun, and an increased  
21 focus on demonstrations, monitoring, and evaluation will inform future adaptation efforts.

1 **Illustrative Case Four: Transportation, Land Use, and Climate Change – Integrating**  
2 **Climate Adaptation and Mitigation in Cape Cod, Massachusetts**

3 Cape Cod, Massachusetts, a region of scenic beauty and environmental significance, is currently  
4 affected by sea level rise, coastal erosion, and localized flooding – impacts that are likely to be  
5 exacerbated by climate change.<sup>162,163</sup> To address these concerns and help meet the state’s  
6 greenhouse gas (GHG) reduction target (25% reduction based on 1990 levels by 2020), the  
7 DOT’s Volpe Center worked with federal, regional, state, and local stakeholders to integrate  
8 climate change into existing and future transportation, land-use, coastal zone, and hazard  
9 mitigation planning through an initiative called the Transportation, Land Use, and Climate  
10 Change Pilot Project.<sup>162,164</sup>

11 The process was initiated through an expert elicitation held in mid-2010 to identify areas on  
12 Cape Cod that are or could potentially be vulnerable to sea level rise, flooding, and erosion. The  
13 Volpe Center then used a geographic information system (GIS) software tool to develop and  
14 evaluate a series of transportation and land-use scenarios for the Cape under future development  
15 projections.<sup>163,165</sup> All scenarios were evaluated against a series of criteria that included: 1)  
16 reduction in vehicle miles traveled (VMT); 2) reduced heat-trapping gas emissions; 3) reduction  
17 in transportation energy use; 4) preservation of natural/existing ecosystems; 5) reduction in  
18 percentage of new population in areas identified as vulnerable to climate change impacts; and 6)  
19 increased regional accessibility to transportation.<sup>162</sup>

20 Once the preliminary scenarios were developed, a workshop was convened in which community  
21 and transportation planners, environmental managers, and Cape Cod National Seashore  
22 stakeholders selected areas for development and transit improvements to accommodate new  
23 growth while meeting the goals of reduced heat-trapping gas emissions, increased resilience to  
24 climate change, and the conservation of natural systems.<sup>163</sup> Through interactive, visualization  
25 tools, participants were able to see in real-time the impacts of their siting decisions, allowing  
26 them to evaluate synergies and potential trade-offs of their choices and to highlight areas where  
27 conflict could or already does exist, such as increasing density of development in areas already  
28 or likely to be vulnerable to climate change.<sup>166</sup> As a result, the stakeholders developed a refined  
29 transportation and land-use scenario that will support the region’s long-range transportation  
30 planning as well as other local, regional, and state plans. This updated scenario identifies  
31 strategies that have climate adaptation and mitigation value, helping to ensure that the region  
32 simultaneously reduces its heat-trapping gas footprint while building resilience to existing and  
33 future changes in climate.<sup>162,163</sup> The overall success of the pilot project stemmed from the  
34 intensive stakeholder interaction at each phase of the project (design, implementation, and  
35 evaluation).

36

1

## Traceable Accounts

### 2 Chapter 28: Adaptation

3 **Key Message Process:** A central component of the process were bi-weekly technical discussions held from October  
 4 2011 to June 2012 via teleconference that focused on collaborative review and summary of all technical inputs  
 5 relevant to adaptation (130+) as well as additional published literature, the iterative development of key messages,  
 6 and the final drafting of the Chapter. An in-person meeting was held in Washington, D.C. in June 2012. Meeting  
 7 discussions were followed by expert deliberation of draft key messages by the authors, and targeted consultation  
 8 with additional experts by the lead author of each key message. Consensus was reached on all key messages and  
 9 supporting text.

<b>Key message #1/6</b>	<b>Substantial adaptation planning is occurring in the public and private sectors and at all levels of government; however, few measures have been implemented and those that have appear to be incremental changes.</b>
<b>Description of evidence base</b>	<p>The key message and supporting text summarize extensive evidence documented in the peer-reviewed literature as well as the more than 130 technical inputs received and reviewed as part of the Federal Register Notice solicitation for public input.</p> <p>Numerous peer-reviewed publications describe that a growing number of sectors, governments at all scales, and private and non-governmental actors are starting to undertake adaptation activity.<sup>9,13</sup> Much of this activity is focused on planning with little literature documenting implementation of activities.<sup>8,11,82</sup> Supporting this statement is also plentiful literature that profiles barriers or constraints that are impeding the advancement of adaptation activity across sectors, scales, and regions.<sup>41,68</sup></p> <p>Additional citations are used in the text of the Adaptation chapter to substantiate this key message.</p>
<b>New information and remaining uncertainties</b>	n/a
<b>Assessment of confidence based on evidence</b>	n/a

10

11

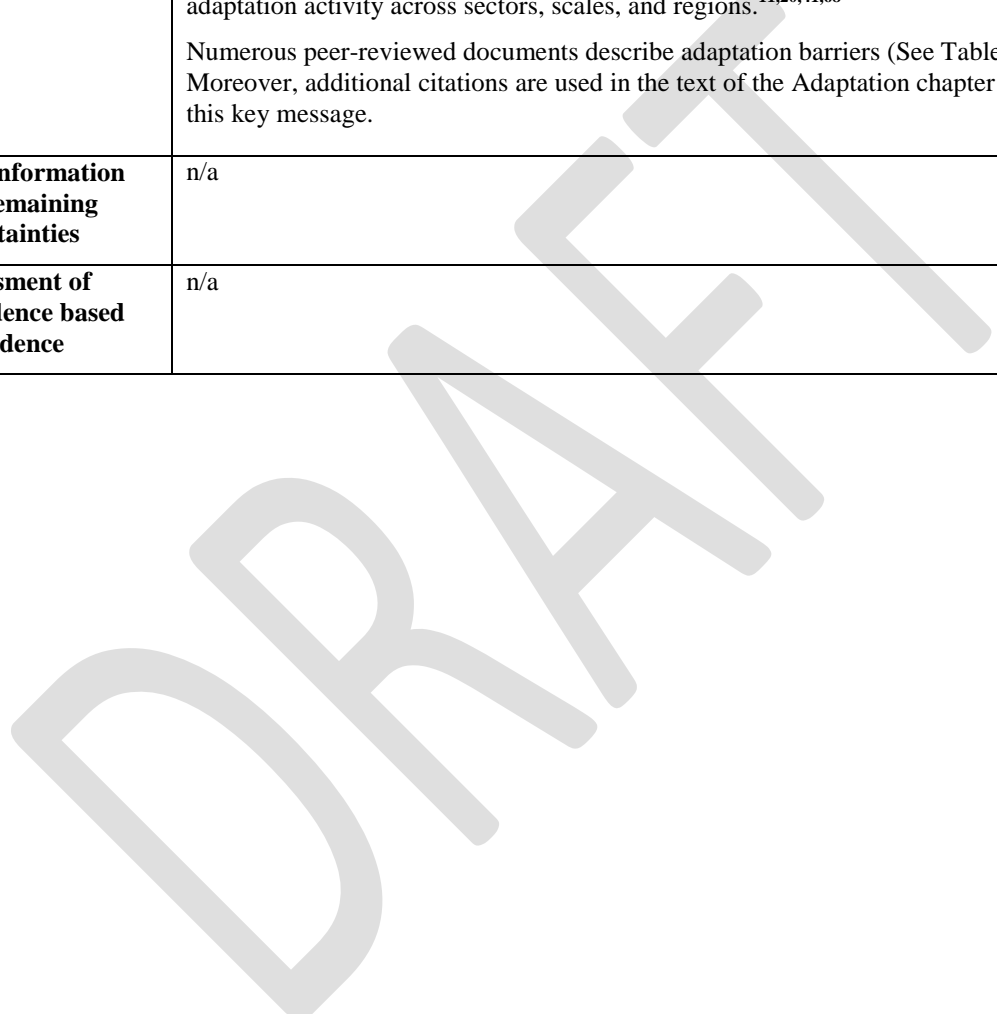
1 **Chapter 28: Adaptation**

2 **Key Message Process:** See key message #1.

<b>Key message #2/6</b>	<b>Barriers to implementation of adaptation action include lack of funding, policy and legal impediments, and difficulty in anticipating climate related changes at local scales.</b>
<b>Description of evidence base</b>	<p>The key message and supporting text summarize extensive evidence documented in the peer reviewed literature as well as the more than 130 technical inputs received and reviewed as part of the Federal Register Notice solicitation for public input. A significant quantity of reviewed literature profiles barriers or constraints that are impeding the advancement of adaptation activity across sectors, scales, and regions.<sup>11,20,41,68</sup></p> <p>Numerous peer-reviewed documents describe adaptation barriers (See Table 28.7). Moreover, additional citations are used in the text of the Adaptation chapter to substantiate this key message.</p>
<b>New information and remaining uncertainties</b>	n/a
<b>Assessment of confidence based on evidence</b>	n/a

3

4



1 **Chapter 28: Adaptation**

2 **Key Message Process:** See key message #1.

<b>Key message #3/6</b>	<b>There is no "one-size fits all" adaptation, but there are similarities in approaches across regions and sectors. Sharing best practices, learning by doing, and iterative and collaborative processes including stakeholder involvement, can help support progress.</b>
<b>Description of evidence base</b>	<p>The key message and supporting text summarize extensive evidence documented in the peer reviewed literature as well as the more than 130 technical inputs received and reviewed as part of the Federal Register Notice solicitation for public input.</p> <p>Literature submitted for the Assessment, as well as additional literature reviewed by the author team, fully supports the concept that adaptations will ultimately need to be selected for their local applicability based on impacts, timing, political structure, finances, and other criteria.<sup>11,89</sup> Similarities do exist in the types of adaptation being implemented, although nuanced differences do make most adaptation uniquely appropriate for the specific implementer. The selection of locally and context-appropriate adaptations is enhanced by iterative and collaborative processes in which stakeholders directly engage with decision makers and information providers.<sup>11,20,27</sup> While there are no "one-size fits all" adaptation strategies, evidence to-date supports the message that the sharing of best practices and lessons learned are greatly aiding in adaptation progress across sectors, systems, and governance systems.<sup>82,85</sup></p> <p>Additional citations are used in the text of the adaptation chapter to substantiate this key message.</p>
<b>New information and remaining uncertainties</b>	n/a
<b>Assessment of confidence based on evidence</b>	n/a

3

4

1 **Chapter 28: Adaptation**

2 **Key Message Process:** See key message #1.

<b>Key message #4/6</b>	Climate change adaptation actions often fulfill other societal goals, such as sustainable development, disaster risk reduction, or improvements in quality of life, and can therefore be incorporated into existing decision-making processes.
<b>Description of evidence base</b>	<p>The key message and supporting text summarize extensive evidence documented in the peer reviewed literature as well as the more than 130 technical inputs received and reviewed as part of the Federal Register Notice solicitation for public input.</p> <p>Literature submitted for the Assessment, as well as additional literature reviewed by the author team, supports the message that a significant amount of activity that has climate adaptation value is initiated for reasons other than climate preparedness and/or has other co-benefits in addition to increasing preparedness to climate and weather impacts.<sup>11,20,82,85,114</sup> In recognition of this and other factors, a movement has emerged encouraging the integration of climate change considerations into existing decision-making and planning processes (i.e., mainstreaming).<sup>5,11,39</sup> The case studies discussed in the chapter amplify this point.</p> <p>Additional citations are used in the text of the adaptation chapter to substantiate this key message.</p>
<b>New information and remaining uncertainties</b>	n/a
<b>Assessment of confidence based on evidence</b>	n/a

3

4

1 **Chapter 28: Adaptation**

2 **Key Message Process:** See key message #1.

<b>Key message #5/6</b>	<b>Vulnerability to climate change is exacerbated by other stresses such as pollution, habitat fragmentation, and poverty. Adaptation to multiple stresses requires assessment of the composite threats as well as trade-offs amongst costs, benefits, and risks of available options.</b>
<b>Description of evidence base</b>	<p>The key message and supporting text summarize extensive evidence documented in the peer reviewed literature as well as the more than 130 technical inputs received and reviewed as part of the Federal Register Notice solicitation for public input.</p> <p>Climate change is only one of a multitude of stresses affecting social, environmental, and economic systems. Activity to-date and literature profiling those activities support the need for climate adaptation activity to integrate the concerns of multiple stresses in decision-making and planning.<sup>16,17,31</sup> As evidenced by activities to-date, integrating multiple stresses into climate adaptation decision-making and vice versa will require the assessment of tradeoffs amongst costs, benefits, the risks of available options, and the potential value of outcomes.<sup>5,89,109</sup></p> <p>Additional citations are used in the text of the adaptation chapter to substantiate this key message.</p>
<b>New information and remaining uncertainties</b>	n/a
<b>Assessment of confidence based on evidence</b>	n/a

3

4

1 **Chapter 28: Adaptation**

2 **Key Message Process:** See key message #1.

<b>Key message #6/6</b>	<b>The effectiveness of climate change adaptation has seldom been evaluated, because actions have only recently been initiated and comprehensive evaluation metrics do not yet exist.</b>
<b>Description of evidence base</b>	<p>The key message and supporting text summarize extensive evidence documented in the peer reviewed literature as well as the more than 130 technical inputs received and reviewed as part of the Federal Register Notice solicitation for public input.</p> <p>Numerous peer-reviewed publications indicate that no comprehensive adaptation evaluation metrics exist, meaning that no substantial body of literature or guidance materials exist on how to thoroughly evaluate the success of adaptation activities.<sup>11,81,108</sup> This is an emerging area of research. A challenge of creating adaptation evaluation metrics is the growing interest in mainstreaming; this means that separating out adaptation activities from other activities could prove difficult.</p> <p>Additional citations are used in the text of the adaptation chapter to substantiate this key message.</p>
<b>New information and remaining uncertainties</b>	n/a
<b>Assessment of confidence based on evidence</b>	n/a

3



**References**

1. Bierbaum, R. M., D. G. Brown, and J. L. McAlpine, 2008: *Coping with Climate Change: National Summit Proceedings*. University of Michigan Press, 256 pp
2. SEGCC, 2007: *Confronting climate change: avoiding the unmanageable and managing the unavoidable*. Report prepared for the United Nations Commission on Sustainable Development. R. Bierbaum, J. P. Holdren, M. MacCracken, R. H. Moss, P. H. Raven, and H. J. Schellnhuber, Eds., 144 pp., Scientific Expert Group on Climate Change, Sigma Xi and the United Nations Foundation, Research Triangle Park, NC and Washington, D.C. . [Available online at [http://www.globalproblems-globalsolutions-files.org/unf\\_website/PDF/climate%20 change avoid unmanagable manage unavoidable.pdf](http://www.globalproblems-globalsolutions-files.org/unf_website/PDF/climate%20change%20avoid%20unmanagable%20manage%20unavoidable.pdf)]
3. McMullen, C. P., and J. R. Jabbour, 2009: *Climate change science compendium 2009*. United Nations Environment Programme
4. Skaggs, R., T. C. Janetos, K. A. Hibbard, and J. S. Rice, 2012: *Climate and Energy-Water-Land System Interactions Technical Report to the U.S. Department of Energy in Support of the National Climate Assessment*, 152 pp., Pacific Northwest National Laboratory, Richland, Washington. [Available online at [http://climatemodeling.science.energy.gov/f/PNNL-21185\\_FINAL\\_REPORT.pdf](http://climatemodeling.science.energy.gov/f/PNNL-21185_FINAL_REPORT.pdf)];  
Wilbanks, T., D. Bilello, D. Schmalzer, and M. Scott, 2012: *Climate Change and Energy Supply and Use*. Technical Report to the U.S. Department of Energy in Support of the National Climate Assessment, 79 pp., Oak Ridge National Laboratory, U.S. Department of Energy, Office of Science, Oak Ridge, TN. [Available online at <http://www.esd.ornl.gov/eess/EnergySupplyUse.pdf>]
5. Wilbanks, T., S. Fernandez, G. Backus, P. Garcia, K. Jonietz, P. Kirshen, M. Savonis, B. Solecki, and L. Toole, 2012: *Climate Change and Infrastructure, Urban Systems, and Vulnerabilities*. Technical Report to the U.S. Department of Energy in Support of the National Climate Assessment, 119 pp., Oak Ridge National Laboratory. U.S. Department of Energy, Office of Science, Oak Ridge, TN. [Available online at <http://www.esd.ornl.gov/eess/Infrastructure.pdf>]
6. Karl, T. R., J. T. Melillo, and T. C. Peterson, Eds., 2009: *Global Climate Change Impacts in the United States*. Cambridge University Press, 189 pp.[Available online at <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts>]
7. Kareiva, P., C. Enquist, A. Johnson, S. H. Julius, J. Lawler, B. Petersen, L. Pitelka, R. Shaw, and J. M. West, 2008: *Preliminary review of adaptation options for climate-sensitive ecosystems and resources*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. S. H. Julius, and J. M. West Eds., 9-1 - 9-66 pp. [Available online at <http://library.globalchange.gov/products/sap-4-4-preliminary-review-of-adaptation-options-for-climate-sensitive-ecosystems-and-resources>]
8. USGS, 2012: *Climate change impacts on biodiversity, ecosystems, and ecosystem services: Technical Input to the National Climate Assessment*. S. F. Carter, I. S. Chapin, N. Grimm, P. Kareiva, M. Ruckelshaus, M. Staudinger, A. Staudt, and B. Stein, Eds., U.S. Geological Survey, Reston, VA
9. Solecki, W., and C. Rosenzweig, 2012: *U.S. Cities and Climate Change: Urban, Infrastructure, and Vulnerability Issues*, Technical Input Report Series, U.S. National Climate Assessment. S. W., and C. Rosenzweig, Eds., U.S. Global Change Research Program, Washington, D.C.
10. Kerr, R. A., 2011: Time to adapt to a warming world, but where's the science? *Science*, **334**, 1052-1053, doi:10.1126/science.334.6059.1052
11. NRC, 2010: *Adapting to Impacts of Climate Change. America's Climate Choices: Report of the Panel on Adapting to the Impacts of Climate Change*. The National Academies Press, 292 pp
12. PCAST, 2011: *Report to the President: Sustainability Environmental Capital: Protecting Society and the Economy* 145 pp., President's Council of Advisors on Science and Technology, Executive Office of the President Washington, D.C. [Available online at

- 1 [http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast\\_sustaining\\_environmental\\_capital\\_re](http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_sustaining_environmental_capital_report.pdf)  
2 [ort.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_sustaining_environmental_capital_report.pdf)];
- 3 Wilby, R. L., and S. Dessai, 2010: Robust adaptation to climate change. *Weather*, **65**, 180-185,  
4 doi:10.1002/wea.543
- 5 13. Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, Eds., 2013: *Assessment of Climate Change in the*  
6 *Southwest United States: A Technical Report Prepared for the National Climate Assessment*. Island press, 528  
7 pp
- 8 14. Winkler, J., J. Andresen, and J. Hatfield, Eds., 2012: *Midwest technical input report: Prepared for the US*  
9 *national climate assessment*. 236 pp
- 10 15. Lamb, H. H., 1982: *Climate, History, and the Modern World*. Methuen
- 11 16. IPCC, 2007: Appendix I: Glossary. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution*  
12 *of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S.  
13 Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, Eds., Cambridge  
14 University Press. [Available online at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-app.pdf>]
- 15 17. NRC, 2007: *Understanding Multiple Environmental Stresses: Report of a Workshop*. National Research  
16 Council, The National Academy Press, 154 pp.[Available online at [www.nap.edu](http://www.nap.edu)]
- 17 18. C2ES, 2012: Climate Change Adaptation: What Federal Agencies are Doing, February 2012 Update 71 pp.,  
18 Center for Climate and Energy Solutions, Arlington, VA. [Available online at  
19 <http://www.c2es.org/docUploads/federal-agencies-adaptation.pdf>]
- 20 19. CEQ, 2011: Federal Actions for a Climate Resilient Nation: Progress Report of the Interagency Climate Change  
21 Adaptation Task Force, 32 pp., The White House Council on Environmental Quality, Office of Science and  
22 Technology Policy, Climate Change Adaptation Task Force, Washington, D.C. [Available online at  
23 [http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011\\_adaptation\\_progress\\_report.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_adaptation_progress_report.pdf) ]
- 24 20. NRC, 2010: Informing an Effective Response to Climate Change. America's Climate Choices: Panel on  
25 Informing Effective Decisions and Actions Related to Climate Change, 348 pp., National Research Council,  
26 Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies,, Washington, D.C. [Available  
27 online at [www.nap.edu](http://www.nap.edu)]
- 28 21. U.S. Government, 2009: Executive Order 13514. Federal Leadership in Environmental, Energy, and Economic  
29 Performance, 52117-52127 pp, Federal Register, Washington, D.C. [Available online at  
30 <http://www1.eere.energy.gov/femp/pdfs/eo13514.pdf>]
- 31 22. ICATF, 2011: National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate, 76  
32 pp., U.S. Interagency Climate Change Adaptation Task Force,. [Available online at  
33 [http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011\\_national\\_action\\_plan.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf)]
- 34 23. National Fish Wildlife and Plants Climate Adaptation Partnership, 2012: National Fish, Wildlife and Plants  
35 Climate Adaptation Strategy978-1-938956-00-3, 120 pp., Association of Fish and Wildlife agencies, Council on  
36 Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric  
37 Administration, and U.S. Fish and Wildlife Service., Washington, D.C. [Available online at  
38 <http://www.wildlifeadaptationstrategy.gov/pdf/NFWPCAS-Final.pdf>]
- 39 24. NOC, 2013: National Ocean Policy Implementation Plan, 32 pp., National Ocean Council, Washington, D.C.  
40 [Available online at  
41 [http://www.whitehouse.gov/sites/default/files/national\\_ocean\\_policy\\_implementation\\_plan.pdf](http://www.whitehouse.gov/sites/default/files/national_ocean_policy_implementation_plan.pdf)]
- 42 25. USGCRP, 2012: The National Global Change Research Plan 2012–2021: A Strategic Plan for the U.S. Global  
43 Change Research Program, 132 pp, The U.S. Global Change Research Program, Washington, D.C. [Available  
44 online at <http://downloads.globalchange.gov/strategic-plan/2012/usgcrp-strategic-plan-2012.pdf>]

- 1 26. The White House, 2013: Executive Order – Preparing the United States for the Impacts of Climate Change,  
2 The White House, Washington, D.C. [Available online at [http://www.whitehouse.gov/the-press-  
4 office/2013/11/01/executive-order-preparing-united-states-impacts-climate-change](http://www.whitehouse.gov/the-press-<br/>3 office/2013/11/01/executive-order-preparing-united-states-impacts-climate-change)]
- 4 27. NPS, 2010: National Park Service Climate Change Response Strategy, 36 pp., U.S. National Park Service  
5 Climate Change Response Program, Fort Collins, Colorado. [Available online at  
6 [http://www.nature.nps.gov/climatechange/docs/NPS\\_CCRS.pdf](http://www.nature.nps.gov/climatechange/docs/NPS_CCRS.pdf)]
- 7 28. Rosenzweig, C. H., R.M., 2012: Building Climate Resilient Centers: New York, NY, NASA's Climate Adaptation  
8 Science Investigator (CASI) Workgroup
- 9 29. Smith, J. B., J. M. Vogel, T. L. Cruce, S. Seidel, and H. A. Holsinger, 2010: Adapting to Climate Change: A Call for  
10 Federal Leadership. Pew Center on Global Climate Change, Arlington, VA. [Available online at  
11 <http://www.c2es.org/docUploads/adaptation-federal-leadership.pdf>]
- 12 30. National Climate Adaptation Summit Committee, 2010: National Climate Adaptation Summit Report, 26 pp.,  
13 University Corporation for Atmospheric Research (UCAR), Boulder, CO. [Available online at  
14 [http://www.joss.ucar.edu/events/2010/ncas/ncas\\_report.pdf](http://www.joss.ucar.edu/events/2010/ncas/ncas_report.pdf)]
- 15 31. OTA, 1993: Preparing for an uncertain climate. Volume I and II (OTA-O-567; OTA-O-568). U. S. Congress, Ed.,  
16 365 pp., Office of Technology Assessment, US Government Printing Office, Washington, D.C. [Available online  
17 at [www.fas.org/ota/reports/9338.pdf](http://www.fas.org/ota/reports/9338.pdf)]
- 18 32. CEQ, 2010: Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions  
19 in Support of a National Climate Change Adaptation Strategy 72 pp., The White House Council on  
20 Environmental Quality (CEQ), Washington, D.C. [Available online at  
21 [http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011\\_adaptation\\_progress\\_report.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_adaptation_progress_report.pdf)]
- 22 33. Goulder, L. H., and R. N. Stavins, 2011: Challenges from state-federal interactions in US climate change policy.  
23 *The American Economic Review*, **101**, 253-257, doi:10.1257/aer.101.3.253;
- 24 Morsch, A., and R. Bartlett, 2011: Policy Brief: State Strategies to Plan for and Adapt to Climate Change - NI  
25 PB 11-08, 11 pp., Nicholas Institute for Environmental Policy Solutions – Duke University, Durham, NC.  
26 [Available online at [http://nicholasinstitute.duke.edu/sites/default/files/publications/state-strategies-to-  
28 plan-for-and-adapt-to-climate-change-paper.pdf](http://nicholasinstitute.duke.edu/sites/default/files/publications/state-strategies-to-<br/>27 plan-for-and-adapt-to-climate-change-paper.pdf)]
- 28 34. Feldman, I. R., and J. H. Kahan, 2007: Preparing for the day after tomorrow: frameworks for climate change  
29 adaptation. *Sustainable Development Law & Policy*, **8**, 31-39, 87-89. [Available online at  
30 <http://digitalcommons.wcl.american.edu/cgi/viewcontent.cgi?article=1162&context=sdlp>]
- 31 35. Moser, S. C., 2009: Good Morning America, 39 pp., California Energy Commission, NOAA-Coastal Services  
32 Center, Sacramento, CA and Charleston, SC. [Available online at [http://www.csc.noaa.gov/publications/need-  
34 for-adaptation.pdf](http://www.csc.noaa.gov/publications/need-<br/>33 for-adaptation.pdf)]
- 34 36. C2ES, cited 2012: State Adaptation Plans, Volume 2012 Center for Climate and Energy Solutions. [Available  
35 online at <http://www.c2es.org/us-states-regions/policy-maps/adaptation>]
- 36 37. AFWA, 2011: State Climate Adaptation Summary Report, 90 pp., Association of Fish and Wildlife Agencies,  
37 Washington, D.C.
- 38 38. Immediate Action Workgroup, 2008: Recommendations Report to the Governor's Subcabinet on Climate  
39 Change. Final Report
- 40 from the Immediate Action Workgroup, April 17, 2008, 86 pp., Immediate Action Workgroup, State of Alaska  
41 Juneau, AK. [Available online at [http://www.climatechange.alaska.gov/docs/iaw\\_rpt\\_17apr08.pdf](http://www.climatechange.alaska.gov/docs/iaw_rpt_17apr08.pdf)]
- 42 39. EPA, cited 2012: State and Local Climate and Energy Program. U.S. Environmental Protection Agency.  
43 [Available online at <http://www.epa.gov/statelocalclimate/index.html>]

- 1 40. Salkin, P. E., 2009: Sustainability and Land Use Planning: Greening. State and Local Land Use Plans and  
2 Regulations to Address Climate Change Challenges and Preserve Resources for Future Generations. *William*  
3 *and Mary Environmental Law and Policy Review*, **34**, 121-170. [Available online at  
4 <http://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=1003&context=wmelpr>]
- 5 41. Keener, V., J. J. Marra, M. L. Finucane, D. Spooner, and M. H. Smith, Eds., 2012: *Climate Change and Pacific*  
6 *Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA)*.  
7 Island Press, 170 pp.[Available online at <http://www.pacificrisa.org/projects/pirca/>]
- 8 42. KDFWR, 2010: Action Plan to Respond to Climate Change in Kentucky: A Strategy of Resilience, 37 pp.,  
9 Kentucky Department of Fish and Wildlife Resources. [Available online at  
10 [http://fw.ky.gov/kfwis/stwg/2010Update/Climate\\_Change\\_Chapter.pdf](http://fw.ky.gov/kfwis/stwg/2010Update/Climate_Change_Chapter.pdf)]
- 11 43. State of Louisiana, 2012: Louisiana’s Comprehensive Master Plan for a Sustainable Coast, draft Jan 2012,  
12 State of Louisiana. Coastal Protection and Restoration Authority, Baton Rouge, LA. [Available online at  
13 <http://www.coastalmasterplan.louisiana.gov/2012-master-plan/final-master-plan/>]
- 14 44. Grannis, J., 2011: Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use. How Governments can Use Land-  
15 Use Practices to Adapt to Sea-Level Rise, 100 pp., Georgetown Climate Center, Washington, D.C. [Available  
16 online at [http://www.georgetownclimate.org/sites/default/files/Adaptation\\_Tool\\_Kit\\_SLR.pdf](http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf)]
- 17 45. Feifel, K., 2010: with Implementation of Maryland's Climate Action Plan: Case study on a project of the  
18 Maryland Department of Natural Resources, 2 pp., EcoAdapt, Island Press. [Available online at  
19 [www.cakex.org/printpdf/case-studies/2829](http://www.cakex.org/printpdf/case-studies/2829) ]
- 20 46. Propst, S. C., cited 2012: Innovative Approaches for Adapting to Water Variability in the West. Georgetown  
21 Climate Center. [Available online at [http://www.georgetownclimate.org/resources/innovative-approaches-](http://www.georgetownclimate.org/resources/innovative-approaches-for-adapting-to-water-variability-in-the-west)  
22 [for-adapting-to-water-variability-in-the-west](http://www.georgetownclimate.org/resources/innovative-approaches-for-adapting-to-water-variability-in-the-west)]
- 23 47. SCIPP, 2012: Southern Climate Impacts and Planning Program Regional Integrated Sciences and Assessments  
24 Program 4th Annual Report: May 1, 2011 - April 30, 2012: Norman, OK and Baton Rouge, LA, Southern  
25 Climate Impacts and Planning Program (SCIPP), Oklahoma Climatological Survey, University of Oklahoma and  
26 Louisiana State University p. 20., Southern Climate Impacts Planning Program, University of Oklahoma,  
27 Louisiana State University, and the National Oceanic and Atmospheric Administration. [Available online at  
28 [http://www.southernclimate.org/publications/SCIPP\\_2011-2012\\_Annual\\_Report.pdf](http://www.southernclimate.org/publications/SCIPP_2011-2012_Annual_Report.pdf)]
- 29 48. Brubaker, M., J. Berner, J. Bell, J. Warren, and A. Rolin, 2010: Climate Change in Point Hope, Alaska: Strategies  
30 for Community Health: Anchorage, AK, Alaska Native Tribal Health Consortium, 44 pp., Center for Climate and  
31 Health. [Available online at [http://www.anthc.org/chs/ces/climate/upload/Climate-Change-and-Health-](http://www.anthc.org/chs/ces/climate/upload/Climate-Change-and-Health-Effects-in-Point-Hope-Alaska.pdf)  
32 [Effects-in-Point-Hope-Alaska.pdf](http://www.anthc.org/chs/ces/climate/upload/Climate-Change-and-Health-Effects-in-Point-Hope-Alaska.pdf) ]
- 33 49. Bronen, R., 2011: Climate-induced community relocations: creating an adaptive governance framework based  
34 in human rights doctrine. *NYU Review Law & Social Change*, **35**, 357-408. [Available online at  
35 <http://socialchangenyu.files.wordpress.com/2012/08/climate-induced-migration-bronen-35-2.pdf>]
- 36 50. Simmonds, J., 2011: Resource for Consideration by the NCA Teams Addressing the Impacts of Climate Change  
37 on Native Communities. Native Communities and Climate Change Project of the University of Colorado Law  
38 School and the Cooperative Institute for Research in Environmental Science.
- 39 51. Lamb, R., and M. V. Davis, 2011: Promoting Generations of Self Reliance: Stories and Examples of Tribal  
40 Adaptation to Change, 27 pp., U.S. Environmental Protection Agency Region 10, Seattle, WA. [Available online  
41 at [http://www.epa.gov/region10/pdf/tribal/stories\\_and\\_examples\\_of\\_tribal\\_adaptation\\_to\\_change.pdf](http://www.epa.gov/region10/pdf/tribal/stories_and_examples_of_tribal_adaptation_to_change.pdf)]
- 42 52. Anguelovski, I., and J. Carmin, 2011: Something borrowed, everything new: innovation and institutionalization  
43 in urban climate governance. *Current Opinion in Environmental Sustainability*, **3**,  
44 doi:10.1016/J.cosust.2010.12017

- 1 53. Gregg, R. M., L. J. Hansen, K. M. Feifel, J. L. Hitt, J. M. Kershner, A. Score, and J. R. Hoffman, 2011: The State of  
2 Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas. A report for the Gordon and  
3 Betty Moore Foundation: Bainbridge Island, WA, EcoAdapt., 145 pp. [Available online at  
4 <http://ecoadapt.org/documents/marine-adaptation-report.pdf>]
- 5 54. Rabe, B. G., 2009: Second-generation climate policies in the states: proliferation, diffusion, and  
6 regionalization. *Changing climates in North American politics: institutions, policymaking, and multilevel*  
7 *governance*, H. Selin, and S. D. VanDeveer, Eds., MIT Press, 67-86;
- 8 Wheeler, S. M., 2008: State and municipal climate change plans: The first generation. *Journal of the American*  
9 *Planning Association*, **74**, 481-496, doi:10.1080/01944360802377973
- 10 55. Tang, Z., S. D. Brody, C. Quinn, L. Chang, and T. Wei, 2010: Moving from Agenda to Action: Evaluating Local  
11 Climate Change Action Plans. *Journal of environmental planning and management*, **53**, 41-62,  
12 doi:10.1080/09640560903399772
- 13 56. Wallis, A., 2011: U.S. Regions Planning for Climate Adaptation. University of Colorado - Denver, School of  
14 Public Affairs, Denver, CO
- 15 57. Dierwechter, Y., 2010: Metropolitan geographies of US climate action: cities, suburbs, and the local divide in  
16 global responsibilities. *Journal of Environmental Policy & Planning*, **12**, 59-82,  
17 doi:10.1080/15239081003625960 ;
- 18 Kahn, M. E., 2009: Urban growth and climate change. *Annual Review of Resource Economics*, **1**, 333-350,  
19 doi:10.1146/annurev.resource.050708.144249;
- 20 Selin, H., and S. D. VanDeveer, 2007: Political Science and Prediction: What's Next for U.S. Climate Change  
21 Policy? *Review of Policy Research*, **24**, 1-27, doi:10.1111/j.1541-1338.2007.00265.x. [Available online at  
22 <http://pubpages.unh.edu/~sdv/US-Climate-Policy.pdf>]
- 23 58. Carmin, J., N. Nadkarni, and C. Rhie, 2012: Progress and Challenges in Urban Climate Adaptation Planning:  
24 Results of a Global Survey, 30 pp., Massachusetts Institute of Technology, ICLEI Local Governments for  
25 Sustainability, Cambridge, MA. [Available online at  
26 <http://web.mit.edu/jcarmin/www/urbanadapt/Urban%20Adaptation%20Report%20FINAL.pdf>]
- 27 59. Binder, L. C. W., J. K. Barcelos, D. B. Booth, M. Darzen, M. M. Elsner, R. Fenske, T. F. Graham, A. F. Hamlet, J.  
28 Hodges-Howell, J. E. Jackson, C. Karr, P. W. Keys, J. S. Littell, N. Mantua, J. Marlow, D. McKenzie, M. Robinson-  
29 Dorn, E. A. Rosenberg, C. O. Stöckle, and J. A. Vano, 2010: Preparing for climate change in Washington State.  
30 *Climatic Change*, **102**, 351-376, doi:10.1007/s10584-010-9850-5
- 31 60. EPA, 2010: Office of Water, EPA 800-R-1-001. U.S Environmental Protection Agency
- 32 61. City of Lewes, 2011: Hazard mitigation and climate adaptation action plan: A community guide developed to  
33 improve public safety, minimize losses and create greater city-wide resilience, 164 pp., Delaware Sea Grant  
34 College Program, ICLEI-Local Governments for Sustainability, and University of Delaware Sustainable Coastal  
35 Communities Program. [Available online at  
36 <http://www.deseagrant.org/sites/deseagrant.org/files/attachments/Lewes%20Hazard%20Mitigation%20and%20Climate%20Adaptation%20Action%20Plan.pdf>]
- 38 62. Stults, M., and J. Pagach, 2011: Preparing for Climate Change in Groton, Connecticut: A Model Process for  
39 Communities in the Northeast. U.S. Environmental Protection Agency Climate Ready Estuaries Program and  
40 the Long Island Sound Study, Washington, D.C. [Available online at [http://www.groton-  
41 ct.gov/depts/plandev/docs/Final%20Report\\_Groton%20Coastal%20Climate%20Change%20ProjectJP.pdf](http://www.groton-ct.gov/depts/plandev/docs/Final%20Report_Groton%20Coastal%20Climate%20Change%20ProjectJP.pdf)]
- 42 63. City of Chicago, 2008: City of Chicago Climate Action Plan: Our City. Our Future, 57 pp. [Available online at  
43 <http://www.chicagoclimateaction.org/filebin/pdf/finalreport/CCAPREPORTFINALv2.pdf>]



- 1 64. Wolf, K., 2009: Adapting to climate change: Strategies from King County, Washington. *PAS Memo*,  
2 **March/April**, 11. [Available online at <http://www.planning.org/pas/memo/previous.htm>]
- 3 65. City of New York, 2012: PlaNYC Progress Report 2012. A Greener, Greater New York, 48 pp, New York.  
4 [Available online at  
5 [http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/PlaNYC\\_Progress\\_Report\\_2012\\_Web.pdf](http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/PlaNYC_Progress_Report_2012_Web.pdf)]
- 6 66. SFRCCC, 2012: A Region Responds to a Changing Climate. Southeast Florida Regional Climate Change  
7 Compact Counties. Regional Climate Action Plan, 80 pp., South Florida Regional Climate Change Compact  
8 Broward, Miami-Dade, Monroe, and Palm Beach Counties, FL. [Available online at  
9 <http://southeastfloridaclimatecompact.org/pdf/Regional%20Climate%20Action%20Plan%20FINAL%20ADA%20Compliant.pdf>]
- 10  
11 67. EPA, 2011: Climate change vulnerability assessments: four case studies of water utility practices. U.S.  
12 Environmental Protection Agency, Washington, DC. [Available online at <http://www.epa.gov/ncea>.]
- 13 68. Horton, R., W. Solecki, and C. Rosenzweig, 2012: Climate Change in the Northeast: A Sourcebook. Draft  
14 Technical Input Report prepared for the U.S. National Climate Assessment
- 15 69. White-Newsome, J. L., B. N. Sánchez, E. A. Parker, J. T. Dvonch, Z. Zhang, and M. S. O'Neill, 2011: Assessing  
16 heat-adaptive behaviors among older, urban-dwelling adults. *Maturitas*, **70**, 85-91,  
17 doi:10.1016/j.maturitas.2011.06.015
- 18 70. Agrawal, A., 2008: The role of local institutions in adaptation to climate change. International Forestry  
19 Research and Institutions Program (IFRI) Working Paper # W08I-3, 47 pp., Natural Resources and  
20 Environment, University of Michigan. [Available online at  
21 [http://www.worldfishcenter.org/sites/default/files/The%20role%20of%20local%20institutions%20in%20ada](http://www.worldfishcenter.org/sites/default/files/The%20role%20of%20local%20institutions%20in%20adaptation%20to%20climate%20change.pdf)  
22 [ptation%20to%20climate%20change.pdf](http://www.worldfishcenter.org/sites/default/files/The%20role%20of%20local%20institutions%20in%20adaptation%20to%20climate%20change.pdf)];
- 23 Guston, D. H., W. Clark, T. Keating, D. Cash, S. Moser, C. Miller, and C. Powers, 2000: Report of the Workshop  
24 on Boundary Organizations in Environmental Policy and Science. Belfer Center for Science and International  
25 Affairs (BCSIA) Discussion Paper 2000-32. Bloustein School of Planning and Public Policy, Rutgers University,  
26 New Brunswick, NJ, Environmental and Occupational Health Sciences Institute at Rutgers University and  
27 UMDNJ-RWJMS, Global Environmental Assessment Project, Environment and Natural Resources Program,  
28 Kennedy School of Government, Harvard University, 41 pp. [Available online at  
29 <http://www.hks.harvard.edu/gea/pubs/huru1.pdf>]
- 30 71. Van Aalst, M. K., T. Cannon, and I. Burton, 2008: Community level adaptation to climate change: the potential  
31 role of participatory community risk assessment. *Global Environmental Change*, **18**, 165-179,  
32 doi:10.1016/j.gloenvcha.2007.06.002
- 33 72. Vose, J. M., D. L. Peterson, and T. Patel-Weynand, Eds., 2012: *Effects of Climatic Variability and Change on*  
34 *Forest Ecosystems: A Comprehensive Science Synthesis for the U.S. Forest Sector. General Technical Report*  
35 *PNW-GTR-870*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 265  
36 pp.[Available online at [http://www.usda.gov/oce/climate\\_change/effects\\_2012/FS\\_Climate1114%20opt.pdf](http://www.usda.gov/oce/climate_change/effects_2012/FS_Climate1114%20opt.pdf)]
- 37 73. CDP, 2011: CDP S&P 500 Report: Strategic Advantage Through Climate Change Action, 49 pp., Carbon  
38 Disclosure Project, New York, NY and London, UK. [Available online at  
39 <https://www.cdproject.net/CDPResults/CDP-2011-SP500.pdf>]
- 40 74. C2ES, 2008: Adapting to climate change: A business approach. F. G. Sussman, and J. R. Freed, Eds., 41 pp.,  
41 Center for Climate and Energy Solutions (C2ES), Arlington, VA. [Available online at  
42 <http://www.c2es.org/docUploads/Business-Adaptation.pdf>]
- 43 75. PWC, 2010: Business leadership on climate change adaptation: Encouraging engagement and action, 36 pp.,  
44 PricewaterhouseCoopers LLP London, UK. [Available online at  
45 <http://www.ukmediacentre.pwc.com/imagelibrary/downloadMedia.ashx?MediaDetailsID=1837>]

- 1 76. WBCSD, 2009: Adaptation: An issue brief for business, 24 pp., World Business Council for Sustainable  
2 Development, Geneva, Switzerland and Washington, D.C. [Available online at  
3 [http://www.preventionweb.net/files/7781\\_Adaptation1.pdf](http://www.preventionweb.net/files/7781_Adaptation1.pdf)]
- 4 77. Agrawala, S., M. Carraro, N. Kingsmill, E. Lanzi, M. Mullan, and G. Prudent-Richard, 2011: Private sector  
5 engagement in adaptation to climate change: Approaches to managing climate risks. *OECD Environment*  
6 *Working Papers*, **39**, doi:10.1787/5kg221jfk1g7-en;
- 7 Oxfam America, cited 2012: The new adaptation marketplace: climate change and opportunities for green  
8 economic growth. Oxfam America. Oxfam America. [Available online at  
9 <http://www.usclimatenetwork.org/resource-database/the-new-adaptation-marketplace.pdf>]
- 10 78. Dell, J., and P. Pasteris, 2010: Adaptation in the Oil and Gas Industry to Projected Impacts of Climate Change.  
11 Society of Petroleum Engineers, 16 pp
- 12 79. Means, E., III, M. Laugier, J. Daw, L. Kaatz, and M. Waage, 2010: Decision support planning methods:  
13 Incorporating climate change uncertainties into water planning. Water Utility Climate Alliance white paper,  
14 113 pp., Water Utility Alliance, San Francisco, CA. [Available online at  
15 [http://www.wucaonline.org/assets/pdf/pubs\\_whitepaper\\_012110.pdf](http://www.wucaonline.org/assets/pdf/pubs_whitepaper_012110.pdf)]
- 16 80. Glick, P., B. A. Stein, and N. A. Edelson, 2011: *Scanning the conservation horizon: a guide to climate change*  
17 *vulnerability assessment*. National Wildlife Federation 176 pp;
- 18 Rowland, E. L., J. E. Davison, and L. J. Graumlich, 2011: Approaches to evaluating climate change impacts on  
19 species: a guide to initiating the adaptation planning process. *Environmental Management*, **47**, 322-337,  
20 doi:10.1007/s00267-010-9608-x;
- 21 West, J. M., S. H. Julius, P. Kareiva, C. Enquist, J. J. Lawler, B. Petersen, A. E. Johnson, and M. R. Shaw, 2009:  
22 US natural resources and climate change: concepts and approaches for management adaptation.  
23 *Environmental Management*, **44**, 1001-1021, doi:10.1007/s00267-009-9345-1
- 24 81. Ingram, K., K. Dow, and L. Carter, 2012: Southeast Region Technical Report to the National Climate  
25 Assessment 334 pp. [Available online at  
26 [http://downloads.usgcrp.gov/NCA/Activities/NCA\\_SE\\_Technical\\_Report\\_FINAL\\_7-23-12.pdf](http://downloads.usgcrp.gov/NCA/Activities/NCA_SE_Technical_Report_FINAL_7-23-12.pdf)]
- 27 82. Lackstrom, K., K. Dow, B. Haywood, A. Brennan, N. Kettle, and A. Brosius, 2012: Engaging Climate-sensitive  
28 sectors in the Carolinas. Technical Report: CISA-2012-03: Carolinas Integrated Sciences and Assessments, 180  
29 pp., Carolinas Integrated Sciences and Assessments (CISA), University of South Carolina, Columbia, SC.  
30 [Available online at  
31 [http://www.cisa.sc.edu/Pubs\\_Presentations\\_Posters/Reports/2012\\_Lackstrom%20et%20al\\_Engaging%20Climate-Sensitive%20Sectors%20in%20the%20Carolinas.pdf](http://www.cisa.sc.edu/Pubs_Presentations_Posters/Reports/2012_Lackstrom%20et%20al_Engaging%20Climate-Sensitive%20Sectors%20in%20the%20Carolinas.pdf)]
- 32
- 33 83. Barrett, J., J. Rose, A. Deonarine, A. Clemetson, J. Pagach, M. Parker, and M. Tedesco, 2011: Sentinel  
34 Monitoring for Climate Change in the Long Island Sound Estuarine and Coastal Ecosystems of New York and  
35 Connecticut, 139 pp., U.S. Environmental Protection Agency, Stamford, CT;
- 36 Ford, J. D., E. C. H. Keskitalo, T. Smith, T. Pearce, L. Berrang-Ford, F. Duerden, and B. Smit, 2010: Case study  
37 and analogue methodologies in climate change vulnerability research. *Wiley Interdisciplinary Reviews:*  
38 *Climate Change*, **1**, 374-392, doi:10.1002/wcc.48. [Available online at  
39 <http://onlinelibrary.wiley.com/doi/10.1002/wcc.48/pdf>];
- 40 Füssel, H. M., 2007: Vulnerability: a generally applicable conceptual framework for climate change research.  
41 *Global Environmental Change*, **17**, 155-167, doi:10.1016/j.gloenvcha.2006.05.002;
- 42 Heller, N. E., and E. S. Zavaleta, 2009: Biodiversity management in the face of climate change: a review of 22  
43 years of recommendations. *Biological Conservation*, **142**, 14-32, doi:10.1016/j.biocon.2008.10.006;

- 1 Hulme, M., and S. Dessai, 2008: Predicting, deciding, learning: can one evaluate the 'success' of national  
2 climate scenarios? *Environmental Research Letters*, **3**, 045013, doi:10.1088/1748-9326/3/4/045013.  
3 [Available online at <http://iopscience.iop.org/1748-9326/3/4/045013>];
- 4 Pahl-Wostl, C., P. Jeffrey, N. Isendahl, and M. Brugnach, 2011: Maturing the new water management  
5 paradigm: progressing from aspiration to practice. *Water resources management*, **25**, 837-856,  
6 doi:10.1007/s11269-010-9729-2. [Available online at  
7 <http://www.evergladeshub.com/lit/pdf11/Pahl11watResMgmt25-837-56-WatMgmt.pdf>]
- 8 84. Fazey, I., J. G. P. Gamarra, J. Fischer, M. S. Reed, L. C. Stringer, and M. Christie, 2010: Adaptation strategies for  
9 reducing vulnerability to future environmental change. *Frontiers in Ecology and the Environment*, **8**, 414-422,  
10 doi:10.1890/080215;
- 11 Few, R., K. Brown, and E. L. Tompkins, 2007: Public participation and climate change adaptation: avoiding the  
12 illusion of inclusion. *Climate Policy*, **7**, 46-59, doi:10.1080/14693062.2007.9685637;
- 13 Smit, B., and J. Wandel, 2006: Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*,  
14 **16**, 282-292, doi:10.1016/j.gloenvcha.2006.03.008. [Available online at  
15 <http://dx.doi.org/10.1016/j.gloenvcha.2006.03.008>]
- 16 85. Preston, B. L., R. M. Westaway, and E. J. Yuen, 2011: Climate adaptation planning in practice: an evaluation of  
17 adaptation plans from three developed nations. *Mitigation and Adaptation Strategies for Global Change*, **16**,  
18 407-438, doi:10.1007/s11027-010-9270-x
- 19 86. Brunner, R. D., T. A. Steelman, L. Coe-Juell, C. M. Cromley, C. M. Edwards, and D. W. Tucker, 2005: *Adaptive*  
20 *Governance: Integrating Science, Policy, and Decision Making*. Columbia University Press, 326 pp;
- 21 Stern, P. C., H. V. Fineberg, and I. Ebrary, 1996: *Understanding Risk: Informing Decisions in a Democratic*  
22 *Society*. National Academy Press, 250 pp. [Available online at  
23 <http://www.nap.edu/openbook.php?isbn=030905396X>];
- 24 The World Bank, 2008: *Climate Resilient Cities: A Primer on Reducing Vulnerabilities to Disaster*. The World  
25 Bank 157 pp
- 26 87. ICLEI, 2012: *Sea Level Rise Adaptation Strategy for San Diego Bay* D. H. Hirschfeld, B., Ed., 133 pp., ICLEI-Local  
27 Governments for Sustainability USA San Diego, CA. [Available online at  
28 [www.sdfoundation.org/Portals/0/.../SLRAStrategy\\_Exec\\_Sum.pdf](http://www.sdfoundation.org/Portals/0/.../SLRAStrategy_Exec_Sum.pdf)];
- 29 Moser, S. C., and J. A. Ekstrom, 2010: A framework to diagnose barriers to climate change adaptation.  
30 *Proceedings of the National Academy of Sciences of the United States of America*, **107**, 22026-22031,  
31 doi:10.1073/pnas.1007887107. [Available online at  
32 <http://www.pnas.org/content/107/51/22026.full.pdf+html>];
- 33 Pyke, C., M. Bennett, M. Johnston, R. Najjar, M. Raub, K. Sellner, S. Stiles, and D. Wardrop, 2012: Adapting to  
34 Climate Change in the Chesapeake Bay: A STAC workshop to monitor progress in addressing climate change  
35 across the Chesapeake Bay. STAC Publication 12-001. Philadelphia, PA, 14 pp. [Available online at  
36 [http://www.chesapeakebay.net/channel\\_files/18086/\(attachment\\_vi.b\)\\_adapting\\_to\\_climate\\_change\\_in\\_the\\_chesapeake\\_bay.pdf](http://www.chesapeakebay.net/channel_files/18086/(attachment_vi.b)_adapting_to_climate_change_in_the_chesapeake_bay.pdf)]
- 37
- 38 88. Sutaria, S., A. Kulungara, K. Wyss, and J. Blumenstock, 2012: 3<sup>rd</sup> National Climate Assessment Feedback  
39 Report. Reference Number 2011-0059, 7 pp., Association of State and Territorial Health Officials (ASTHO),  
40 Arlington, VA
- 41 89. Burkett, V., and M. Davidson, 2012: *Coastal Impacts, Adaptation and Vulnerabilities: A Technical Input to the*  
42 *2013 National Climate Assessment*. Island Press, 216 pp



- 1 90. Federspiel, S., 2012: Climate Change Adaptation Planning, Implementation, and Evaluation: Needs,  
2 Resources, and Lessons for the 2013 National Climate Assessment, 62 pp., University of Michigan School of  
3 Natural Resources and Environment, Ann Arbor, MI;
- 4 Hammill, A., and T. Tanner, 2011: Harmonising climate risk management: adaptation screening and  
5 assessment tools for development co-operation. *OECD Environment Working Papers*, **36**, 53,  
6 doi:10.1787/5kg706918zvl-en
- 7 91. Wilby, R. L., and K. Vaughan, 2011: Hallmarks of organisations that are adapting to climate change. *Water and*  
8 *Environment Journal*, **25**, 271-281, doi:10.1111/j.1747-6593.2010.00220.x
- 9 92. Groves, D. G., and R. J. Lempert, 2007: A new analytic method for finding policy-relevant scenarios. *Global*  
10 *Environmental Change*, **17**, 73-85, doi:10.1016/j.gloenvcha.2006.11.006
- 11 93. Lempert, R. J., D. G. Groves, S. W. Popper, and S. C. Bankes, 2006: A general, analytic method for generating  
12 robust strategies and narrative scenarios. *Management Science*, **52**, 514-528, doi:10.1287/mnsc.1050.0472;
- 13 Williams, B. K., and E. D. Brown, 2012: Adaptive Management: The U.S. Department of the Interior  
14 Applications Guide 136 pp., U.S. Department of the Interior, Adaptive Management Working Group,  
15 Washington, D.C. [Available online at <http://www.doi.gov/ppa/upload/DOI-Adaptive-Management-Applications-Guide-WebOptimized.pdf>]
- 16
- 17 94. Moore, S., E. Zavaleta, and R. Shaw, 2012: Decision-Making Under Uncertainty: An Assessment of Adaptation  
18 Strategies and Scenario Development for Resource Managers. Publication number: CEC-500-2012-027.,  
19 California Energy Commission. University of California, Santa Cruz, Sacramento, CA. [Available online at  
20 <http://www.energy.ca.gov/2012publications/CEC-500-2012-027/CEC-500-2012-027.pdf>]
- 21 95. Moser, S. C., 2012: Adaptation, mitigation, and their disharmonious discontents: an essay. *Climatic Change*,  
22 **111**, 165-175, doi:10.1007/s10584-012-0398-4. [Available online at  
23 [http://www.susannemoser.com/documents/Moser\\_essay\\_accepted\\_clean\\_11-1-2011\\_withTablesFigures.pdf](http://www.susannemoser.com/documents/Moser_essay_accepted_clean_11-1-2011_withTablesFigures.pdf)]
- 24
- 25 96. NRC, 2004: *Adaptive management for water resources project planning*. Panel on Adaptive Management for  
26 Resource Stewardship, National Research Council, The National Academies Press, 113 pp
- 27 97. Ford, J. D., L. Berrang-Ford, and J. Paterson, 2011: A systematic review of observed climate change adaptation  
28 in developed nations. *Climatic Change*, **106**, 327-336, doi:10.1007/s10584-011-0045-5. [Available online at  
29 <http://link.springer.com/content/pdf/10.1007%2Fs10584-011-0045-5>]
- 30 98. Dovers, S. R., and A. A. Hezri, 2010: Institutions and policy processes: the means to the ends of adaptation.  
31 *Wiley Interdisciplinary Reviews: Climate Change*, **1**, 212-231, doi:10.1002/wcc.29
- 32 99. Janetos, A. C., R. S. Chen, D. Arndt, M. A. Kenney, D. Abbasi, T. Armstrong, A. Bartuska, M. Blair, J. Buizer, T.  
33 Dietz, D. Easterling, J. Kaye, M. Kolian, M. McGeehin, R. O'Connor, R. Pulwarty, S. Running, R. Schmalensee, R.  
34 Webb, J. Weltzin, S. Baptista, C. A. F. Enquist, J. Hatfield, M. Hayes, K. B. Jones, C. McNutt, W. Meier, M. D.  
35 Schwartz, and M. Svoboda, 2012: National Climate Assessment Indicators: Background, Development, and  
36 Examples. A Technical Input to the 2013 National Climate Assessment Report., 59 pp. [Available online at  
37 <http://downloads.usgcrp.gov/NCA/Activities/NCA-Indicators-Technical-Input-Report-FINAL--3-1-12.pdf>]
- 38 100. EPA, 2010: Climate Resilience Evaluation and Awareness Tool 2pp., U.S. Environmental Protection Agency,  
39 Office of Water. [Available online at [water.epa.gov/infrastructure/.../climate/upload/CREAT-Factsheet.pdf](http://water.epa.gov/infrastructure/.../climate/upload/CREAT-Factsheet.pdf)]
- 40 101. Parry, M., N. Arnell, P. Berry, D. Dodman, S. Fankhauser, C. Hope, S. Kovats, R. Nicholls, D. Satterthwaite, R.  
41 Tiffin, and T. Wheeler, 2009: Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC  
42 and Other Recent Estimates, 116 pp., International Institute for Environment and Development, London, UK.  
43 [Available online at <http://pubs.iied.org/pdfs/11501IIED.pdf>];

- 1 Sussman, F., N. Krishnan, K. Maher, R. Miller, C. Mack, P. Stewart, K. Shouse, and B. Perkins, 2013: Climate  
2 change adaptation cost in the US: what do we know? *Climate Policy*, **in press**, 1-41,  
3 doi:10.1080/14693062.2013.777604
- 4 102. Ruth, M., D. Coelho, and D. Karetnikox, 2007: The US Economic Impacts of Climate Change and the Costs of  
5 Inaction. A Review and Assessment by the Center for Integrative Environmental Research (CIER) at the  
6 University of Maryland, 52 pp, College Park, MD. [Available online at  
7 <http://www.cier.umd.edu/climateadaptation/>]
- 8 103. McCollum, D. W., J. A. Tanaka, J. A. Morgan, J. E. Mitchell, K. A. Maczko, L. Hiding, W. E. Fox, and C. S. Duke,  
9 2011: Climate Change Effects on Rangelands: Affirming the Need for Monitoring. RMRS Human Dimensions  
10 Research Program: Discussion Paper, 27 pp., USDA Forest Service, Rocky Mountain Research Station, Fort  
11 Collins, CO. [Available online at [http://gis.fs.fed.us/rm/value/docs/climate\\_change\\_effects\\_rangelands.pdf](http://gis.fs.fed.us/rm/value/docs/climate_change_effects_rangelands.pdf)]
- 12 104. Ekstrom, J. A., S. C. Moser, and M. Torn, 2011: Barriers to Climate Change Adaptation: A Diagnostic  
13 Framework. Final Project Report. Publication Number: CEC-500-2011-004, 94 pp., California Energy  
14 Commission. , Sacramento, CA. [Available online at <http://www.energy.ca.gov/2011publications/CEC-500-2011-004/CEC-500-2011-004.pdf>]
- 15  
16 105. Bierbaum, R., J. B. Smith, A. Lee, L. Carter, F. S. I. Chapin, P. Fleming, S. Ruffo, S. McNeeley, M. Stutls, E.  
17 Wasley, and L. Verduzco, 2013 A Comprehensive Review of Climate Adaptation in the United States: More  
18 Than Before, but Less Than Needed. *Journal of Mitigation and Adaptation Strategies for Global Change*, **18**,  
19 361-406, doi:10.1007/s11207-012-9423-1
- 20 106. Adger, W. N., S. Agrawala, M. M. Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K.  
21 Takahashi, 2007: Ch. 17: Assessment of Adaptation Practices, Options, Constraints and Capacity. *Climate*  
22 *Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth*  
23 *Assessment Report of the Intergovernmental Panel on Climate Change*, M. L. Parry, O. F. Canziani, J. P.  
24 Palutikof, P. J. van der Linden, and C. E. Hanson, Eds., Cambridge University Press, 717-743;
- 25 McIlgorm, A., S. Hanna, G. Knapp, P. Le Floc'H, F. Millerd, and M. Pan, 2010: How will climate change alter  
26 fishery governance? Insights from seven international case studies. *Marine Policy*, **34**, 170-177,  
27 doi:10.1016/j.marpol.2009.06.004
- 28 107. Barsugli, J. J., J. M. Vogel, L. Kaatz, J. B. Smith, M. Waage, and C. Anderson, 2012: Two faces of uncertainty:  
29 climate science and water utility planning methods. *Journal of Water Resources Planning and Management*,  
30 **138**, 389-395, doi:10.1061/(ASCE)WR.1943-5452.0000188;
- 31 Dilling, L., and M. C. Lemos, 2011: Creating usable science: opportunities and constraints for climate  
32 knowledge use and their implications for science policy. *Global Environmental Change*, **21**, 680-689,  
33 doi:10.1016/j.gloenvcha.2010.11.006 ;
- 34 Fowler, H. J., and R. L. Wilby, 2007: Beyond the downscaling comparison study. *International Journal of*  
35 *Climatology*, **27**, 1543-1545, doi:10.1002/joc.1616. [Available online at  
36 <http://onlinelibrary.wiley.com/doi/10.1002/joc.1616/pdf>];
- 37 Larsen, L., A. L. Steiner, E. S. Mallen, N. Kahn, S. Kalafatis, M. Ryen, P. Sotherland, and A. B. Tawfik, 2011:  
38 Climate Downscaling and Urban Planning Implications in Three Great Lakes Cities. *Journal of the American*  
39 *Planning Association: Journal of the American Planning Association*, p. [submitted for publication];
- 40 McNie, E. C., 2007: Reconciling the supply of scientific information with user demands: an analysis of the  
41 problem and review of the literature. *Environmental Science & Policy*, **10**, 17-38,  
42 doi:10.1016/j.envsci.2006.10.004;
- 43 Mitchell, J. E., Ed., 2010: *Criteria and Indicators of Sustainable Rangeland Management*. University of  
44 Wyoming Extension Publication No. SM-56, 227 pp.[Available online at  
45 <http://www.sustainableland.org/pdf/SM56.pdf>];

- 1 Romsdahl, R. J., L. Atkinson, and J. Schultz, 2013: Planning for climate change across the US Great Plains:  
2 concerns and insights from government decision-makers. *Journal of Environmental Studies and Sciences*, **3**, 1-  
3 14, doi:10.1007/s13412-012-0078-8
- 4 108. Hauser, R., and J. Jadin, 2012: Rural Communities Workshop Technical Report to the 2013 National Climate  
5 Assessment, 38 pp;
- 6 Lebow, B., T. Patel-Weyand, T. Loveland, and R. Cantral, 2012: Land Use and Land Cover National  
7 Stakeholder Workshop Technical Report. Report prepared for 2013 National Climate Assessment, 73 pp
- 8 109. Needham, H. F., L. Carter, and B. D. Keim, 2012: Gulf Coast Climate Needs Assessment Interviews, 20 pp.,  
9 Southern Climate Impacts Planning Program (SCIPP). [Available online at  
10 [http://www.southernclimate.org/publications/Gulf\\_Coast\\_Assessment\\_Final.pdf](http://www.southernclimate.org/publications/Gulf_Coast_Assessment_Final.pdf)]
- 11 110. Schramm, P. J., 2012: National Climate Assessment Health Sector Workshop Report: Northwest Region, 28  
12 pp, Seattle, Washington. [Available online at  
13 [http://www.joss.ucar.edu/ohhi/nw\\_nca\\_health\\_sector\\_feb12/Health\\_and\\_CC\\_NW\\_Report.pdf](http://www.joss.ucar.edu/ohhi/nw_nca_health_sector_feb12/Health_and_CC_NW_Report.pdf)]
- 14 111. Brugger, J., and M. Crimmins, 2011: Weather, Climate, and Rural Arizona: Insights and Assessment Strategies.  
15 A Technical Input to the U.S. National Climate Assessment, 80 pp., U.S Global Climate Research Program,  
16 Washington, D.C.
- 17 112. GAO, 2009: Alaska native villages: Limited progress has been made on relocating villages threatened by  
18 flooding and erosion. Government Accountability Office Report GAO-09-551, 53 pp., U.S. Government  
19 Accountability Office. [Available online at <http://www.gao.gov/new.items/d09551.pdf>]
- 20 113. Levin, S. A., and W. C. Clark, 2010: Toward a Science of Sustainability: Report from Toward a Science of  
21 Sustainability Conference *Toward a Science of Sustainability*, Airlie Center, Warrenton, Virginia Center for  
22 International Development Working Papers. [Available online at  
23 <http://www.nsf.gov/mps/dms/documents/SustainabilityWorkshop2009Report.pdf>]
- 24 114. NRC, 2009: A Transportation Research Program for Mitigation and Adapting to Climate Change and  
25 Conserving Energy Special Report 299, 136 pp., National Research Council,; Committee for Study on  
26 Transportation Research Programs to Address Energy and Climate Change,; Transportation Research Board of  
27 the National Academies, Washington, D.C. [Available online at [www.trb.org](http://www.trb.org)]
- 28 115. Adger, W. N., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D. R. Nelson, L. O. Naess, J. Wolf, and A.  
29 Wreford, 2009: Are there social limits to adaptation to climate change? *Climatic Change*, **93**, 335-354,  
30 doi:10.1007/s10584-008-9520-z;
- 31 McNeeley, S. M., 2012: Examining barriers and opportunities for sustainable adaptation to climate change in  
32 Interior Alaska. *Climate Change*, **111**, 835-857, doi:10.1007/s10584-011-0158-x. [Available online at  
33 <http://link.springer.com/content/pdf/10.1007%2Fs10584-011-0158-x>]
- 34 116. Carpenter, S. R., and W. A. Brock, 2008: Adaptive capacity and traps. *Ecology and Society*, **13**, 40. [Available  
35 online at <http://www.ecologyandsociety.org/vol13/iss2/art40/>];
- 36 Craig, R. K., 2008: Climate change, regulatory fragmentation, and water triage. *FSU College of Law, Public Law  
37 Research Paper No. 288*;
- 38 Folke, C., 2006: Resilience: the emergence of a perspective for social–ecological systems analyses. *Global  
39 Environmental Change*, **16**, 253-267, doi:10.1016/j.gloenvcha.2006.04.002. [Available online at  
40 <http://www.sciencedirect.com/science/article/pii/S0959378006000379>];
- 41 Jantarasami, L. C., J. J. Lawler, and C. W. Thomas, 2010: Institutional barriers to climate change adaptation in  
42 US national parks and forests. *Ecology and Society*, **15**, 33. [Available online at  
43 <http://www.ecologyandsociety.org/vol15/iss4/art33/>];

- 1 Lee, K. N., 1993: *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Island Press,  
2 255 pp;
- 3 Nelson, D. R., W. N. Adger, and K. Brown, 2007: Adaptation to Environmental Change: Contributions of a  
4 Resilience Framework. *The Annual Review of Environment and Resources*, **32**, 395-419,  
5 doi:10.1146/annurev.energy.32.051807.090348. [Available online at  
6 [http://eprints.icrisat.ac.in/4245/1/AnnualReviewofEnvResources\\_32\\_395-419\\_2007.pdf](http://eprints.icrisat.ac.in/4245/1/AnnualReviewofEnvResources_32_395-419_2007.pdf)]
- 7 117. Moser, S. C., and J. A. Ekstrom, 2012: Identifying and Overcoming Barriers to Climate Change Adaptation in  
8 San Francisco Bay: Results from Case Studies. Publication number: CEC-500-2012-034 186 pp., California  
9 Energy Commission, Sacramento, CA. [Available online at <http://www.energy.ca.gov/2012publications/CEC-500-2012-034/CEC-500-2012-034.pdf>]
- 10  
11 118. Ding, D., E. W. Maibach, X. Zhao, C. Roser-Renouf, and A. Leiserowitz, 2011: Support for climate policy and  
12 societal action are linked to perceptions about scientific agreement. *Nature Climate Change*,  
13 doi:10.1038/nclimate1295
- 14 119. Leiserowitz, A., E. Maibach, C. Roser-Renouf, and N. Smith, 2012: Climate change in the American mind:  
15 Public support for climate & energy policies in March 2012. Yale Project on Climate Change Communication.,  
16 Yale University and George Mason University, New Haven, CT. [Available online at  
17 <http://environment.yale.edu/climate/files/Policy-Support-March-2012.pdf>];
- 18 Smith, J. B., J. M. Vogel, and J. E. C. Iii, 2009: An architecture for government action on adaptation to climate  
19 change. An editorial comment. *Climatic Change*, **95**, 53-61, doi:10.1007/s10584-009-9623-1
- 20 120. Doria, M. F., E. Boyd, E. L. Tompkins, and W. N. Adger, 2009: Using expert elicitation to define successful  
21 adaptation to climate change. *Environmental Science & Policy*, **12**, 810-819, doi:10.1016/j.envsci.2009.04.001  
22 ;
- 23 Gifford, R., 2011: The dragons of inaction: psychological barriers that limit climate change mitigation and  
24 adaptation. *American Psychologist*, **66**, 290-302, doi:10.1037/a0023566 ;
- 25 Kahan, D. M., H. Jenkins-Smith, and D. Braman, 2011: Cultural cognition of scientific consensus. *Journal of*  
26 *Risk Research*, **14**, 147-174, doi:10.1080/13669877.2010.511246;
- 27 Leiserowitz, A., 2006: Climate change risk perception and policy preferences: The role of affect, imagery, and  
28 values. *Climatic Change*, **77**, 45-72, doi:10.1007/s10584-006-9059-9;
- 29 Renn, O., 2011: The social amplification/attenuation of risk framework: application to climate change. *Wiley*  
30 *Interdisciplinary Reviews: Climate Change*, **2**, 154-169, doi:10.1002/wcc.99. [Available online at  
31 <http://onlinelibrary.wiley.com/doi/10.1002/wcc.99/pdf>];
- 32 Renn, O., A. Klinke, and M. van Asselt, 2011: Coping with complexity, uncertainty and ambiguity in risk  
33 governance: a synthesis. *AMBIO: A Journal of the Human Environment*, **40**, 231-246, doi:10.1007/s13280-010-  
34 0134-0;
- 35 Verweij, M., M. Douglas, R. Ellis, C. Engel, F. Hendriks, S. Lohmann, S. Ney, S. Rayner, and M. Thompson, 2006:  
36 Clumsy solutions for a complex world: the case of climate change. *Public Administration*, **84**, 817-843,  
37 doi:10.1111/j.1540-8159.2005.09566.x-i1;
- 38 Weber, E. U., and P. C. Stern, 2011: Public understanding of climate change in the United States. *American*  
39 *Psychologist*, **66**, 315-328, doi:10.1037/a0023253;
- 40 Kahan, D., D. Braman, P. Slovic, J. Gastil, and G. Cohen, 2007: The Second National Risk and Culture Study:  
41 Making Sense of - and Making Progress In - The American Culture War of Fact (October 3, 2007). GWU Legal  
42 Studies Research Paper No. 370; Yale Law School, Public Law Working Paper No. 154; GWU Law School Public  
43 Law Research Paper No. 370; Harvard Law School Program on Risk Regulation Research Paper No. 08-26, 23,

- 1 doi:10.2139/ssrn.1017189. [Available online at  
2 [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=1017189](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1017189)]
- 3 121. NOAA, 2010: Adapting to Climate Change: A Planning Guide for State Coastal Managers, 133 pp., NOAA Office  
4 of Ocean and Coastal Resource Management, Silver Spring, MD. [Available online at  
5 <http://coastalmanagement.noaa.gov/climate/docs/adaptationguide.pdf>]
- 6 122. HDLNR, 2011: The Rain Follows The Forest: A Plan to Replenish Hawaii's Source of Water, 24 pp., Department  
7 of Land and Natural Resources, State of Hawai'i. [Available online at  
8 <http://hawaii.gov/dlnr/chair/pio/nr/2011/The-Rain-Follows-the-Forest.pdf>]
- 9 123. EPA, cited 2013: Adaptation Efforts: EPA New England: New England Federal Partners. U.S. Environmental  
10 Protection Agency. [Available online at <http://www.epa.gov/region1/eco/energy/adaptation-efforts-epane.html>]
- 11
- 12 124. PWD, cited 2013: Green City, Clean Waters. Philadelphia Water Department. [Available online at  
13 <http://www.phillywatersheds.org/ltcpu/>]
- 14 125. City of Keene, 2010: Keene Comprehensive Master Plan. City of Keene, Keene, New Hampshire. [Available  
15 online at [http://www.ci.keene.nh.us/sites/default/files/CMPprint-final-1027-fullversion\\_2.pdf](http://www.ci.keene.nh.us/sites/default/files/CMPprint-final-1027-fullversion_2.pdf)]
- 16 126. NYCDEP, cited 2013: Green Infrastructure Plan and Annual Reports. New York City Department of  
17 Environmental Protection [Available online at  
18 [http://www.nyc.gov/html/dep/html/stormwater/nyc\\_green\\_infrastructure\\_plan.shtml](http://www.nyc.gov/html/dep/html/stormwater/nyc_green_infrastructure_plan.shtml)]
- 19 127. ICLEI, cited 2013: Homer, Alaska's Climate Adaptation Progress Despite Uncertainties. ICLEI,. [Available online  
20 at <http://www.cakex.org/virtual-library/2555>]
- 21 128. State of Alaska Division of Community and Regional Affairs Planning and Land Management, cited 2012:  
22 Newtok Planning Group. State of Alaska. [Available online at  
23 [http://www.commerce.state.ak.us/dca/planning/npg/Newtok\\_Planning\\_Group.htm](http://www.commerce.state.ak.us/dca/planning/npg/Newtok_Planning_Group.htm)]
- 24 129. Maus, E., 2013: Case Studies in Floodplain Regulation, 14 pp. [Available online at  
25 <http://www.georgetownclimate.org/sites/default/files/Case%20Studies%20in%20Floodplain%20Regulation%206-3-final.pdf>]
- 26
- 27 130. Cameron, L., M. Stanbury, R. Wahl, and S. Manente, 2011: Michigan Climate and Health Adaptation Plan  
28 (MICHAP) 2010 – 2015 Strategic Plan, 14 pp., Division of Environmental Health: Michigan Department of  
29 Community Health
- 30 [Available online at [http://www.michigan.gov/documents/mdch/MDCH\\_climate\\_change\\_strategicPlan\\_final\\_1-24-2011\\_343856\\_7.pdf](http://www.michigan.gov/documents/mdch/MDCH_climate_change_strategicPlan_final_1-24-2011_343856_7.pdf)]
- 31
- 32 131. City of Grand Rapids, cited 2013: The Office of Energy and Sustainability. City of Grand Rapids, MI. [Available  
33 online at <http://grcity.us/enterprise-services/officeofenergyandsustainability/Pages/default.aspx/>]
- 34 132. City of Tulsa, cited 2013: Rooftop to River. The Tulsa Program. City of Tulsa, OK. [Available online at  
35 <http://www.smartcommunities.ncat.org/articles/rooftop/program.shtml>]
- 36 133. TFS, cited 2013: Wildland Urban Interface: Texas Firewise Communities. Texas A&M Forest Service. [Available  
37 online at <http://texasforests.tamu.edu/main/article.aspx?id=1602>]
- 38 134. Carter, L., 2012: personal communication.
- 39 135. Gregg, R. M., cited 2013: Estero de Limantour Coastal Watershed Restoration Project [Case study on a project  
40 of the Point Reyes National Seashore]. Product of EcoAdapt's State of Adaptation Program. [Available online  
41 at <http://www.cakex.org/case-studies/1083>]
- 42 136. Sustainable Communities Leadership Academy, cited 2013: Front Range, Intermountain & Desert Southwest  
43 Region: A Regional Climate Leadership Academy For The Western Adaptation Alliance. Sustainable



- 1 Communities Leadership Academy. [Available online at  
2 <http://sustainablecommunitiesleadershipacademy.org/workshops/regional-western-adaptation-alliance>]
- 3 137. Navajo Nation Department of Water Resources, 2003: Navajo Nation Drought Contingency Plan, 163 pp.,  
4 Division of Natural Resources, Department of Water Resources, Water Management Branch, Fort Defiance,  
5 AZ, Navajo Nation. [Available online at  
6 [http://www.frontiernet.net/~nndwr\\_wmb/PDF/drought/drghtcon\\_plan2003\\_final.pdf](http://www.frontiernet.net/~nndwr_wmb/PDF/drought/drghtcon_plan2003_final.pdf)]
- 7 138. English, P., K. Fitzsimmons, S. Hoshiko, T. Kim, H. G. Margolis, T. E. McKone, M. Rotkin-Ellman, G. Solomon, R.  
8 Trent, and Z. Ross, 2007: Public Health Impacts of Climate Change in California: Community Vulnerability  
9 Assessments and Adaptation Strategies. Report No. 1: Heat-Related Illness and Mortality. California  
10 Department of Public Health and the Public Health Institute. [Available online at  
11 [http://www.ehib.org/papers/Heat\\_Vulnerability\\_2007.pdf](http://www.ehib.org/papers/Heat_Vulnerability_2007.pdf)]
- 12 139. SFBCDC: An International Competition for Ideas Responding to Sea Level Rise in San Francisco Bay and  
13 Beyond. San Francisco Bay Conservation and Development Commission [Available online at  
14 <http://www.risingtidescompetition.com/risingtides/Home.html>]
- 15 140. City of Flagstaff, 2012: City of Flagstaff Resiliency and Preparedness Study, 57 pp., City of Flagstaff Climate  
16 and Adaptation Management. [Available online at <http://flagstaff.az.gov/index.aspx?nid=1732>]
- 17 141. USFS, 2011: Adapting to Climate Change at Olympic National Forest and Olympic National Park, 144 pp., U.S.  
18 Forest Service, Pacific Northwest Research Station. [Available online at  
19 [http://www.fs.fed.us/pnw/pubs/pnw\\_gtr844.pdf](http://www.fs.fed.us/pnw/pubs/pnw_gtr844.pdf)]
- 20 142. Wolf, K., 2009: Adapting to Climate Change: Strategies from King County, Washington, 11 pp., American  
21 Planning Association. [Available online at  
22 [http://www.nerrs.noaa.gov/doc/pdf/training/strategies\\_king\\_county.pdf](http://www.nerrs.noaa.gov/doc/pdf/training/strategies_king_county.pdf)]
- 23 143. City of Portland, 2009: Climate action plan 2009, 63 pp., City of Portland Bureau of Planning and Sustainability  
24 and Multnomah County Sustainability Program, Portland, Oregon. [Available online at  
25 <http://www.portlandoregon.gov/bps/article/268612>]
- 26 144. LRAP, cited 2013: Louisiana Resiliency Assistance Program. The Office of Community Development – Disaster  
27 Recovery Unit and Louisiana State University Coastal Sustainability Studio. [Available online at  
28 <http://resiliency.lsu.edu/>]
- 29 145. The Nature Conservancy, 2011: Alligator River National Wildlife Refuge Grows, 12 pp., The North Carolina  
30 Chapter of The Nature Conservancy. [Available online at  
31 [http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/northcarolina/afield-spring-  
32 2011.pdf](http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/northcarolina/afield-spring-2011.pdf)]
- 33 146. Bloetscher, F., B. Heimlich, and D. E. Meeroff, 2011: Development of an adaptation toolbox to protect  
34 southeast Florida water supplies from climate change. *Environmental Reviews*, **19**, 397-417, doi:10.1139/a11-  
35 011. [Available online at add <http://www.nrcresearchpress.com/doi/pdf/10.1139/a11-011>]
- 36 147. NAST, 2000: Climate Change Impacts on the United States: The Potential Consequences of Climate Variability  
37 and Change, Report for the US Global Change Research Program, 163 pp., U.S. Global Climate Research  
38 Program, National Assessment Synthesis Team, Cambridge, UK. [Available online at  
39 <http://library.globalchange.gov/downloads/download.php?id=124>]
- 40 148. IPCC, 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A  
41 Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.* C. B. Field, V.  
42 Barros, T.F. Stocker, D. Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, K. J. Mach, G.-K. Plattner, S.K. Allen, M.  
43 Tignor, and P. M. Midgley, Eds. Cambridge University Press, 582 pp.[Available online at [http://ipcc-  
44 wg2.gov/SREX/images/uploads/SREX-All\\_FINAL.pdf](http://ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf)];

- 1 Kates, R. W., W. R. Travis, and T. J. Wilbanks, 2012: Transformational adaptation when incremental  
2 adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences*, **109**, 7156-  
3 7161, doi:10.1073/pnas.1115521109. [Available online at [www.pnas.org/content/109/19/7156.full.pdf+html](http://www.pnas.org/content/109/19/7156.full.pdf+html)]
- 4 149. Hayes, M., and R. Pulwarty, 2012 Drought, Risk Management, and Policy: Decision-Making Under Uncertainty.  
5 *Drought and Water Crises*, L. C. C. Botterill, G. C., Ed., CRC Press
- 6 150. NOAA, 2012: State of the climate: Drought Annual 2012. National Climatic Data Center, National  
7 Environmental Satellite and Information Service;
- 8 Schwalm, C. R., C. A. Williams, and K. Schaefer, 2012: Hundred-Year Forecast: Drought. *The New York Times*,  
9 August 11, 2012. [Available online at [http://www.nytimes.com/2012/08/12/opinion/sunday/extreme-  
10 weather-and-drought-are-here-to-stay.html?\\_r=0](http://www.nytimes.com/2012/08/12/opinion/sunday/extreme-weather-and-drought-are-here-to-stay.html?_r=0)]
- 11 151. Cayan, D. R., T. Das, D. W. Pierce, T. P. Barnett, M. Tyree, and A. Gershunov, 2010: Future dryness in the  
12 southwest US and the hydrology of the early 21st century drought. *Proceedings of the National Academy of  
13 Sciences of the United States of America*, **107**, 21271-21276, doi:10.1073/pnas.0912391107. [Available online  
14 at <http://www.pnas.org/content/early/2010/12/06/0912391107.full.pdf+html>];
- 15 Christensen, N., and D. P. Lettenmaier, 2006: A multimodel ensemble approach to assessment of climate  
16 change impacts on the hydrology and water resources of the Colorado River Basin. *Hydrology and Earth  
17 System Sciences*, **3**, 3727-3770, doi:10.5194/hessd-3-3727-2006;
- 18 Hidalgo, H. G., T. Das, M. D. Dettinger, D. R. Cayan, D. W. Pierce, T. P. Barnett, G. Bala, A. Mirin, A. W. Wood,  
19 C. Bonfils, B. D. Santer, and T. Nozawa, 2009: Detection and attribution of streamflow timing changes to  
20 climate change in the western United States. *Journal of Climate*, **22**, 3838-3855, doi:10.1175/2009jcli2470.1.  
21 [Available online at <http://journals.ametsoc.org/doi/abs/10.1175/2009JCLI2470.1>];
- 22 Pierce, D. W., T. P. Barnett, H. G. Hidalgo, T. Das, C. Bonfils, B. D. Santer, G. Bala, M. D. Dettinger, D. R. Cayan,  
23 A. Mirin, A. W. Wood, and T. Nozawa, 2008: Attribution of declining western US snowpack to human effects.  
24 *Journal of Climate*, **21**, 6425-6444, doi:10.1175/2008JCLI2405.1 [Available online at  
25 <http://journals.ametsoc.org/doi/abs/10.1175/2008JCLI2405.1>];
- 26 Seager, R., and G. A. Vecchi, 2010: Greenhouse warming and the 21st century hydroclimate of southwestern  
27 North America. *Proceedings of the National Academy of Sciences of the United States of America*, **107**, 21277-  
28 21282, doi:10.1073/pnas.0910856107. [Available online at  
29 <http://www.pnas.org/content/107/50/21277.full.pdf>]
- 30 152. Gray, S. T., J. J. Lukas, and C. A. Woodhouse, 2011: Millennial-length records of streamflow from three major  
31 Upper Colorado River tributaries. *JAWRA Journal of the American Water Resources Association*, **47**, 702-712;
- 32 Woodhouse, C. A., S. T. Gray, and D. M. Meko, 2006: Updated streamflow reconstructions for the Upper  
33 Colorado River Basin. *Water Resources Research*, **42**, doi:10.1029/2005WR004455
- 34 153. Brown, C., 2010: The end of reliability. *Journal of Water Resources Planning and Management*, **136**, 143-145,  
35 doi:10.1061/(ASCE)WR.1943-5452.65
- 36 154. Western Governors' Association, 2006: Water Needs and Strategies for a Sustainable Future 26 pp., Western  
37 Governors' Association, Western States Water Council, Denver, CO. [Available online at  
38 <http://www.westgov.org/wga/publicat/Water06.pdf>];
- 39 —, 2008: *Water Needs and Strategies for a Sustainable Future: Next Steps*. Western Governors'  
40 Association, 37 pp;
- 41 —, 2010: *Water Needs and Strategies for a Sustainable Future: 2010 Progress Report*. Western Governors'  
42 Association and Western States Water Council, Denver, CO. [Available online at  
43 [http://www.westgov.org/wswc/wswc\\_2010\\_complete%20-compressed.pdf](http://www.westgov.org/wswc/wswc_2010_complete%20-compressed.pdf)]

- 1 155. USACE, 2009: Western States Watershed Study: Report to the Western States Water Council 42 pp., U.S.  
2 Army Corps of Engineers
- 3 156. USBR, 2011: Reclamation Managing Water in the West. SECURE Water Act Section 9503(c) - Reclamation  
4 Climate Change and Water 2011. P. Alexander, L. Brekke, G. Davis, S. Gangopadhyay, K. Grantz, C. Hennig, C.  
5 Jerla, D. Llewellyn, P. Miller, T. Pruitt, D. Raff, T. Scott, M. Tansey, and T. Turner, Eds., 226 pp., U.S.  
6 Department of the Interior, Policy and Administration, U.S. Bureau of Reclamation, Denver, CO. [Available  
7 online at <http://www.usbr.gov/climate/SECURE/docs/SECUREWaterReport.pdf>];  
8 —, 2011: Reclamation Managing Water in the West: Interim Report No. 1, Colorado River Basin Water  
9 Supply and Demand Study, Status Report. U.S. Department of the Interior, U.S. Bureau of Reclamation,  
10 Denver, CO. [Available online at <http://www.usbr.gov/lc/region/programs/crbstudy/Report1/StatusRpt.pdf>]
- 11 157. USFS, cited 2012: Northern Institute of Applied Climate Science: Climate Change Response Framework. U.S.  
12 Department of Agriculture, U.S. Forest Service. [Available online at  
13 <http://nrs.fs.fed.us/niacs/climate/framework/>]
- 14 158. Swanston, C. W., M. Janowiak, L. R. Iverson, L. R. Parker, D. J. Mladenoff, L. Brandt, P. Butler, M. St. Pierre, A.  
15 M. Prasad, S. Matthews, M. P. Peters, and D. Higgins, 2011: Ecosystem vulnerability assessment and  
16 synthesis: a report from the Climate Change Response Framework Project in northern Wisconsin. Gen. Tech.  
17 Rep. NRS-82, 142 pp., U.S. Department of Agriculture, Forest Service, Northern Research Station, Newtown  
18 Square, PA. [Available online at <http://www.nrs.fs.fed.us/niacs/climate/northwoods/>]
- 19 159. Joyce, L. A., G. M. Blate, S. G. McNulty, C. I. Millar, S. Moser, R. P. Neilson, and D. L. Peterson, 2009: Managing  
20 for multiple resources under climate change: national forests. *Environmental Management*, **44**, 1022-1032,  
21 doi:10.1007/s00267-009-9324-6;
- 22 Miles, P. D., 2010: Forest Inventory EVALIDator web-application version 4.01 beta. US Department of  
23 Agriculture, Forest Service, Northern Research Station Forest Inventory and Analysis, St. Paul, MN. [Available  
24 online at <http://fiatools.fs.fed.us/Evalidator4/tmattribute.jsp>];
- 25 WDNR, 2009: Forest ownership and parcelization. Wisconsin Department of Natural Resources, Madison, WI;  
26 —, cited 2012: Wisconsin's Statewide Forest Assessment 2010. Wisconsin Department of Natural  
27 Resources. [Available online at <http://dnr.wi.gov/topic/ForestPlanning/assessment2010.html>]
- 28 160. Swanston, C. J., M., 2012: Forest adaptation resources: Climate change tools and approaches for land  
29 managers. *Notes*
- 30 161. Butler, P., M. Janowiak, L. Brandt, and C. Swanston, 2011: Lessons learned from the Climate Change Response  
31 Framework Project in Northern Wisconsin: Newtown Square, PA, USDA Forest Service, 24 pp. [Available  
32 online at [http://www.nrs.fs.fed.us/niacs/local-resources/docs/LESSONS\\_LEARNED\\_from\\_the\\_CCRFP.pdf](http://www.nrs.fs.fed.us/niacs/local-resources/docs/LESSONS_LEARNED_from_the_CCRFP.pdf) ];
- 33 Janowiak, M. K., P. R. Butler, C. W. Swanston, L. R. Parker, M. J. St. Pierre, and L. A. Brandt, 2012: Adaptation  
34 workbook. *Forest adaptation resources: Climate change tools and approaches for land managers. General  
35 Technical Report NRS-87*, C. Swanston, and M. Janowiak, Eds., U.S. Department of Agriculture, Forest Service,  
36 35-56. [Available online at [http://www.nrs.fs.fed.us/pubs/gtr/gtr\\_nrs87.pdf](http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs87.pdf)]
- 37 162. DOT, 2011: Interagency Transportation, Land Use, and Climate Change Cape Cod Pilot Project: Cape Cod  
38 Commission Action Plan, 22 pp., U.S. Department of Transportation: Federal Highway Administration, John A.  
39 Volpe National Transportation Systems Center. [Available online at  
40 [www.volpe.dot.gov/coi/ppoa/publiclands/projects/docs/ccc\\_action\\_plan.pdf](http://www.volpe.dot.gov/coi/ppoa/publiclands/projects/docs/ccc_action_plan.pdf)]
- 41 163. —, 2011: Interagency Transportation, Land Use, and Climate Change Cape Cod Pilot Project. One-Pager., 20  
42 pp., U.S. Department of Transportation: Federal Highway Administration, John A. Volpe National  
43 Transportation Systems Center, Washington, D.C.
- 44 164. Commonwealth of Massachusetts, 2004: Massachusetts Climate Protection Plan, 54 pp, Boston, MA



- 1 165. ESRI, cited 2012: Climate Change Scenario Planning for Cape Cod: A Collaborative Exercise in GeoDesign,  
2 ArcNews, Volume Fall 2011: Redlands, CA, ESRI. ESRI. [Available online at  
3 <http://www.esri.com/news/arcnews/fall11articles/climate-change-scenario-planning-for-cape-cod.html>]  
4 166. Lennertz, B., 2011: High-Touch/High-Tech Charrettes. *Planning*, American Planning Association, 26 pp.  
5

DRAFT