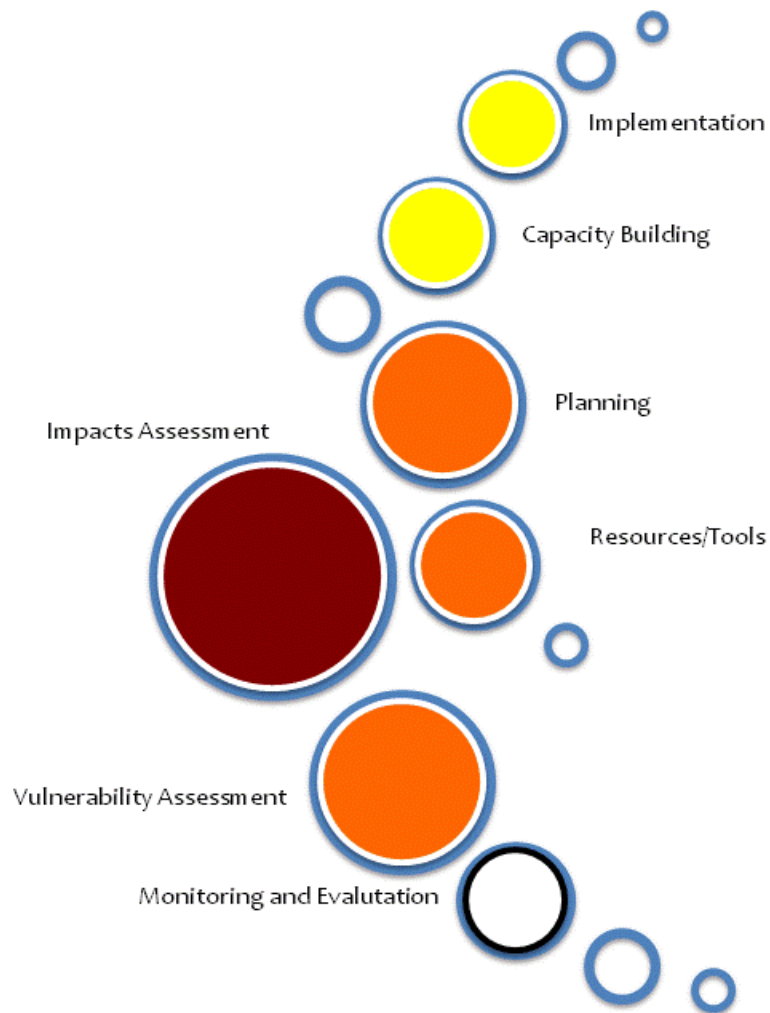


The State of Adaptation in the United States

An Overview



Lara Hansen, Rachel M. Gregg, Vicki Arroyo, Susan Ellsworth, Louise Jackson and Amy Snover

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Foreword

It is with great pleasure that the authors of this report share their synopsis of the state of adaptation in the United States. While this paper does not provide a complete survey of all that is afoot in the United States, we feel that it does provide a sense of the range of activities that are underway. Part of the story of adaptation in the United States is the underlying theme that as a country we are not doing enough to address the effects of climate change. In general there has been an inattention to this growing challenge and the effects of this disinterest will not be unfelt.

The authors are heartened by the MacArthur Foundation's interest in addressing this problem. We hope that you find our assessment, insights and recommendations useful, but more importantly, we hope that they are used and more action is taken. Thank you for your interest in this issue, and for the difference you will no doubt make.

Note to readers: While this document can certainly be read in its entirety, it can also be accessed piecemeal. Readers may wish to start with Chapter 1 (An Overview of Opportunities), then follow up with Chapter 2 (Promoting Adaptation through Policy) and a sectoral chapter aligned with their particular interest (Chapters 3, 4 or 5). All of the chapters have been written so they can be read independently, however the most holistic path to enlightenment would be to review the entire document.

Chapter 1: An Overview of Opportunities

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With input from Vicki Arroyo, Susan Ellsworth, Rachel M. Gregg, Louise Jackson, and Amy Snover

Over the past two decades the adaptation landscape has changed dramatically. From its early days as a vague theoretical concept, which was often viewed as a threat to advocating for the reduction of greenhouse gas emissions, it has developed into a widely, albeit not universally, recognized governmental mandate to reduce societal vulnerability to climate change. While it is important to appreciate the progress that we are making on this issue, it is impossible to ignore the urgent need to do more. Smart investment can be made by reflecting on what is already underway in order to determine where to build on existing efforts and where to innovate new approaches to fill the gaps in the path forward.

While resources are precious and limited, analysis and planning without engaging in action is not a prudent use of resources. There are many identifiable opportunities to make a difference in climate change adaptation in the United States. **This report highlights adaptation action opportunities based on identified gaps:**

- 1. Implementing adaptive actions**
- 2. Building capacity for doing the work of adaptation**
- 3. Creating cross-sectoral linkages**
- 4. Monitoring and evaluating progress and outcomes**
- 5. Overcoming uncertainty**
- 6. Funding: using what we already have and getting more where needed**
- 7. Advertising adaptation to increase action**

Recurring solutions relevant to these gaps include:

- **Create an Adaptation Help Desk** to support those trying to get ideas into actions but lacking sufficient expertise.
- **Support jurisdictions that want to take action** and implement adaptation approaches for better long-term outcomes.
- **Share the lessons of what is being done** and learned between groups.

In this report we provide illustrative examples of the variety of work on climate change adaptation that is underway in the United States. This is by no means an exhaustive survey of the field; however it does provide insight into the dominant focus of work to date, the resultant gaps, and the opportunities available for advancing this essential aspect of sustainability. We focus on four areas of activity — agriculture, natural resources, human communities, and policy. The general trends relevant to these sectors can be applied more broadly to other sectors and countries.

Adaptation can be thought of as a cycle of activities that ultimately — if successful — reduces vulnerability to climate change. This process starts with identifying the impacts of climate change to determine the types of problems climate change might pose. This includes all of the research on the causes and the global, regional, and local manifestations of climate change, often referred to as **impacts assessments**.

Adaptation may not be the best name for this developing field of practice; however it does seem to be the one it has. Here are a few **definitions of adaptation** so you'll know it when you see it.

Adaptation is ...

- *Human efforts* to reduce the negative effects of or respond to climate change — not to be confused with evolutionary or biological adaptation.¹
- *Changes in social-ecological systems* in response to actual and expected impacts of climate change, in the context of interacting non-climatic changes. Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations, aim to meet more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities.²
- *Insurance*, given a non-zero probability that climate change will have an adverse affect on your investment. Here “insurance” is any action you take to protect your investment, and an “investment” is anything you care about.

It is also necessary to determine which of those changes make a target (people, place, or resource) vulnerable or less likely to achieve or maintain its desired state. This analysis is often achieved through a **vulnerability assessment**. If something is identified as vulnerable to climate change, **planning** can be undertaken to reduce the vulnerability. Plans often include establishing frameworks for approaching the problems identified in the assessment and developing implementable strategies to reduce the vulnerability.

¹ Hansen, L.J. and J.R. Hoffman. 2010. *Climate Savvy: Adapting Conservation and Resource Management to a Changing World*. Island Press, Washington, DC.

² Moser, S. C. and Julia Ekstrom. 2010. A framework to diagnose barriers to climate change adaptation. *PNAS* 107 (51): 22026-22031, DOI:10.1073/pnas.1007887107.

Throughout even these initial steps, there is a frequent need to **build capacity**, either because those who have identified the vulnerability do not feel equipped to develop a response or because the constituency who would need to participate in the process does not have the necessary tools and training for assessment, planning or implementation. Capacity building can also be as simple as raising awareness so there is a realization that climate change is a relevant issue and that there are approaches for addressing it. Once there is a critical mass of capacity and an actionable plan, there can be movement to **implementation** (where actual adaptation action happens), though it can happen in the absence of both in cases of autonomous adaptation. Inherent in the quandary of climate change is the reality that, from a human perspective, it will happen in perpetuity and without us knowing exactly what will happen. This means that effective adaptation will itself need to adapt to continuing changes, and in a manner that includes multiple options given the inherent uncertainty. To effectively address this challenge and have a clear sense of how climate change is manifest (since in many cases we won't know until it happens), it is necessary to incorporate **monitoring and evaluation** into adaptation efforts to determine what is working (so it can be more thoroughly exploited) as well as what isn't working (so it can be corrected). Things that have worked in the past may not work today and things that work today may not work tomorrow. Theoretically this process could be thought of as a loop that looks like this:

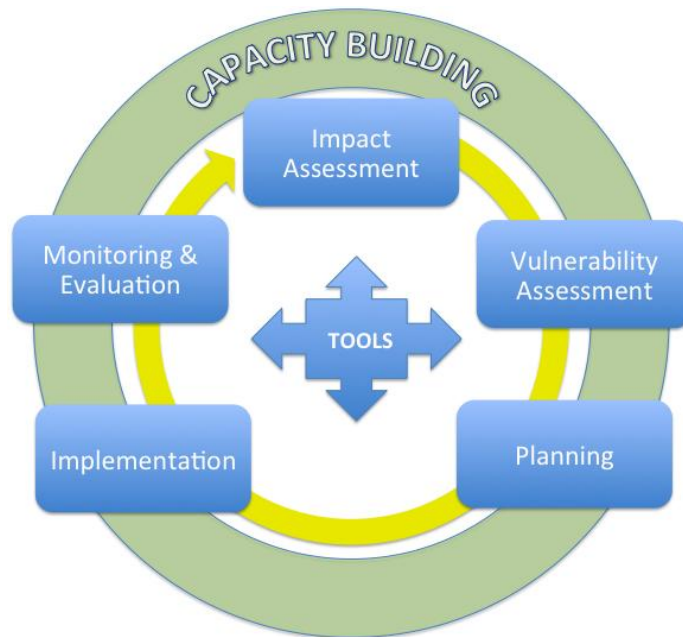


Figure 1. Theoretical adaptation cycle. [N.B. The Adaptation Process is not a one-way path to a solution, rather it is an iterative, perpetual endeavor to improve our understanding and adjust our approaches to achieve better outcomes as the climate changes and we learn more.]

The monitoring and evaluation step should feed back to interventions at multiple stages much like any other adaptive management model. However in reality the process occurring today in the United States is much more *ad hoc*, with parties engaging anywhere along the continuum. In reality the amalgamation of current adaptation efforts looks more like this:

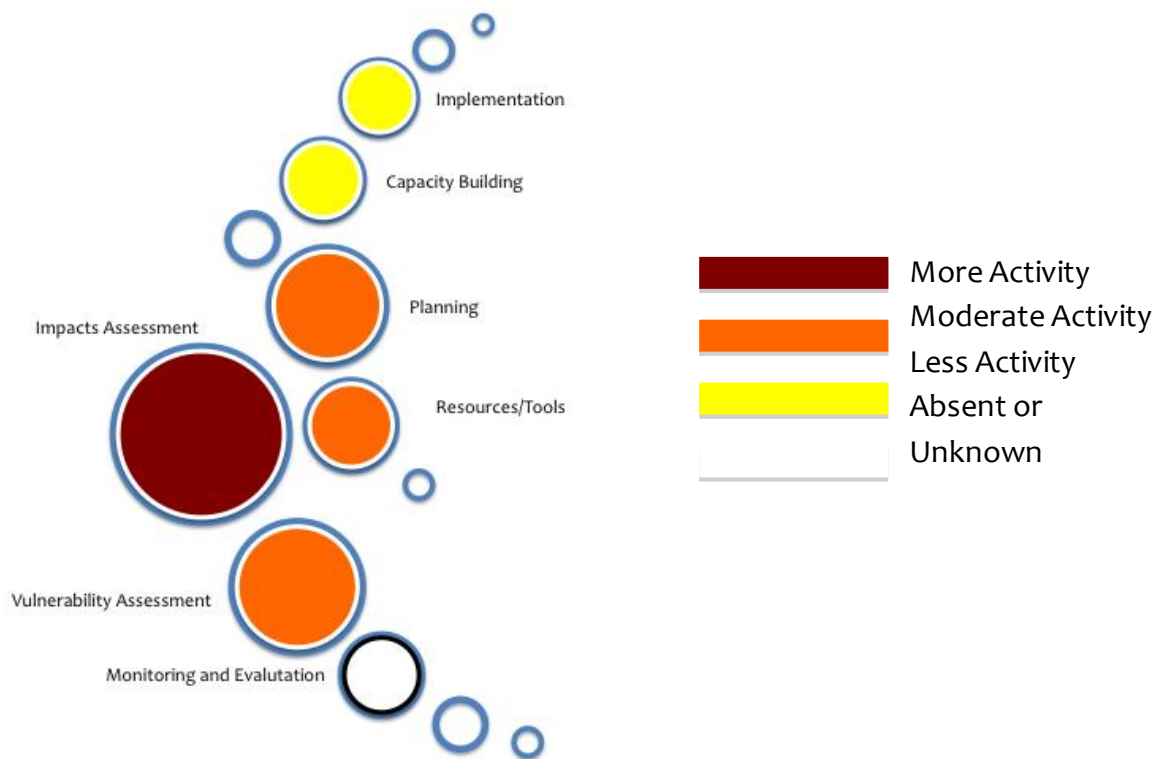


Figure 2. Presently in the United States there is variable development of our ability at these various stages.

The majority of effort around climate change adaptation in the United States to date has focused on increasing our understanding of the problem. This is true for all sectors and it is obviously where one needs to start. The federal government created the U.S. Global Change Research Program (USGCRP) in 1989, a year after the Intergovernmental Panel on Climate Change was created, in order “to understand, assess, predict, and respond to human-induced and natural processes of global change.” Through its consortium of agencies³, the USGCRP has conducted or supported extensive work in the areas of understanding, assessing, and predicting the effects of climate change. This research has

³ The USGCRP is comprised of the Departments of Commerce, Defense, Energy, Interior, State, Transportation, Health and Human Services, and Agriculture, as well as the National Aeronautics and Space Administration, the National Science Foundation, the Smithsonian Institution, the Agency for International Development and the Environmental Protection Agency (EPA). The USGCRP is overseen by the Executive Office of the President through the Office of Science and Technology Policy, the Council on Environmental Quality, and the Office of Management and Budget.

been the underpinning of most national efforts in the area of impact assessment and has, in turn, provided data and other resources for developing vulnerability assessments. While these assessments do not eliminate the uncertainty inherent in climate change (and all other future planning endeavors), they provide a solid understanding of the trends and likely scenarios the United States can anticipate in the coming decades and centuries. This wealth of scientific understanding continues to grow and will be an asset to all adaptation steps. Unfortunately, activity in the other steps is lagging behind.

While there has been some systematic planning leading to climate change problem identification activities (impacts and vulnerability assessment), the majority of adaptation activities have been more *ad hoc*. In the absence of top-down directives, a coordinated national effort, or even widespread national recognition of the significance of projected climate change and the urgency of preparing for it, adaptation actions have tended to occur in isolation and often without recognition or connection to other efforts. In isolation, interested groups have recognized the potential problems climate change will bring and have tried addressing them — sometimes learning from and sharing the results of their experiences with others sometimes not. Some adaptation efforts occur under the radar as a result of the political polarization of the issue and lack of public support for addressing climate change. Finally, adaptive actions are often undertaken to meet existing challenges that have not necessarily been recognized as climate change issues. It is difficult to identify these adaptation activities because even those undertaking them don't realize that they are. In these cases it is hard to share the lessons or link the actors to the larger adaptation community.

There has been a fair amount of adaptation planning with the development of many formal state, local, and sectoral adaptation plans, as well as some national planning. It is, however, unclear where many of these plans stand with regard to implementation or efficacy. It appears that implementation is significantly less common than plan development, based on the number of examples of each. In the case of efficacy this is largely unknown, owing to a lack of monitoring and evaluation efforts associated with even the implemented adaptation efforts. There are a growing number of tools and resources for the adaptation community but new practitioners can still find it hard to find what they need to make decisions. Progress in all steps of the adaptation cycle (assessment, planning, implementation, tools development and monitoring) is hindered by a limited amount of capacity building to train the managers and planners who need to be part of the process for it to blossom. In fact, capacity building itself is hindered by a lack of capacity.

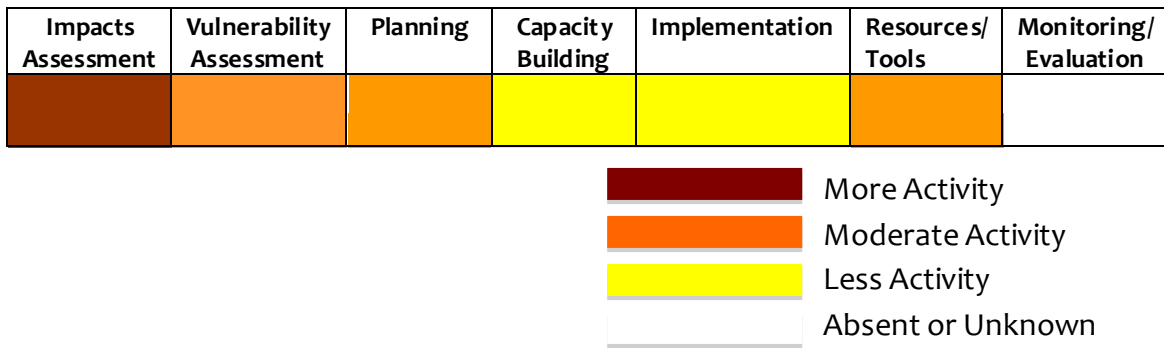


Figure 3. Activity levels vary in the stages of the adaptation process in the United States for all sectors. Significant effort has gone into problem identification (particularly impact assessments), some effort has gone into planning and tools development, there is insufficient effort toward capacity building and implementation, and there is essentially an absence of monitoring and evaluation of adaptation efficacy.

What opportunities are right for you?

The benefit of lagging activity in most areas of climate change adaptation in the United States is that there are ample opportunities to make a difference. Here the adage “the best place to start is somewhere” could not be more true.

Because there are so many opportunities to add value in the adaptation arena, selecting the right opportunity is, in part, determined by considering one’s own goals. It is important to consider what you expect to achieve by supporting adaptation and what your desired outcomes are. In essence, it is good to consider what you envision successful adaptation including prior to deciding what sort of activities you want to pursue. It is hard to generalize good and bad opportunities in the world of adaptation; however, this does not mean that action should be taken in a completely random manner.

In this paper we explore the sectors of policy, agriculture, built environment, and natural resources independently, but note that these four areas are tightly intertwined and should not be thought of independently of one another. Unfortunately, most adaptation to date does just that. For example, California’s first adaptation strategy in 2009 was developed as seven separate sectoral strategies that included public health, biodiversity and habitat, ocean and coastal resources, water management, agriculture, and forestry. Clearly there are interactions between virtually all of these, so creating them separately can carry significant risks. First, given their interactive nature, there is a high likelihood of missing opportunities to develop more innovative, potentially longer-term solutions. Second, when working independently, there is a higher likelihood of developing adaptation strategies for one sector that would be maladaptation strategies for another. One could easily see the potential for this when considering agriculture, water management, public health, and biodiversity and habitat all separately. Given scenarios

like this, it seems clear that **adaptation success will be more likely by building solutions across sectors**. To make this happen, we need to **create more multi-stakeholder and multi-sectoral processes and approaches**. Investing in activities that employ such a vision or develop the tools to support them would be of high value.

Questions that can help you assess how you might prioritize adaptation opportunities include:

1. What are your existing organizational goals and how are they vulnerable to climate change?
2. What are your desired outcomes from engaging in adaptation work?
 - a. Reducing the vulnerability of your own organizational goals.
 - b. Addressing climate change and adaptation in addition to your existing portfolio, but as a separate endeavor.
3. At what scale do you prefer to work?
 - a. Catalyze a national dialogue or movement in order to inspire adaptation activity.
 - b. Focus on a particular climate risk and work at the scale most relevant to it.
 - c. Work toward top-down governmental mandates or foster individual project efforts.
 - d. Facilitate a network of individual projects for increased learning.
4. Who do you want to work with?
 - a. Those already engaged.
 - b. Those yet to know they should be engaged.
 - c. A particular demographic (e.g., poor, policymakers, grassroots).
 - d. Those who provide information and training to facilitate adaptation.
 - e. Those doing the implementing.
5. Does cross-sectoral work come naturally to your organization or do you prefer to consider single factors first?
6. What approach are you most comfortable with supporting efforts to effect?
 - a. Increased sustainability.
 - b. Developing engineered solutions to develop with challenges as they emerge.
 - c. Supporting general resilience.
 - d. Making economic and social arguments for action (cost of action versus inaction).
 - e. Supporting adaptation to stimulate mitigation.

In contrast to the first process in California, Washington's Climate Change Response Strategy⁴ was developed by separate working groups (working lands and waters, human health and security, ecosystems/species/habitats, built environment infrastructure, and communities) who focused on topics relevant across working groups and addressed by each group independently and together. The process also included stakeholder participants from multiple levels of governments, as well as non-governmental entities; however, please note that, given our place on the adaptation learning curve, there would be value in single-sector endeavors, particularly if the participants were cognizant of the reality of interactive factors in the single-sector approach.

Cross-Sectoral Coastal Regions

One area where the cross-sectoral approach is easy is in coastal regions. Not only does aquatic meet terrestrial in those regions but, given the human affinity for coastal living, human activities (communities, agriculture) and natural resources often intersect in smaller geographies managed by a patchwork of regulations and regulatory entities. These regions are also among the first to be grappling with how to integrate climate change into planning and management. Analysis of coastal adaptation efforts might be a good place to start learning cross-sectoral lessons for translation to other regions and sectors.

Are there significant gaps and what can be done about them?

The wealth of opportunities in the field of adaptation is, of course, the result of myriad gaps. Based on the synthesis found in each of the subsequent chapter (policy, agriculture, human communities and natural resources), several common gaps were identified. For each of these gaps, highlighted in the box at the beginning of this chapter, there are great opportunities to fill them:

1. Implementation.

Today there is an obvious lack of adaptation implementation. There has been considerable work done in the area of impact assessment, as well as a fair amount of vulnerability assessment and planning, but very little actual implementation of these plans. We need to make adaptation implementation the standard practice, rather than allow the process to stall after a plan or framework for how to consider climate change in our work is created. In reality we need implementation of adaptation or action for all of the gaps described in this report.

Opportunities for Implementation

- Funding should be contingent on a defined path to implementation. While there is a need to fund vulnerability assessments and planning processes, there is little

⁴ http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm

reason to do so if these activities will not be used to improve management or other tangible practices.

- Identifying opportunities where there is commitment to and opportunity for implementation. Some geographies and sectors are more likely to have commitment to implementation, either due to a pressing vulnerability (water supply, flooding, or infestation), regulatory requirement, or political will. There is no reason not to reward those who are likely to move the ball forward and provide lessons for those following behind them.
- Create an Adaptation Help Desk. Currently it can be hard for those that need adaptation assistance in many sectors or regions to find it. Creating a cross-organizational bureau to provide on-call help for those who need it could move implementation forward. Such a service could be part reference librarian, part technical support, and part country doctor making house calls. It could also include a Research & Development branch that can generate the information you need if it doesn't exist. There are some resources that attempt to do pieces of this (the NOAA Regional Integrated Science and Assessment programs, some extension agents associated with Sea Grant and NOAA Coastal Services), but the need far outweighs the supply and, in many of those cases, they have their own mandate that can complicate their ability to provide a desired service.
- Support the creation of guidance/training/external support to demonstrate ways to use existing resources (money, personnel and mandate) to make adaptation happen. Adaptation is not limited simply by a lack of willingness or interest. For example, several states have adaptation strategies but little demonstrated implementation. In many cases this is because they have no money to make it happen. However, there is a wealth of opportunities for incorporating adaptation into existing programs covered by existing funds to get better long-term outcomes in the face of climate change. Creating guidance/training/external support that advises and guides through examples and interpretation of existing mandates would be a tremendous asset and a solid step toward mainstreaming adaptation, thereby simplifying the path to implementation. This could be another role of the Adaptation Help Desk.

2. Capacity to do the work of adaptation

Because climate change is a new challenge and adaptation is even newer, most practitioners (managers, planners, and regulators—current or future) have had no formal training on the issues related to either. The educational programs of past decades, as well as those of today, do not prepare practitioners for integrating climate change into their work. As a result, building informed, innovating adaptation capacity in the sectors discussed in this paper (or any others) requires both a short- and long-term capacity building effort. Long-term capacity building includes efforts to training people in the field of adaptation so they can do it themselves —“teaching them to fish” so to speak. Short-term capacity building includes efforts to assist people who are ready to do the work of adaptation but don't have what they need to do it themselves — this would require finding others to “fish” for them. In either case there is a need to create a critical mass of

people who are trained or connect to the extra capacity they need in order to make adaptation happen at a meaningful density.

Opportunities for Capacity Building

- “Fishing”:
 - Adaptation Help Desk. Again this on-tap expertise would be able to provide support, with a cross-sectoral suite of experts available to step in and provide the required capacity. This could include everything from legal assistance to technical information to designing and facilitating processes for adaptation development and implementation.
 - Developing new or promoting existing online tools (technical and social) to solicit, gather, and generate the information or capacity needed to support adaptation.
- “Teaching people to fish”:
 - Support development, distribution, and implementation of educational curriculum for undergraduate, graduate, and professional schools.
 - Provide adaptation training for those already in the workforce, perhaps through professional societies or other continuing education approaches. This can include formal training opportunities, peer-to-peer learning networks, guidebooks, and other resources.

3. Cross-sectoral linkages

As discussed in the opportunities section there is a great need to move adaptation to the next level by building multi-sectoral/multi-stakeholder processes and approaches. However, there often are no mechanisms to make these conversations happen.

Opportunities for Cross-Sectoral Linkages

- Create or network critical mass for cross-sectoral activity by creating **cohorts** across sectors to address common or adjacent issues. For example, the Yolo County (California) Climate Change Compact has a county coordinator who interfaces with all levels of government in addition to the private sector to develop climate change actions (adaptation and mitigation) that work across these jurisdictions and sectoral interests. This project has a low budget but facilitates the sharing of lessons between sectors through dialogue and site visits to create better countywide solutions. Similar networks are being developed in other regions (Southeast Florida Regional Climate Change Compact, Los Angeles Regional Collaborative for Climate Action, and the Department of Interior Landscape Conservation Cooperatives, although these largely focus on natural resource issues). Particular attention should be paid to supporting cohorts focused on meeting local cross-sectoral goals (e.g., improved zoning practices, transportation development, water allocation).

- Make efforts to document and share the processes of these cohorts so they can be replicated or create infrastructure (virtual or real) to replicate the process.
- Provide external support for these cohorts by giving them access to expertise, training, and other resources. This should start by taking advantage of what is already known about adaptation, getting cohorts plugged in to the existing adaptation community, and not wasting effort by reinventing the wheel. Again, a multi-sectoral Adaptation Help Desk could provide such support to cross-sectoral cohorts.
- Support efforts to develop cross-sectoral conversations, information exchange, raise awareness, and encourage enrichment through venues like the National Adaptation Forum and the American Society of Adaptation Professionals.
- Support and promote adaptation information clearinghouses that are accessible to all people looking for case studies that either promote cross-sectoral thinking or highlight cross-sectoral approaches in action. Two existing resources for this are the Georgetown Climate Center Adaptation Clearinghouse and the Climate Adaptation Knowledge Exchange.
- Take advantage of existing, multiple stressor models for assessing and addressing the key interactive stresses created by adding climate change to an already complex landscape (see details in the next paragraph).

There is a deeper level to the issue of cross-sectoral linkages and that is increasing our understanding of the multiple-stressor implications of climate change. For most of the existing challenges to the environment and human communities (e.g., pollution, poverty, aging infrastructure) climate change either exacerbates the problem or is exacerbated by the problem. Unfortunately in most cases we have only an intuitive understanding of the ramifications of these compounding effects. So not only is it necessary to encourage communication between sectors and jurisdictions who already know they need to include climate change in their planning, but it is necessary to better coordinate to even understand the interactive effects of these multiple stressors among multiple sections across multiple jurisdictions. Fortunately there are existing multiple-stressor models that can be applied to climate change — we just need to start recognizing it in that light.

4. Monitoring and evaluation to improve practice

As noted in Figure 3, there is a dearth of effort in the area of monitoring and evaluation. The demonstrable lack of monitoring and evaluation steps is not just bad process, but it means that we don't know what does and does not work in terms of adaptation. This is true for practice, process, and scale. A few efforts are just beginning internationally (Bangladesh) and, while there is an effort to cover this topic in the National Climate Assessment, only a handful of nascent projects have information to share. Systematically supporting projects that include monitoring and evaluation in order to assess adaptation efficacy would dramatically increase the size of this endeavor, which is key to completing the adaptation cycle.

What is successful adaptation?

As the Cheshire Cat so eloquently said in Lewis Carroll's *Alice in Wonderland*, "If you don't know where you are going, any road will get you there." In the wonderland of climate change this sentiment could not be more appropriate. While anything we do today will yield some future result in relation to climate change, the likelihood that we achieve our desired outcome increases if we take advantage of those aspects of climate change adaptation that we do control — clearly defining what outcome we would want if adaptation were to work and assessing whether or not we are going in the right direction.

There is an additional challenge in that direct sectors may have different desired outcomes and the paths to achieving those outcomes or the outcomes themselves may be mutually exclusive or efforts to achieve them may be at cross purposes. Developing visions of desired outcomes jointly is likely a key to not ending up on someone else's road and never arriving at your destination.

Opportunities for Monitoring and Evaluation

- Support efficacy testing:
 - Create a monitoring tool kit that recommends *short-term markers* or milestones for adjusting adaptation interventions and *long-term markers* for assessing whether the underlying goal was achieved. There are excellent examples of these sorts of endpoints from ecology and epidemiology.
 - Make monitoring and evaluation a requirement of MacArthur adaptation-related grant making. This is fiscally prudent for the foundation, as it not only allows you to determine whether your grants are achieving their stated goal, but also allows you to learn what approaches are effective in order to better hone future funding and advise grantees. However, some metrics may not be measurable for decades; therefore it is important to create both short- and long-term metrics for gauging efficacy. There will also be cases with no appropriate short-term metrics and leaps of faith will be required.
 - Provide direction on how to access data to support monitoring (e.g., climate change parameters, ecological change, demographic information).
- Conduct sectoral or national efficacy analysis and synthesis:
 - Adaptation strategy efficacy: We have the ability to examine the results of those project that have incorporated monitoring and evaluation (see examples in other chapters: New York City, South Bay Salt Ponds, agriculture)
 - Guidance efficacy: Adaptation guidance documents have been available for well over a decade, and more appear every day. It seems prudent to assess the effectiveness of these resources in engaging, informing, and motivating

people around adaptation, as well as determining whether the guidance is sound in its suggestions. Such information could help to strengthen next generation adaptation guidance, rather than nibbling at the edges.

- Create mechanisms for sharing lessons learned:
 - Through a grantee network that builds into broader adaptation information exchanges, make sharing of lessons relating to efficacy of adaptation work part of the community.

5. Overcoming uncertainty

We are not going to eliminate uncertainty in relation to climate change or anything else we make decisions about, but adaptation activities in the United States seem particularly stymied by the concept of uncertainty. In fact, we probably have greater certainty about the trajectory of climate change than we do about the economy, human population growth, or flu pandemic. Yet uncertainty and a quest for more information continue to be excuses for inaction. Unfortunately, inaction itself has a cost in that it prevents us from making informed decisions.

Opportunities for Overcoming Uncertainty

- Develop innovative ways to deliver the resources and training needed to support decision-making in the face of uncertainty. This could include approaches for dealing with multiple future outcomes affected by climate and other changes (anthropogenic or natural), as well as additional capacity for under-resourced adaptation efforts to serve as translators, topical experts, or process facilitators.
- Support efforts like Climate Central, 350.org, and the Alliance for Climate Protection to get clear messages on climate change to a non-scientific audience. These messages could address extreme weather, local socio-economic concerns, personally observable changes, or other ideas that have yet to be imagined. For example, the public is generally unmoved by global climatological change or changing decadal oscillations; however the public cares when repeated flooding events affect their family, cost their county, or compromise other services. Scientists tend to bristle at linking individual events to climate change and the public generally does not connect climate change to these events. However, even if a given event is not scientifically linkable to the global trend, it can certainly illustrate the sort of change people will have to learn how to deal with or develop adaptation strategies for.
- Support efforts to overcome barriers to implementing solutions. In many cases there is consideration given to evaluating different future conditions in decision-making as a method for overcoming uncertainty; however, some planning processes contain rules about the futures you can assume, often with an existing mandate to plan for the past or other hurdles to using multiple futures. For example, if officials make planning decisions that deviate from Federal Emergency Management Agency (FEMA) flood maps in order to better protect a community from danger, damages, and costs, does this open them up to litigation? The same is

true in regard to making decisions on coastal planning in relation to sea level rise projections.

6. Funding

While everyone always suggests that more money will solve problems, the funding need is a bit more complex. Certainly there are adaptation activities that require additional funds; however there is also a need to better understand how much of adaptation falls into the range of activities you already should be doing with funds you already have with an awareness of and ability to modify for changing conditions. Given the current financial crisis in many jurisdictions in the United States, where even basic services go unfunded, there are a growing number of cases where more funding is needed, but other cases where decision are being made and funds are available to take action on them, adaptation action may require a reconsideration of the actions taken with existing funds.

Opportunities for Funding

- Provide guidance on and examples of the need, opportunities, and mechanisms for using existing structures, funding, and mandates to make adaptation happen without additional resources. Such guidance can be developed by conducting a large-scale review of existing management structures/regulations, as well as engaging with decision makers to explore a variety of specific decision to explore climate risks and how existing structures do or do not reduce vulnerability to those risks.
- Create innovate online methods of engagement to demonstrate these ideas and reach a heretofore less engaged segment of the audience (e.g., those who have assumed adaptation was not something they could take on due to fiscal constraints).

7. Advertising adaptation to increase action

Along with the need to build capacity is the need to raise awareness. Many people are still not aware that they can engage in adaptation and even fewer understand that it is essential for positive outcomes. Creating a broader cognizance that there are actions that could be taken to reduce vulnerability to climate change could go a long way toward achieving mainstreamed implementation. Approaches to raising awareness should be targeted at:

- 1) Those who don't know they could be doing something to prepare for and respond to climate change impacts; and
- 2) Those who don't know that what they are doing is adaptation and are, therefore, not sharing what they are learning and are perhaps not doing it as proactively as they could be.

The goal of “advertising” is to entice people to start engaging in adaptation activities, ideally through the full spectrum. At EcoAdapt we refer to this as “stepping on the adaptation ladder of engagement.”

Opportunities in Advertising

There are a lot of climate change communication analyses and products, mostly focusing on individual behavioral change or national mitigation policy development. There is much less on communicating about climate risks and how to deal with them (e.g., adaptation). Support for this area of work could include:

- Research what works around adaptation communication — through case study analysis, focus groups or other communication research tools — to create guidance on what is most effective.
- Develop communication campaigns that can be implemented on a variety of scales (generic broad audience to participants in specific adaptation processes). This could be based on research, or could start simultaneous to research, based on some early information that has been gleaned by adaptation support practitioners to date. For example, there is currently a good deal of effort to use the new Intergovernmental Panel on Climate Change (IPCC) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change* report⁵ to motivate adaptation. California has been using the launch of that report, coupled with local examples that speak to the state’s residents to build a constituency for their growing efforts on adaptation.

Key Issues

Climate change is not occurring in a vacuum. It is happening on the complex tableau of human society and an anthropogenically altered environment. It is hard to identify anything that is not in some way affected by or affecting climate change. However, there are a few key issues that either compound the challenges of dealing with climate change or will be exacerbated by climate change in a manner that affects many sectors of society.

- **A paradigm of stationarity.** For centuries we have lived under relatively stable climactic conditions. It was likely this stability that allowed human societies to prosper from an evolutionary perspective. However, in reality the climate was never stable, yet the relative stability we have enjoyed, coupled with a relatively high adaptive capacity, has led to our assumption that conditions are stable in our

⁵ Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.). 2011. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 1-19. <http://ipcc-wg2.gov/SREX/report/>

social, economic, and environmental planning and management endeavors. In some cases, like the Colorado River's water allocation, the foibles of this stationary model have been evident for decades. Even in cases where the failings of the paradigm have been evident, little has been done to change these assumptions. Accepting a new paradigm with change and variability as the basic assumption for management and planning will take time; however, the longer it takes the more vulnerable our interim decisions will be as they will become less appropriate for the conditions around them.

- **Water.** Human and environmental demographic patterns are, to a large extent, based on the location of water. Communities were established where water was available — on rivers and lakes, as well as marine coastlines. Species migrate along paths that allow for access to water; however, the patterns of water availability for consumption and industry are slowly changing, both in terms of where and when it is available (and when and where it is needed). The hazards posed by water are also changing, such as flooding from rising sea levels and altered precipitation patterns. How we plan and manage water is going to be an increasing challenge that will require more resources over time.
- **Financially strapped governments** (from local to federal). While the complaint that there are insufficient resources for adaptation is frequently countered by the contention that existing funds spent in a climate-smart manner are adaptation, the problem is not solved if there are no funds at all. Many city, county, state, and even federal programs are operating with insufficient funds to achieve their mandated goal. Addressing climate change would have to become a cost savings from the status quo to overcome this obstacle. Although there are cases where long-term cost savings can be reaped from effective adaptation that reduces risk and avoids costly future expenditure to correct for bad planning decisions, there are few cases where historically under-financed and degrading existing efforts can be saved by adaptation efforts that are also under-financed. Efforts will have to be made to find those win-win opportunities but the societal challenge to develop ways to fund government work that protects resources and serves a common good will clearly also need to be addressed.

Key Geographies

The American landscape is not consistent in the application of adaptation approaches. In general, coastal regions are considerably more advanced in their efforts, with many coastal states having developed adaptation plans. However there are some notable inland exceptions, including Colorado, Wisconsin, and Chicago. There is opportunity in supporting regions that are already engaged, as well as trying to instigate activities in regions that lag behind.

One can overlay adaptation activity on regional vulnerability to try to identify regions that are highly vulnerable or particularly robust. While this calculus is complicated by socioeconomic (who has the funds to protect their community from harm) and cultural

(who may not want to move owing to historic affinities) factors, it is not an impossible analysis for those truly wanting to support the most vulnerable among us (human and environmental). Back of the envelope calculations point to low elevation coastal regions, already water-stressed regions, and densely populated urban areas with large urban heat islands. However, in some cases selecting a target geography based on vulnerability (the southeast, for example) may also point you to those regions least interested in addressing climate change due to political or skeptic status.

Building the Matrix into Adaptation Planning

In many regions of the United States there are adaptation activities being undertaken by an interested or mandated party isolated from the landscape around them. For example, many federal agencies manage public lands and have been mandated to start developing adaptation strategies. In the west many of these holdings are quite large, however some federal lands are quite small and effective adaptation will require collaboration with the state, local or private land owners surrounding them. This realization is growing; however the mechanisms for facilitating these efforts are nascent. The Department of Interior Landscape Conservation Cooperatives, obviously working at the landscape level, have the potential to stimulate this approach, however very few of them have developed the mechanisms for engaging the broader regional community, especially private land owners. Often the approach is too academic or research-oriented to entice collaboration with these parties. This effort to include the matrix in adaptation planning will be a key to developing more holistic models of management and planning that increase landscape/community resilience.

At what scale can adaptation efforts have the greatest impact?

Adaptation efforts occur at all scales. In each of the sectoral chapters we discuss examples of activities occurring from the federal to the local level. Given that effective adaptation will be how we integrate climate change into our thinking on all issues there really is something that can and must be done at all levels. However where we see the “rubber meeting the road” is at the local level. That is where the impacts become personal and the management strategies are often implemented. The local and the county level is often where land use and building code decisions are made. Granted these can be influenced by state and local government, again indicating the importance of action at those levels, but the manifestation of adaptation action has largely been at that local level to date. In some cases this may be the result of greater empowerment to action, such as the case of Ron Sims and King County, Washington where a mandate for adaptation action did not exist but they saw the need for action and made it happen. It is interesting to note that while action seems to be occurring most often at the local level, this is the level where climate projections are least accurate.

Cross-jurisdictional local efforts can happen

There are examples around the United States of local regions recognizing the threat of climate change to their community or common interest and working together to develop solutions.

The Los Angeles Regional Collaborative for Climate Action and Sustainability: A consortium of southern California entities (government, utilities, NGOs, and universities) working to create a climate change action plan for the region that works cross-jurisdictionally. They also aim to provide resources relevant to the region.⁶

One Bay Area: Led by regional agencies (air, transit, development and local government) they are working to coordinate the efforts of the nine counties and more than 100 municipalities in the San Francisco Bay area around sustainability goals. Their efforts include integrating adaptation into that sustainability approach.⁷

Florida Reef Action Plan: In southern Florida, regional parties united to develop a plan to protect natural resources and, by extension, the economies of local communities. What started as an exploration of approaches to improving coral reef health in the face of climate change grew into a multi-county, federal, state, and local, cross-sectoral, multiple stakeholder developed and approved plan to address climate change in the region. In the end it also included activities to address greenhouse gas emissions and enhance mitigation efforts. This was led by a regional consortium, the Florida Reef Resilience Program, but included tourism and fishing interests, as well as governmental agencies.⁸

Although these approaches are far from the norm, figuring out how to develop these **regional and holistic processes that integrate multiple sectors is likely a more effective path to sustainability that is inherently adaptive**. A clear opportunity is supporting these types of processes and sharing their approach so that others can create a version that works for their region.

⁶ <http://www.environment.ucla.edu/larc/>

⁷ <http://www.onebayarea.org/>

⁸ http://ecoadapt.org/data/library-documents/FL_Reef_Action_Plan.pdf

Scale Issues

There are opportunities for adaptation enhancement at all scales. In most cases your adaptation efforts will be most effective where you have the greatest interest, an existing investment, or a potentially fruitful opportunity. Some questions that can help frame the ideal scale for your goals include:

1. Does your organization tend to prefer working at a particular scale?
2. What type of change do you want to effect? Do you want to create national mandates? Do you want to see local implementation? Do you want to leverage activities across regions?
3. What size entities does your organization prefer to work with? Large national? Regional coordinators? Small local?

Eight Good Bets

Based on the needs and recommendations found in this report the authors have identified eight “good bets” to move adaptation in the United States forward. These are all quick and achievable endeavors that help to fill a number of the gaps that were identified in the four sectors—agriculture, human communities and natural resources.

1. **The First National Adaptation Forum: Action Today for a Better Tomorrow.** A national conference being planned for spring 2013 geared toward adaptation practitioners of all walks. This meeting aims to help build adaptation knowledge for those who implement it. It will serve as a capacity-building opportunity and has a meeting flow designed to increase cross-sectoral linkages. The organizing committee includes governmental, NGO, academic, and private sector representatives.
2. **Adaptation Help Desk.** As indicated in the sections above, such a resource could be part of addressing several adaptation gaps in the United States. This resource could bring together existing adaptation capacity (such as EcoAdapt, the Georgetown Climate Center, and the Climate Impacts Group, as well as a variety of others listed in the key players section. These key players would, ideally, be free from institutional mandates that constrain some other adaptation service providers (such as government agencies) and already be innovators and respected partners in the area of adaptation support. Together these parties could create an Adaptation Help Desk to simultaneously consider and integrate legal, scientific and process considerations for adapting policy, as well as natural resources, human communities, and the built environment.
3. **American Society of Adaptation Professionals (ASAP).** This society aims to organize and support the needs of climate change adaptation professionals – in

academia, public, and the private and non-profit sectors – working on adaptation from national to local scales and within or across multiple sectors. ASAP has gathered many climate adaptation professionals to build professional standing and to consolidate efforts across a diffuse, but increasingly emergent, profession. This group is in its nascent stages but has an engaged participant group and plans to use the National Adaptation Forum as an opportunity for its first public convening.

4. **Take stock of existing guidance**, research, and practitioner needs to develop the guidance needed to:
 - Advance the leaders in adaptation further by allowing them guidance about which resources may help them;
 - Help those new to adaptation move forward without reinventing the wheel, speeding their path; and
 - Assess the efficacy of existing guidance. Throughout this report you will find mention of countless guidance documents, tools, and other resources, yet as with adaptation efforts, there is no effort to determine whether the advice and guidance they provide is useful, used, or effective.
5. **Climate change adaptation communication.** Most people don't know what adaptation is by name and many don't know what it is even when you explain it. There is a need to develop framing and messaging for the public and policymakers about what adaptation is, why it is necessary, and what it entails. Somehow we need to make it understandable, approachable, and embraceable.
6. **Kick-start adaptation implementation** (especially at the state and local level). Provide incentives to implement more challenging or experimental approaches which include mechanisms for assessing efficacy through monitoring and evaluation.
7. **Identify Pathways for Success.** This includes an analysis and synthesis of technical mechanisms (including project, process, and monitoring design), legal mechanisms, and metrics of success for effective adaptation. From this good replicable models of successful adaptation can be developed.
8. **Move the climate change agenda beyond its current perception as being an environmental issue.** Make it central to good planning and management for social and economic sustainability and well-being. This includes efforts to broaden the scope of climate change adaptation to show cross-sectoral linkages and the synergies that evolve through multi-sectoral cooperation.

Take Home Message

Dr. Stephen Schneider was widely known for saying that getting society to address climate change effectively is “a marathon, not a sprint.” People often pointed out that he seemed to be moving awfully quickly for a marathon. I like to point out that he said it was a marathon, not a stroll in the park.

The bottom line as one considers how to approach the field of adaptation is that none of these areas (the sectors or steps in the adaptation continuum) are a done deal in the United States, therefore support efforts in any area add value. There are limitless paths before you, which can all yield benefits for society. The most important thing is to take one and travel down it at speeds a bit faster than a stroll in the park.

Differences can be made, but only if we start making them. Opportunities for the MacArthur Foundation to make a difference in the United States in regard to climate change adaptation are vast. The information in this report can give you a sense of where various existing pieces reside, and there are many opportunities to fill the gaps through expanding or connecting what is already in place, as well as by creating new pieces. New participants in the adaptation arena are always welcome, as the need is great.

Focus: Climate Change Adaptation and the U.S. Military

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For a number of years the U.S. military has been aware that climate-generated effects on human communities may create security issues or initiate conflict requiring military intervention, including loss of life and property, infrastructure damage or destruction, degradation of human services (e.g. drinking water, sewage treatment), and mass migration.^{9,10,11} Climate change may also create new conditions that would require military involvement; for example, melting sea ice will open the Arctic's Northwest Passage, allowing for novel maritime transportation routes and newly exposed natural resources that will necessitate coordinated approaches to human and environmental security.¹² The Department of Homeland Security (DHS) and Department of Defense (DoD) house the five main branches of the U.S. military responsible for addressing these issues.

The DHS, under which the Coast Guard operates, has created a Climate Change Adaptation Task Force to develop recommendations and a plan of action. Priority climate-related issues include protection of facilities, improvements to disaster response and recovery equipment, and redesign or restoration of ships and aircraft to withstand extreme weather events.¹³

The DoD, under which the Army, Air Force, Navy, and Marine Corps operate, is especially concerned about sustaining military readiness in a changing climate and is undertaking a number of activities¹⁴ to address these concerns, such as:

- Investing in tools, resources, and models that can assess vulnerability of military infrastructure to climate change impacts;

⁹ McKeown, T.J. 2008. Climate Change, Population Movements, and Conflict. In *Global Climate Change: National Security Implications*. 2008. Carolyn Pumphrey (Ed.) Strategic Studies Institute, Carlisle, PA. <http://www.strategicstudiesinstitute.army.mil/pdf/files/pub862.pdf>

¹⁰ Department of Defense. 2010. Quadrennial Defense Review Report. February 2010. <http://www.defense.gov/qdr/qdr%20as%20of%2029jan10%201600.PDF>

¹¹ Interagency Climate Change Adaptation Task Force. 2011. Federal Actions for a Climate Resilient Nation: Progress Report of the Interagency Climate Change Adaptation Task Force. http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_adaptation_progress_report.pdf

¹² Department of Defense. 2010. Quadrennial Defense Review Report. February 2010. <http://www.defense.gov/qdr/qdr%20as%20of%2029jan10%201600.PDF>

¹³ Department of Homeland Security. 2010. Department of Homeland Security Strategic Sustainability Performance Plan. <http://www.dhs.gov/xlibrary/assets/mgmt/dhs-strategic-sustainability-performance-plan.pdf>

¹⁴ Center for Climate and Energy Solutions (C2ES). 2012. Climate Change Adaptation: What Federal Agencies Are Doing. <http://www.c2es.org/docUploads/federal-agencies-adaptation.pdf>

- Enhancing collaboration with other foreign defense forces to build resilience through the Defense Environmental International Cooperation Program;
- Incorporating guidelines for vulnerability and sea level rise assessments of DoD facilities in Legacy Resource Management Program grants; and
- Participating in the development of *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*, a guidance document to support analyses of natural resource management in a changing climate, among others.

In addition, specific branches of the DoD are addressing climate change¹⁵:

- The U.S. Army Corps of Engineers (USACE) has released the following reports: *Climate Change Adaptation Policy Statement*, *Climate Change Adaptation Plan and Report*, and *Guidance on Incorporating Future Sea-Level Change Projections into Planning and Design*. Numerous adaptation pilot projects are underway and the USACE is involved in several committees and working groups, such as the Climate Change and Water Working Group (with the Bureau of Reclamation, U.S. Geological Survey, and National Oceanic and Atmospheric Administration).¹⁶
- The U.S. Navy established the Task Force Climate Change in 2009 to address potential issues and responses. This task force has created the:
 - *Arctic Roadmap (2009)*, a five-year strategic plan to address security, readiness, and resource management issues in the region;
 - *Climate Change Roadmap (2010)*, a plan to address climate change impacts on missions and infrastructure and partnership opportunities with other federal agencies, NGOs, and academia; and
 - *National Security Implications of Climate Change for U.S. Naval Forces (2011)*.

¹⁵ Center for Climate and Energy Solutions (C2ES). 2012. Climate Change Adaptation: What Federal Agencies Are Doing. <http://www.c2es.org/docUploads/federal-agencies-adaptation.pdf>

¹⁶ Gregg, R. M. 2010. *Planning for Climate Change in the U.S. Army Corps of Engineers* [Case study on a project of the U.S. Army Corps of Engineers]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2771> (Last updated December 2010)

Chapter 2: Promoting Adaptation through Policy

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Adapting to climate change presents many challenges: impacts will cross jurisdictional lines and affect many sectors simultaneously. For example, increased flooding from sea level rise and extreme weather will affect coastal development and ecosystems, infrastructure, and critical facilities, threatening both people and property. To meet these and other challenges, governments must develop adaptation plans, coordinate among different vertical levels and horizontal silos, and integrate adaptation into existing management and regulatory frameworks. In addition to fostering adaptation throughout the public sector, government can also play a role in eliminating barriers that inhibit successful private sector adaptation. Such barriers can include existing subsidies, investments, and policies that promote maladaptive behaviors.

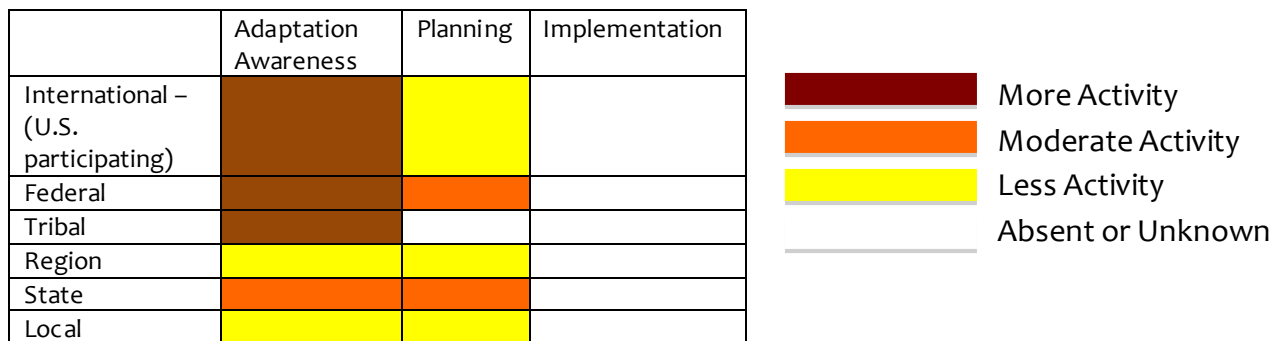


Figure 1. Adaptation policy activity efforts vary considerably across jurisdictions and sectors in the United States. Significant effort has gone into adaptation awareness across jurisdictions. Some effort has gone into planning but it varies by location, for example, coastal states and communities are generally doing more planning than inland jurisdictions. Implementation efforts are nascent at all levels.

The good news is that adaptation planning is already happening in some sectors and communities and planning capacity has dramatically evolved over the last decade. Planning is occurring on a number of scales (federal, state, regional, local, tribal, and in the private sector) and plans are becoming more sophisticated in their analysis of

¹⁷ The author appreciates input from Jessica Grannis, Robert Stumberg, and Gabe Weil and from Research Assistant Lissa Lynch on this chapter. Discussion of state adaptation efforts was informed by work with Terri Cruce for an upcoming ABA book on climate adaptation: Vicki Arroyo & Terri Cruce, “State and Local Adaptation to Climate Change,” in *The Law of Adaptation to Climate Change* (Michael B. Gerrard & Katrina F. Kuh eds., forthcoming 2012).

potential impacts and consideration of the range of policy responses. The drive to adapt can be attributed to many factors: growing understanding of climate risks, increasing damage from extreme events, greater availability of data and tools to assess risks, and growing interest in building the long-term resilience of our communities.

In spite of the failure to pass federal climate legislation, adaptation planning is occurring in a number of states and communities even in the absence of federal incentives or a dedicated source of funding. Still, adaptation mostly occurs on an *ad hoc* basis, reflecting different drivers (elected officials, agency staff, advocates), threatened impacts (sea level rise, floods, heat waves), and vulnerable sectors (transportation, energy, ecosystems). As concern and capacity increase, more jurisdictions are following the leaders and reinventing planning models to address unique local needs; however, the vast majority of jurisdictions are not prepared for the changes in store.

To date, planning has generally been done in a centralized manner through specific exercises to develop adaptation plans. Implementation of these plans has often been more challenging. To a large extent, “adaptive measures” are being applied or implemented in a *reactive* manner. That is, as state and local jurisdictions experience climate impacts, such as flooding from sea level rise and increased precipitation, they are adapting as they can (read: coping) based on available information and resources. However, in order to *proactively* adapt to impacts, planners need to anticipate climate change impacts when making regulatory and investment decisions *in advance of impacts* across key sectors and functions. Early efforts to promote such proactive planning benefitted from external support, but resource limitations and political changes have inhibited the ability to replicate these early efforts on a widespread basis. “Mainstreaming” climate considerations (including rising sea levels and variability of precipitation) into existing planning efforts across agencies and sectors is vital to ensuring that future plans, policies, and investments promote resilience, yet few jurisdictions have figured out how to “mainstream” adaptation in this manner.

From early experience with planning, we can derive lessons about what is driving adaptation (at all levels of government) and what challenges to adaptation persist. This chapter provides a brief summary of planning activities at various levels, noting the authorities and drivers for each planning process. Gaps and opportunities to promote successful adaptation in both the public and private sectors are discussed along with recommendations for moving forward.

Inventory of Adaptation Planning

All levels of government have roles in planning and implementing adaptation to climate change:

- *Federal* — Federal agencies are developing and funding the development of climate science and models and providing technical support and guidance. A common refrain of those working on adaptation at the subnational level or in the private sector is that the federal government should develop and communicate the best available science in a readily accessible form to public and private decision-makers and resource managers in state and local governments¹⁸ yet there has been debate in Washington, D.C. about the creation of a national climate service. The federal government also administers its own programs and lands. It is a major landholder and manages a diversity of lands, resources, habitats, and species. It also finances and manages billions of dollars worth of infrastructure and funds programs (providing levees and bridges, flood insurance, farm subsidies) that affect the behavior of other government entities, the private sector, and individuals. Relevant federal agencies need to coordinate with other agencies and partner with other entities to promote resilience to climate change impacts.¹⁹
- *State* — State agencies are often the drivers of adaptation planning efforts and provide technical support and oversight to local planning processes. State agencies are planning how to integrate adaptation when administering state programs, funding, and state lands. Even those not consciously considering the impacts of climate change (including rising sea levels) in their planning are indirectly affecting public, private, and individual resilience through their existing policies and investment strategies.
- *Local* — Most adaptation will occur at the local level and communities where we live and work will be the ones who primarily experience its impacts. Local governments are charged with making the basic land use and public investment decisions that will be critical to implementing adaptive measures on the ground. Local governments are also the first responders in the case of extreme weather events (e.g., fires, heat waves) and oversee siting, design, and building practices that can be amended to include anticipated changes.
- *Tribes* — Tribes are particularly vulnerable to climate change, which will impact the natural resources on which many tribes rely for subsistence and cultural practices. Adaptation is beginning to be incorporated into planning efforts such as water rights negotiation and relocation of coastal villages; however, inadequate resources and the

¹⁸ See e.g., Government Accountability Office 10-113, *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions*, Report to the Chairman, Select Committee on Energy Independence and Global Warming, House of Representatives (Oct. 2009); Committee on Strategic Advice on the U.S. Climate Change Science Program; National Research Council, *Restructuring Federal Climate Research to Meet the Challenges of Climate Change* (National Academies Press, 2009).

¹⁹ See generally Government Accountability Office 10-114, *Climate Change Adaptation: Information on Selected Federal Efforts to Adapt to a Changing Climate* (Oct. 2009); Katie Theoharides et. al., *Climate Change Adaptation across the Landscape: A Survey of Federal and State Agencies, Conservation Organizations and Academic Institutions in the United States*, Association of Fish and Wildlife Agencies, Defenders of Wildlife, The Nature Conservancy, & The National Wildlife Federation (2009).

lack of comprehensive federal programs to assist tribes with planning have limited tribal involvement in adaptation planning.

All of these levels of government have a role to play in anticipating likely changes and revising plans, policies, investments, and programs with climate change in mind. In addition, the private sector has a role in preparing for climate change and government policies can either promote or inhibit progress. The next sections will expand on their roles and opportunities and provide more historical context.

Federal Planning

As federal legislation to address climate change (and promote adaptation through planning and funding mechanisms) stalled, the Obama Administration began to move forward with promoting adaptation through existing authority. President Obama signed Executive Order (E.O.) 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, on October 5, 2009.²⁰ Section 16 of the E.O. directs federal agencies to participate in a Climate Change Adaptation Task Force and directs the task force to develop recommendations for how the policies and practices of the federal agencies can be made compatible with a national adaptation strategy.

The E.O. has led to a flurry of planning activities at the federal level, though such planning is often aimed first at resources and infrastructure directly owned or controlled by the government and implementation of changes is generally not yet underway. The federal government is simultaneously engaging in three distinct roles in adaptation planning: interagency coordination and planning, federal agency adaptation planning, and federal pilots to provide technical support for specific state and local planning efforts (described below). These efforts are improving coordination horizontally across agencies and vertically through levels of government²¹; however, resources are limited and could be further strained by proposed cuts in federal funding or curbs on agency authority.

Interagency Climate Change Adaptation Task Force

The Interagency Climate Change Adaptation Task Force (Task Force) is co-chaired by the Council on Environmental Quality (CEQ), the National Oceanic and Atmospheric Administration (NOAA), and the Office of Science and Technology Policy (OSTP). In

²⁰ Exec. Order No. 13,514, 3 C.F.R. 13514. 2010.

www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf.

²¹ See generally White House Council on Environmental Quality. 2010. *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy* (Oct. 5, 2010),

<http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>.

October 2010, the task force issued a progress report setting out, among others, the following goals²²:

- Encourage adaptation planning across the federal government.
- Ensure access to scientific information about climate change impacts.
- Use a collaborative approach on issues that cut across federal agencies, such as water management, public health, oceans and coasts, and community adaptation.
- Enhance international adaptation through the design of U.S. foreign assistance.
- Coordinate federal support for local, state, and tribal needs.

Federal Agency Planning

The CEQ is also spearheading adaptation planning at individual agencies, as required by the E.O. In March 2011, the CEQ issued “Implementation Instructions” that require each agency to establish a climate change adaptation policy, participate in CEQ-sponsored workshops, analyze agency vulnerabilities to climate change, and identify adaptation priorities for fiscal year 2012.^{23,24} In October 2011, the task force released its 2011 Progress Report,²⁵ which showed that agency plans are primarily aimed at assessing vulnerability of their assets and operations. The next stage will be to cover agency policies, programs, and permitting processes.

To date, the following agencies have adopted policies or plans for adapting to climate change:

U.S. Department of Transportation (DOT): The Policy Statement on Climate Change Adaptation²⁶ guides the integration of climate adaptation strategies into DOT planning, missions, programs, and operations. Its guiding principles for adaptation are to adopt integrated approaches; prioritize the most vulnerable, apply risk-management methods and tools; and apply ecosystem-based approaches.

²² White House Council on Environmental Quality. 2010. *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy* (Oct. 5, 2010). <http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>.

²³ White House Council on Environmental Quality. 2011. *Federal Agency Climate Change Adaptation Planning Implementation Instructions* (Mar. 4, 2011). http://www.whitehouse.gov/sites/default/files/microsites/ceq/adaptation_final_implementing_instructions_3_3.pdf.

²⁴ White House Council on Environmental Quality. 2011. *Federal Agency Climate Change Adaptation Planning Support Document* (Mar. 4, 2011). http://www.whitehouse.gov/sites/default/files/microsites/ceq/adaptation_support_document_3_3.pdf.

²⁵ White House Council on Environmental Quality. 2011. *Federal Actions for a Climate Resilient Nation: Progress Report of the Interagency Climate Change Adaptation Task Force* (Oct. 28, 2011). http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_adaptation_progress_report.pdf.

²⁶ U.S. Department of Transportation. 2011. *Policy Statement on Climate Change Adaptation* (June 2011). <http://www.dot.gov/docs/climatepolicystatement.pdf>.

U.S. Department of the Interior (DOI): Secretarial Order 3226, Amendment No. 1,²⁷ requires each DOI bureau and office to analyze potential climate impacts in planning and priority setting, coordinate policy review and guidance with the Climate Change Coordinator in the Office of Environmental Policy and Compliance, and use *Adaptive Management: The U.S. Department of the Interior Technical Guide* as a decision-making framework.

U.S. Department of Agriculture (USDA): The Policy Statement on Climate Change Adaptation²⁸ requires the Climate Change Program Office to develop a USDA Climate Change Adaptation Plan by June 4, 2012. It also directs USDA agencies to analyze how climate change may impact their missions, policies, and programs; coordinate actions with USDA's Global Change Task Force; and consider climate change impacts in long-term planning and priority setting.

U.S. Forest Service (USFS): The 2010 National Roadmap for Responding to Climate Change²⁹ guides the USFS in improving climate change resilience in national forests and working lands through three types of actions: assessing current risks, vulnerabilities, policies, and gaps in knowledge; engaging internal and external partners in seeking solutions; and managing for resilience in ecosystems and human communities, through adaptation, mitigation, and sustainable consumption strategies. It also uses a scorecard to track the agency's implementation.

NOAA: The NOAA Next Generation Strategic Plan³⁰ sets four long-term goals:

- Climate adaptation and mitigation — improving the scientific understanding of climate change.
- Weather-ready nation — preparing for and responding to weather-related events;
- Healthy oceans — sustaining marine fisheries, habitats, and biodiversity within healthy and productive ecosystems.
- Maintaining resilient coastal communities and economies — maintaining environmentally and economically sustainable communities that can adapt to the impact and hazards of climate change.

²⁷ U.S. Department of the Interior. 2009. *Secretarial Order 3226 Amendment No. 1 – Climate Change and the Department of Interior* (Jan. 16, 2009).

http://www.blm.gov/pgdata/etc/medialib/blm/wy/programs/science.Par.46189.File.dat/SO_3226A1.pdf.

²⁸ U.S. Department of Agriculture, Office of the Secretary. 2011. *Departmental Regulation 1070-001: Policy Statement on Climate Change Adaptation* (June 3, 2011). <http://www.ocio.usda.gov/directives/doc/DR1070-001.pdf>.

²⁹ U.S. Forest Service. 2010. *National Roadmap for Responding to Climate Change* (July 2010). <http://www.fs.fed.us/climatechange/pdf/roadmap.pdf>.

³⁰ National Oceanic and Atmospheric Administration. 2010. *Next Generation Strategic Plan* (Dec. 2010). http://www.ppi.noaa.gov/wp-content/uploads/NOAA_NGSP.pdf.

The U.S. Army Corps of Engineers (USACE): Sea Level Change Considerations for Civil Works Programs³¹ provides guidance for evaluating the vulnerability of USACE projects and incorporating effects of sea level rise into the management, planning, engineering, design, and maintenance of projects.

Because these agencies control much of the important land, resources, and infrastructure that will be affected and gather the relevant data on climate conditions and impacts, their efforts will be central to successful adaptation at the national level. Their policies and investments inform or drive other public and private sector actions as well. Their progress is encouraging; however, more must be done to relate plans and policy statements to actual changes on the ground.

Interagency Efforts

In addition to individual efforts, successful adaptation requires coordination. Federal agencies are engaging in several interagency planning processes to address impacts that cross sectors and jurisdictional boundaries. These processes are designed to break down silos within and across agencies and promote cooperation. They are taking place through making interagency agreements and providing more specific “place-based” analyses. They are designed to assess the impact of climate change on specific locales or sectors and include the following examples:

- *Gulf Coast Study*: For many years now, USDOT and the U.S. Geological Survey have been supporting a study of potential impacts to transportation infrastructure along the vulnerable Gulf Coast.³² Initiated before Hurricane Katrina, the effort involves a number of government agencies, outside experts, stakeholders, and others. This project crosses jurisdictional silos and evaluates risks to critical infrastructure.
- *The U.S. Global Change Research Program’s (USGCRP) Adaptation Science Workgroup*:³³ The workgroup ensures that federal adaptation decisions are informed by collaborative studies across scientific disciplines.
- *The National Climate Assessment*: Also under the auspices of USGCRP, this is an interagency process that receives input from academics, NGOs, and the private sector designed, in part, to frame risks for the benefit of adaptation decision-making.
- *The National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*: This movement was led by the Interagency Climate Change Adaptation

³¹ U.S. Army Corps of Engineers. 2011. *Sea Level Change Considerations for Civil Works Programs*, Circular No. 1165-2-212 (Oct. 1, 2011). <http://planning.usace.army.mil/toolbox/library/ECs/EC11652212Nov2011.pdf>.

³² U.S. Climate Change Science Program. 2008. *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I* (March 2008). <http://www.climatechange.gov/Library/sap/sap4-7/final-report/sap4-7-final-all.pdf>.

³³ <http://www.globalchange.gov/what-we-do/adaptation-science>.

Task Force³⁴ and designed to help managers of freshwater resources “assure adequate water supplies, safeguard water quality and aquatic ecosystems, and protect human life, health and property.”

- *The National Fish, Wildlife, and Plants Climate Adaptation Strategy*:³⁵ This is a collaborative effort led by CEQ and involving the U.S. Fish and Wildlife Service, NOAA, and state and tribal governments to develop a common strategy for reducing the negative impacts of climate change on fish, wildlife, and plants.

Federal Support for State and Local Pilots

In addition to cooperation across the federal government, federal agencies are increasingly supporting state, local, and sectoral adaptation efforts through pilot studies, guidance, and technical assistance. This vertical coordination between levels of government is essential to building the technical capacity of state and local governments that have limited monetary and human resources. Some federal agencies active in this endeavor include:

- The Centers for Disease Control and Prevention (CDC) — they are working in the public health arena to promote cooperation across relevant agencies to assist communities in planning for and responding to excessive heat (the Environmental Protection Agency [EPA], NOAA, the Department of Homeland Security [DHS], *CDC’s Excessive Heat Event Guidebook*).³⁶ The CDC also created the Climate-Ready States and Cities Initiative³⁷ to assist health departments in preparing for and responding to the health effects of climate change. In 2010, this initiative awarded \$5.25 million to ten state and local health departments.
- NOAA — has developed regional climate science centers and Regional Integrated Science and Assessment programs (RISAs) to provide scaled-down climate data to inform adaptation decisions at regional, state, and local levels. For example, NOAA entered into a memorandum of understanding with the Western Governors Association to assist with adaptation planning for the western United States.³⁸
- The U.S. Department of Interior (DOI) — provides information through its Regional Climate Science Centers and Landscape Conservation Cooperatives, a

³⁴ Interagency Climate Change Adaptation Task Force. 2011. *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate* (Oct. 2011).

http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf.

³⁵ <http://www.wildlifeadaptationstrategy.gov/>

³⁶ Environmental Protection Agency. 2006. *Excessive Heat Events Guidebook*, EPA 430-B-05-005 (June 2006).

http://www.epa.gov/heatisd/about/pdf/EHEguide_final.pdf.

³⁷ http://www.cdc.gov/climatechange/climate_ready.htm.

³⁸ Western Governors Association and NOAA. 2011. Memorandum of Understanding, Collaboration on Information Service Needs and State Capacity Building for Efficient State Adaptation to Climate Variability and Change (June 30, 2011). <http://www.westgov.org/initiatives/climate>.

network of public-private partnerships that provide shared science to ensure the sustainability of America's land, water, wildlife, and cultural resources.³⁹

Challenges remain in determining which level and agency of government should take the lead on certain issues pertaining to adaptation. These federal programs were designed to support state and local efforts, recognizing that state and local governments are on the front lines in responding to a range of threats from climate change. State and local governments have also initiated and led their own planning processes. The next section identifies progress in some of these jurisdictions.

State and Local Adaptation

A number of state and local governments are adapting to climate change without federal mandates, guidance, or funding. As they search for ways to make their states and communities more resilient, these subnational actors are experimenting with policies that provide important lessons to government at all levels. Traditional state and local functions are at the heart of adapting to climate change (e.g., land use and planning, water resources, wildlife management, transportation, public health, coastal management), so it is both unlikely and undesirable for federal policy to displace or preempt state and local adaptation.⁴⁰

As of this writing, seventeen states have (or soon will have) adopted adaptation plans. Many of these are coastal states, where impacts of climate change are already being felt. These plans identify the impacts of climate change, assess implications for vital sectors and resources, and recommend policies to mitigate these impacts. About half of the plans focus solely on adaptation, while the others address mitigation as well. No plans are written as if they are one-time efforts, rather, they all propose measures to support continued and iterative planning and implementation. States with adequate capacity are already working on progress reports and new recommendations to their initial plan.⁴¹

³⁹ U.S. Department of the Interior, Secretarial Order No. 3289-A1, 3 (Feb. 22, 2010).

⁴⁰ See Federal Highway Administration. 2008. *Summary Report: Peer Workshop on Adaptation to Climate Change Impacts*, Appendix A: Adaptation of Transportation Infrastructure to Global Climate Change Effects: Implications for Design and Implementation. http://www.fhwa.dot.gov/planning/statewide/pwsacci_a.htm; K.M. Wright and C. Hogan. 2008. *The Potential Impacts of Global Sea-Level Rise on Transportation Infrastructure*, ICF International. <http://climate.dot.gov/impacts-adaptations/pdf/entire.pdf>; Environmental Protection Agency: Office of Water. 2008. *2008 National Water Program Strategy: Response to Climate Change*. http://www.epa.gov/ow/climatechange/docs/TO5_DRAFT_CCR_Revised_10-16.pdf; J.A. Dewar and M. Wachs. 2006. *Transportation Planning, Climate Change, and Decisionmaking Under Uncertainty; Operational Responses to Climate Change Impacts*. RAND Corporation. http://elips.doi.gov/app_SO/index.cfm?fuseaction=searchSO&keyword=3289; see generally K. Trisolini. 2010. *All Hands on Deck: Local Governments and the Potential for Bidirectional Climate Change Regulation*, 62 STAN. L. REV. 669; D.E. Adelman and K.H. Engel. 2008. *Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority*, 92 MINN. L. REV. 1796.

⁴¹ Maryland Commission on Climate Change. 2011. *Adaptation and Response and Scientific and Technical Working Groups, Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change - Phase 2: Building societal, Economic, and Ecological Resilience*.

Additionally, some states are creating sector- or impact-specific adaptation plans, either as supplements (e.g., New York’s Sea Level Rise Plan) or substitutes to statewide plans (e.g., Michigan’s Climate and Health Adaptation Plan).

The authority behind these plans varies. Some states — including Alaska, California, Florida, Maryland, New Hampshire, New York, Vermont, and Virginia — are undertaking this planning by executive order of the governor. Other states (Connecticut, Maine, Massachusetts, Oregon, and Washington) used existing statutory authorities (Washington’s activities were undertaken both under an Executive Order and legislation). While there are clear benefits to having an engaged governor who directs agency work on climate change, the work may be undone when that governor leaves office (such as happened in Florida and Virginia).

Legislation may provide more staying power, though some states have moved forward without either type of explicit authority. For example, Minnesota, Wisconsin and Pennsylvania have “bottom up” processes driven by agencies or academic institutions. These initiatives have the benefit of stakeholder engagement but could encounter limitations due to lack of political will. Carrying out these objectives often requires the cooperation of multiple government agencies. Promoting adaptation planning in states that have not begun formal processes through one of the mechanisms above represents one important opportunity for foundation support, especially since early funding for these programs is no longer available. Another opportunity involves working with states and communities (and the resource people who serve them) to move existing plans into practice through prioritizing a series of actions and implementing them. Working across jurisdictions would allow for leveraging resources and sharing lessons and some regional coordination is already underway and should be fostered.

To date, many of the federal and state plans focus on assessing the vulnerability of government assets rather than broader policy and planning decisions that affect their investments and authorities. This limited scope of early adaptation planning is often a function of limited authority and resources. In addition to the seventeen states with multi-sector adaptation plans, a number of states focus on particular sectors of interest (e.g., Colorado focused on water supply, and Michigan focused on public health). Some states are directing or assisting local action through websites, decision frameworks, planning grants, and more (California’s Cal-Adapt web-based tool, for example, facilitates public and private adaptation planning).

http://www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf; Maryland Update to the Governor and General Assembly. 2010.
http://www.mde.state.md.us/assets/document/Air/ClimateChange/Report_1.pdf ; 2009 California Climate Adaptation Strategy First Year Progress Report. 2010. <http://www.energy.ca.gov/2010publications/CNRA-1000-2010-010/CNRA-1000-2010-010.PDF>; Alaska's IAWG 2009 Final Report: Recommendations to the Governor's Sub-Cabinet on Climate Change. 2009.
http://www.climatechange.alaska.gov/docs/iawg_finalrpt_12mar09.pdf.

A number of local communities are also preparing for climate change. From family farms in the Midwest to the New York City subway system, climate change is already affecting our communities. Nearly two dozen diverse communities have climate adaptation plans, including coastal communities such as Homer, Alaska; Groton, Connecticut; and Miami-Dade, Florida that face threats from sea level rise and coastal storms. Great Lakes communities such as Milwaukee, Chicago, and Green Bay are bracing for more extreme weather including precipitation, wind, and heat waves. Many in the southwest are facing drought.

Some communities are adapting, without formally acknowledging that they are responding to threats from climate change. Several communities along the Mississippi River have “adapted” to repetitive flooding by relocating vulnerable buildings and setting aside green space to help absorb the water and minimize future disruption and costs. For example, officials in Dubuque, Iowa relocated homes and businesses out of a flood-prone zone and, as a result, enhanced the quality of life for its residents and avoided millions of dollars in damages from recent flood events.⁴²

Despite these successes, adaptive planning is not yet widespread. While some local governments are preparing for a new normal, most are still oblivious to the changes they face. Some regions are more likely to incorporate climate change into their planning: one recent survey of mayors found those in the west and northeast are most likely to be planning for climate change, while others in our most vulnerable regions, the southwest and southeast, are notably absent. Among other opportunities, promoting adaptation planning efforts in these vulnerable sectors and regions could be aided by external support.

Tribal Adaptation

Tribal nations are particularly vulnerable to the impacts of climate change for a number of reasons, including the practice of natural resource-dependent subsistence activities, a historic and intimate relationship with the environment, and the place-based regime of tribal rights as established by treaties.⁴³

Planning for the effects of climate change on water resources is a high priority for tribes, as altered water quantity and quality will have major impacts on valued aquatic species and tribal trust resources.⁴⁴ For example, as the Columbia River Treaty (“the Treaty”) is being renegotiated by the United States, Canada, Native American tribes, and Canadian

⁴² J. Carey. 2011. *After the Deluge*, Scientific American (Dec. 2011), p. 72 – 75.

⁴³ K.A. Rose. 2010. *Tribal Climate Change Adaptation Options: A Review of The Scientific Literature*. http://www.tribesandclimatechange.org/documents/nccc/nccc20110105_0008.pdf; Intertribal Climate Change Working Group. 2009. *A Tribal White Paper on Climate Change Adaptation and Mitigation*. <http://209.206.175.157/documents/climatechange.pdf>.

⁴⁴ Intertribal Climate Change Working Group. 2009. *A Tribal White Paper on Climate Change Adaptation and Mitigation*. <http://209.206.175.157/documents/climatechange.pdf>.

First Nations, climate change impacts on water availability and quality have become a pivotal issue for allocation between hydropower production and aquatic cultural resources. The Bonneville Power Administration, the Army Corps of Engineers (“the Corps”), and the Bureau of Reclamation are analyzing how climate change will affect the Treaty and have begun to engage with the tribes of the Columbia River Inter-Tribal Fish Commission; however, additional resources and greater tribal participation are necessary to sufficiently protect the tribes’ interests in the negotiation process.⁴⁵

The Swinomish Indian Tribal Community in Washington is a recognized leader in vulnerability assessment and adaptation planning, in large part because of the federal assistance they have received to do this work. They are also committed to sharing their expertise with other tribal communities.

Climate change adaptation planning will also be critical for coastal tribes as sea level rise and increased storm activity threaten coastal villages. In 2009, the GAO estimated that 31 Alaska Native villages faced imminent threats from flooding and erosion; of those, at least twelve have decided to relocate. Federal programs to assist with preparedness and relocation are limited and there is no single comprehensive federal program or lead federal agency to coordinate assistance to tribes.⁴⁶ The village of Kivalina exemplifies the challenges faced in relocating a coastal village: the relocation process is at a stalemate due to the failure of federal, state, and village officials to agree on a relocation site. In 2006, Corps released the *Kivalina Relocation Master Plan*, examining alternatives and potential relocation sites for the village and concluding that remaining at — or improving — the existing site are not suitable options because of flooding and erosion. The village identified a preferred relocation site, Kiniktuuraq, which the Corps deemed unsuitable due to the potential for flooding and erosion there. However, the village rejected the Corps’ proposed alternative site because it would have been more expensive and difficult to continue their subsistence activities.⁴⁷ The logistic, economic, cultural, and political challenges faced by the village of Kivalina will likely be faced by many threatened coastal communities that seek to relocate as sea levels rise.

Identification of Needs and Gaps

The early planning exercises outlined above have also exposed the numerous obstacles governments face in adaptation planning and implementation. Many of these barriers have been identified by the Government Accountability Office (GAO) in reports evaluating

⁴⁵ *Id.* at 11.

⁴⁶ U.S. Government Accountability Office. 2009. Alaska Native Villages: Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion (June 2009). http://www4.nau.edu/tribalclimatechange/resources/docs/res_GAOReptAkVillagesJune09.pdf.

⁴⁷ Gregg, R. M. 2010. *Relocating the Village of Kivalina, Alaska Due to Coastal Erosion* [Case study on a project of the Kivalina Relocation Planning Committee]. Product of EcoAdapt’s [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2773> (Last updated December 2010)

adaptation at all levels of government.⁴⁸ A report published prior to formation of the White House Interagency Climate Change Adaptation Task Force found that, in spite of having no coordinated approach to adaptation at that time, early efforts to begin adaptation planning were met with significant challenges including: (1) available attention and resources are focused on more immediate needs, making it difficult for adaptation efforts to compete for limited funds; (2) insufficient site-specific data, such as local projections of expected changes, make it hard to predict the impacts of climate change, and thus difficult for officials to justify the current costs of adaptation efforts for less certain future benefits; and (3) adaptation efforts are constrained by a lack of clear roles and responsibilities among federal, state, and local agencies. While progress is being made on all of these fronts, many of these challenges remain. We identify gaps in specific stages below.

Planning Stage

Although the art of adaptation planning is advancing, it is far from a conventional practice. While plans have been developed by a variety of government agencies at all levels, most jurisdictions have not engaged on the issue in any significant manner. Even where planning has occurred, many of these processes have faltered or not recognized their full potential due to lack of sustained political support, lack of funding, and lack of technical and administrative capacity. The following is a list of gaps that hinder planning:

- **Technical capacity for assessing impacts:** Planners must first assess their vulnerabilities to incremental threats and to more frequent and more severe episodic events, such as heat waves and hurricanes. Information about climate change often comes from global climate models that, because of their coarse resolution, cannot readily be used to project impacts at a regional or local level. Planners need technical support to down-scale and translate climate data (i.e., provide at a more finely-grained resolution) in order to assess localized impacts. As the GAO identified, this lack of data (or translators) prevents development of models to predict impacts for specific locales, which makes it difficult for officials to predict local consequences and therefore justify the costs of adaptation in terms of future benefits.
- **Policy options for responding to impacts:** In order to develop an effective adaptation strategy, planners will have to consider the specific socioeconomic, geographic and political characteristics of their communities and their legal and regulatory responsibilities and constraints, and tailor their responses to meet unique local needs. Although there is also a wealth of generic information on climate change and adaptation, this information is not generally organized in a manner that allows decision makers to effectively identify and evaluate which

⁴⁸ U.S. Government Accountability Office. 2011. Testimony Before the Subcommittee on Financial Services and General Government, Committee on Appropriations, U.S. Senate (July 28, 2011). <http://www.gao.gov/assets/130/126793.pdf>.

policy options to adopt in a given context. In deciding between options, policymakers must assess tradeoffs between options and the legal and administrative feasibility of implementation. To do so, policymakers need well-organized, coherent guidance and tools to be able to understand their options and take action in advance of a disaster.

- **Intergovernmental coordination:** An integrated response to climate change will also require increasingly greater resources and inter-governmental coordination, both vertical and horizontal. In our federal system, no single level of government has sufficient capacity on its own and relevant responsibilities are divided among a number of agencies, jurisdictions, and laws. This presents both a barrier and an opportunity: there is no single pathway or policy, but there are many forums in which to pursue adaptation.
- **Economic analysis of long-term costs and benefits:** One of the primary barriers to implementation is cost — even the most willing jurisdictions are having difficulty getting their communities to bear large up-front costs to mitigate uncertain long-term risks. However, many “adaptive measures” can have significant long-term benefits and co-benefits that are, as yet, not quantified. Green or white roofs and other measures to adapt to urban heat islands (urban areas that are hotter due to paved and dark surfaces and lack of vegetation) have other environmental benefits — they filter polluted runoff and lessen the need for energy consumption, thus reducing both water quality impacts and greenhouse gas emissions. In order to “sell” adaptation, quantifying the costs of inaction and the variety of economic and environmental benefits of adaptation are key factors in motivating the relevant standard-setting bodies to update building and design codes (e.g., ASHRAE⁴⁹, LEED⁵⁰) and convincing policymakers to understand and appreciate the need for change.

Implementation Stage

Despite planning efforts, there are few examples of actual implementation on any significant scale. At all levels of government, there needs to be a transition from planning to action. While planning is an essential first step, a plan without action is of limited value. At the implementation stage, policymakers face several barriers:

- **Legal uncertainty:** Decision makers have little information about how to legally implement recommended policies or manage potential liability and government entities may not have clear authority to regulate. Federal, state, and local agencies often have competing powers and overlapping jurisdiction over affected resources. These legal uncertainties often stymie public and private sector adaptation.

⁴⁹ <http://www.ashrae.org/about-ashrae>

⁵⁰ <http://www.usgbc.org/DisplayPage.aspx?CategoryID=19>

- **Monitoring and evaluation:** Once adaptive measures are implemented, government entities must evaluate whether they have successfully made communities more resilient to impacts. There are numerous challenges in measuring costs avoided and determining what metrics to use to define and measure resilience.
- **Financing mechanisms:** In order to successfully adapt, public entities will need to fund implementation. With diminishing budgets at federal, state, and local levels, policymakers will need to find innovative methods to raise public revenues and encourage private investment in adaptive measures. At the same time, current government investment patterns and subsidies must be evaluated to determine whether they allow, promote, or discourage consideration of climate change.

Moving Forward

The focus of a new phase of adaptation work in the United States should be on **promoting successful implementation**. This will **require supporting leaders** at all levels of government to experiment with different mechanisms, such as: (1) **using existing authority to “mainstream” adaptation** into policies and programs and **push adaptation “down-the-food-chain”** into local planning and regulation (zoning and land use ordinances, comprehensive plans, hazard mitigation plans, coastal management plans, etc.); and (2) where required, **amending existing laws and regulations or adopting new laws** and regulations to require consideration of climate impacts. Once leaders have adopted successful models, they can be replicated by other jurisdictions.

As outlined above, early adaptation planning has often occurred in a silo of its own. Rather than seeing adaptation as something that is done outside of — or “to” — a sector or agency, **adaptation should be mainstreamed, as noted above, through “asking the climate question” at all levels of decision making**. For example, consideration of climate impacts should be folded into all planning processes that affect regulatory and investment decisions, such as Transportation Plans, Coastal Zone Management Plans, Hazard Mitigation Plans, Wildlife Action Plans, Water Resource Plans, Heat Event Plans, Emergency Preparedness Plans, and more. Additionally, to the extent permitted by existing authority, climate impacts should be considered when making regulatory decisions. Some jurisdictions are requiring applicants seeking development permits to consider the impacts from climate change through the site plan review process (e.g., Hull, Massachusetts applicants are required to evaluate how a development project may be affected by sea level rise over its lifetime). Finally, policymakers can support adaptation when making investment decisions. For “mainstreaming” to work, incentives must be aligned: funding should prioritize those projects that can show that the investment is “sustainable” with respect to a range of impacts.

Second, **where existing authority is not sufficient, policymakers and regulators should seek amendments to laws and regulations or promote new legislation or ordinances**. In some cases, amendments will be required to allow for consideration of future conditions

(versus historical conditions). For example, under current provisions of the National Flood Insurance Act, the Federal Emergency Management Agency is not allowed to consider future sea level rise or climate change impacts on streamflow patterns (i.e., risk of high flows) when developing regulatory floodplain maps (“FIRMs”). If FIRMS could be updated to reflect future climate conditions, local communities participating in the National Flood Insurance Program would be empowered to regulate development in consideration of future flood risks — a critical step toward promoting responsible development in an era of climate change. Even before national reform can be realized, however, pilot programs to support communities wanting to incorporate new sea level rise projections in their own zoning and investment strategies can provide an important first step and would benefit from foundation support.

Legislation has already been proposed at the federal level to promote adaptation. The Safeguarding America's Future and Environment Act⁵¹ (referred to the Senate Environment and Public Works Committee) would “establish an integrated federal program to respond to ongoing and expected impacts of climate variability and change” by encouraging resource protection and cooperation among state, local, and tribal governments. The Climate Change Health Protection and Promotion Act⁵² (referred to the House Subcommittee on Health) directs the Department of Health and Human Services to publish a strategic plan to “assist health professionals to prepare for and respond to the impacts of climate change on public health in the United States and other nations, particularly developing nations” and prepare a report in conjunction with the National Research Council and the Institute of Medicine to assess what health professionals will need to prepare for climate change impacts. In April 2012, the Coastal Climate Change Planning Act was re-introduced in the House (it had been offered in previous Congressional sessions) to amend the Coastal Zone Management Act to assist states with adaptation planning and response.⁵³

However, other legislative efforts would undermine adaptation. In November 2011, the House Appropriations Committee prohibited NOAA from reorganizing to create a Climate Service Center.⁵⁴ Recent amendments to House Appropriation bills attempted to prohibit the use of federal funds for the Department of Homeland Security’s Climate Change Adaptation Task Force⁵⁵ and implementation of the Department of Agriculture’s Policy Statement on Climate Change Adaptation⁵⁶; however, neither restriction was included in the bills as finally passed by both the House and Senate.⁵⁷

⁵¹ S. 1881, 112th Cong. (2011).

⁵² H.R. 3314, 112th Cong. (2011).

⁵³ H.R. 4314, 112th Cong. (2012).

⁵⁴ House Appropriations Committee, Summary: Fiscal Year 2012 Appropriations “Mini-Bus” Agriculture, Commerce/Justice/Science, Transportation/Housing and Urban Development, and Continuing Resolution (Nov. 14, 2011), http://appropriations.house.gov/UploadedFiles/11.14.11_Minibus_-_Detailed_Summary.pdf.

⁵⁵ H.Amdt 378, Amending H.R. 2017 (Homeland Security Appropriation), 112th Cong. (2011).

⁵⁶ H.Amdt 467, Amending H.R. 2112 (Agriculture Appropriation), 112th Cong. (2011).

⁵⁷ H.R. 2017, 112th Cong. (2012); H.R. 2112, 112th Cong. (2012).

Support for efforts to promote proactive public policy by building support in key constituencies presents one important opportunity for foundation support; however, even beyond the federal agency and legislative processes, there is a great deal of work that can be done to support adaptation planning and implementation at the state and local level. **Funders could support leading communities and those who serve them in developing replicable models and methods to disseminate lessons learned and build networks to connect adaptation efforts across the country.** The following principles could be used to move adaptation forward in a manner that leverages scarce resources:

- **The power of a good model:** Regulations tend to be model-driven — policymakers often borrow and adapt model codes to meet local needs. This creates an opportunity to spread adaptation — once a successful model is developed it will be adapted and replicated by others. There is already evidence of this happening with some existing “tool kits” and by sharing this information through adaptation databases and networks (for example, Georgetown’s Sea Level Rise Toolkit was amended to serve Hawaii by the Center for Island Adaptation and Policy and ultimately informed legislation pending in that state).
- **The power of leaders:** Strong leaders will be needed to overcome the many challenges of adaptation. Implementing adaptive measures will require a significant investment of time, staff, and resources by actors who are bold, experimental, and willing to take action in the face of uncertainty and even anger important stakeholders (e.g., landowners, developers) in order to change the status quo. These leaders should be supported with resources and outside expertise to bolster their chances for success.
- **The power of networks:** Beyond specific models, experiences and lessons can be shared among states and communities through peer-to-peer exchanges and dissemination through broader networks, webinars, workshops, and clearinghouses (e.g., www.adaptationclearinghouse.org). Targeted outreach to educate vulnerable regions, sectors, and institutions is also important. Providing support for networks that reach the affected sectors and decision-makers (transit agencies, utility commissions, lenders, standard-setting entities, developers and others in the private sector) will be vital to minimizing the hardship to our society and economy.
- **The power of incentives:** For adaptation to occur on a widespread basis, incentives must be aligned in a way that rewards risk reduction and promotes resilience. Current federal funding for projects and practices often contributes to maladaptive behavior: building in a flood plain, planting crops in ill-suited locations, developing barrier islands with the help of new bridges, etc. Analyzing existing incentives and formulating recommendations that realign incentives to promote more sustainable investment and resilience in human and natural systems is an important step in catalyzing both public and private sector adaptation.

Outreach to key constituencies on adaptation will have the added benefit of raising awareness of climate mitigation as well, as the full extent of the challenge before us becomes evident. Looking for win-win solutions from both adaptation and mitigation perspectives is worthwhile and, in some sectors (such as curbing heat in the built environment), there are complementary opportunities for policies and investment.

It bears noting that some of the approaches and tools identified above have benefited from the early support of other foundations. For example, early adaptation policy efforts in the United States were supported by the Rockefeller Foundation, which has apparently concluded its domestic policy-focused work. The Kresge Foundation supports place-based adaptation and sharing case studies as models. These efforts identified some key lessons that can be shared and have fostered important relationships to build upon.

Much more can and must be done, however, to improve our understanding of impacts, evaluate legal and policy options, build a portfolio of tool kits and best practices, promote successful adaptation across the public and private sectors through changing policies, investments and incentives, and demonstrate the benefits of building a more resilient world.

Chapter 3: Scope of Agricultural Adaptation in the United States: The Need for Agricultural Adaptation

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The potential impacts of climate change vary widely across the nation's ecologically and economically diverse agricultural landscapes. Differential changes in average temperature and precipitation stand to directly impact agriculture in the following ways⁵⁸:

- New pests and/or more severe pest damage
- Reduced chill hours
- Changing growing degree days
- Sea level rise and salt water intrusion
- Increased irrigation demands
- Reduced water availability for irrigation

At the same time, costs of energy and petroleum-based inputs, new local, state and federal climate-related regulations, shifting markets, and urban pressure will impact farmers differently within different sectors and eco-regions. There is an urgent need for adaptation strategies tailored to the regionally unique impacts on farmers, or containing sufficient flexibility to account for these differential impacts.

Nevertheless, scientific research on agriculture and climate change has focused primarily on management practices to reduce emissions of carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄) — the three most significant agriculturally related greenhouse (GHG) gasses.^{59,60} Some attention has been devoted to assessing the vulnerabilities of different crops to changes in seasonal weather, water supply, pests and diseases; and biophysical factors affecting agricultural production.⁶¹

⁵⁸ Climate Change Science Program (CCSP). 2008. The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. A report by the U.S. Climate Change Science Program and the subcommittee on global change research, 362 pp. USDA, Washington, D.C., USA. (revision to be released in 2013).

⁵⁹ Lal, R., J. A. Delgado, et al. 2011. Management to mitigate and adapt to climate change. *Water Conservation* 66: 276-285.

⁶⁰ Smith, P. and J. E. Olesen. 2010. Synergies between the mitigation of, and adaptation to, climate change in agriculture. *The Journal of Agricultural Science* 148: 543-552.

⁶¹ Rosenzweig, C. and F. N. Tubiello. 2007. Adaptation and mitigation strategies in agriculture: an analysis of potential synergies. *Mitigation and Adaptation Strategies for Global Change* 12: 855-873.

These aspects of mitigation and vulnerability assessment constitute only some of the considerations necessary to successfully plan for and manage risks associated with climate change in agricultural regions. All too often current approaches fail to address the full range of challenges and opportunities faced by farmers, as well as communities which rely on agriculture for food and essential ecosystem services.

Directly related to this work is a growing chorus of support for agricultural policy reform, particularly from environmental organizations who use vulnerability and mitigation assessments as part of a larger advocacy platform for sustainable agriculture. Support for climate change adaptation within such agricultural platforms remains nascent or non-existent.

Currently, a groundswell of support and interest in sustainable farming practices, organic, and buy local campaigns is significantly shaping agricultural industries in the United States. This movement is relevant to climate change issues, such as crop diversification, food miles, and petroleum-based inputs, but it is mainly driven by considerations of human health, environmental toxicity, and resource depletion. Linking these issues with climate change adaptation would further support long-term sustainability and the resilience of United States agriculture.

Defining Agricultural Adaptation

Strictly defined, agricultural adaptation refers to technical measures of and modifications to farm practices that help mitigate risk or realize opportunities in light of actual or expected changes in climate.⁶² However, it can also be understood as a set of strategies, including policies, programs, and other actions that increase resilience to the unavoidable impacts of climate change.⁶³ This more inclusive definition relates to the pursuit of innovative and synergistic approaches to climate adaptation, not only for crop choices and management, but also for opportunities within the aforementioned sustainable food movement and with land use strategies that preserve farmland even with the difficulties climate change imposes.

Numerous initiatives that fall within this more inclusive definition may not currently identify as advancing agricultural adaptation to climate change, such as those working to promote more ecological or “sustainable” practices (e.g., Green Lands Blue Waters, Rodale Institute). Adaptation can also include measures to capitalize on new regulations or ethics related to climate change. For example, when farmers change production or post-harvest practices to take advantage of the increasing demand for bio-energy, which can be derived from crop residues, a farmer could be understood as “adapting” because

⁶² Wall, E. and B. Smit. 2008. Climate change adaptation in light of sustainable agriculture. *Journal of Sustainable Agriculture* 27(1). <http://www.mendeley.com/research/climate-change-adaptation-light-sustainable-agriculture>

⁶³ National Agricultural Statistics Service (NASS). 2007. USDA Census of Agriculture, United States Department of Agriculture, National Agricultural Statistics Service.

he or she is increasing resilience to periods of fuel shortage or high costs which may accompany climate change. In the same manner, one could also view a farmer who decides to shift his or her marketing strategies to take advantage of increasing demand for local food with less food miles as adapting. In this regard, it is valuable also to recognize the overlapping and mutually reinforcing relationship between mitigation and adaptation, whereby many measures that help reduce GHG emissions from agriculture may simultaneously help farmers remain economically viable.

Agricultural adaptation occurs at multiple scales. For instance, the establishment of a local food hub (i.e., a logistics hub facilitating storage, aggregation, and distribution of products from medium- and small-scale growers) could be considered an adaptive measure to increase industry networks, as well as a mechanism to support increasing diversity within the food system, both of which confer resilience and agricultural adaptation to climate change.

Land use planning is an aspect of agricultural adaptation to climate change that has, so far, received little attention.⁶⁴ Planning to preserve farmland must grapple with the increasing vulnerability of farmers to climate change and the economic consequences that may force farmers to sell their land for industrial or urban development. Fragmentation and loss of farmland further undermines adaptation to climate change because farmers lose benefits associated with a large farming community, such as sourcing inputs, accessing information, and sharing equipment. Preservation of farmland can be considered both an adaptation and mitigation strategy, since GHG emissions are far lower per acre than in the built environment.⁶⁵

Finally, the issue of private or public investments to support agricultural adaptation to climate change requires more attention,⁶⁶ not only for innovations that support crop and livestock production in uncertain climates, but also for transportation, processing, and distribution. Planning for climate-resilient systems that provide environmental and social benefits is a major challenge, but can also be seen as an opportunity for revamping America's food system in a more sustainable way.

Activities Currently Underway in Climate Change and Agriculture

The following section includes a snapshot of major activities related to climate change and agriculture as divided among seven different processes and five levels of authority

⁶⁴ Jackson, L.E., et al. In press. Agricultural mitigation and adaptation to climate change in Yolo County, CA. Report to the California Energy Commission Climate Change Scenarios Program.

⁶⁵ Haden, V.R., M. Dempsey, S. Wheeler, W. Salas, and L.E. Jackson. Use of local greenhouse gas inventories to prioritize opportunities for climate action planning and voluntary mitigation by agricultural stakeholders in California. In press, *Journal of Environmental Planning and Management*.

⁶⁶ Antle, J.M. and S.M. Capalbo. 2010. Adaptation of agricultural and food systems to climate change: an economic and policy perspective. *Applied Economic Perspectives Policy* 32: 386-416. doi: 10.1093/aep/ppq015

(federal to local). The processes include: impacts assessment and research, vulnerability assessment and research, planning processes, capacity building, implementation, resource/tool creation, and monitoring and evaluation. A final category represents activities that encompass the whole arc of climate and agricultural processes, referred to as Entire Arc. In each category we provide examples of existing activities, while those with no entries indicate that we are not aware of any relevant activities in the United States

In analyzing current activities related to climate change and agriculture, it is important to recognize that the majority of activities encompass a range of different processes. For instance, many impact assessments inform vulnerability assessments which, in turn, are used in planning and resource development.

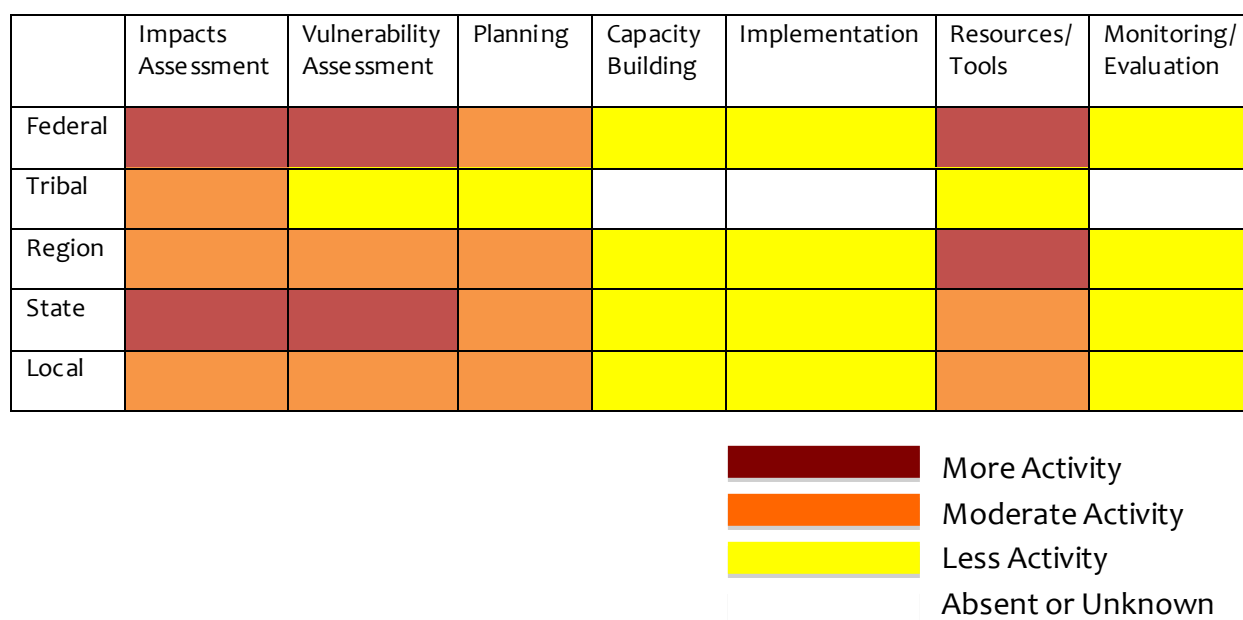


Figure 1. Relative adaptation effort by activity and jurisdictional level relevant to agriculture in the United States.

Problem Identification: Impacts and Vulnerability Assessments

Impacts Assessment/Research

The vast majority of work on climate change and agricultural adaptation to date has taken the form of impact assessment, which typically assesses both the effect of climate shifts on farming practices, while acknowledging the reciprocal effect of these practices on GHG emissions and the climate. Impacts on agriculture typically include shifts in growing degree days, new pests, the changing availability of water, etc., while agriculture’s impact on the climate is usually explained as deriving from livestock enteric

fermentation and manure management, soil amendments (namely inorganic fertilizers), and mechanized agriculture.

Nearly all vulnerability assessments and adaptive strategies are based on an impact assessment, which may or may not have been conducted by the same institution pursuing the adaptation activity. Impact assessments differ significantly in scope, often differentiated by those conducting original field-based research versus those compiling findings from other assessments. Universities have conducted much of the impact and vulnerability assessment research and synthesis available, often times doing so in conjunction and/or funded by local, state, or federal governments. Examples of climate change and agricultural assessments include:

- National: U.S. Global Change Research Program, National Climate Assessment⁶⁷ — currently underway, this assessment includes both a comprehensive impact and vulnerability assessment for seven crop categories, which are fed into a series of adaptation concepts, needs, and opportunities.
- Regional: University of Arizona, Climate Assessment for the Southwest⁶⁸ — this is part of national climate assessment that identifies water resources as a major hurdle for agricultural adaptation.
- Tribal: United Nations University, Indigenous People’s Climate Assessment⁶⁹ (in progress) — this assessment provides an indigenous framework for adaptation within agriculture and other livelihoods based on nine different indigenous-led assessments, including one from the Pacific Northwest.
- State: California Climate Change Research Center⁷⁰ — sponsors numerous research studies related to agriculture and resource management, with a particular emphasis on water resources and is an ongoing effort with dozens of studies underway or planned.
- Local: University of California, Davis, and the California Energy Commission, Yolo County Climate and Agriculture Assessment⁷¹ — this assessment uses an interdisciplinary case study in one county (Yolo County) on agricultural adaptation to climate change dealing with production as well as regional land use issues

Vulnerability Assessment

Vulnerability assessments are an important component of agricultural adaptation to climate change and generally build directly on impact assessments. Here we define vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of *climate* and *global change*, including *climate variability* and *extremes*, as

⁶⁷ <http://www.globalchange.gov/what-we-do/assessment>

⁶⁸ <http://www.climas.arizona.edu/>

⁶⁹ http://www.unutki.org/default.php?doc_id=96

⁷⁰ <http://www.climatechange.ca.gov/research/>

⁷¹ <http://agadapt.ucdavis.edu/>

well as climate change in conjunction with other stressors.”⁷² Significant work has been undertaken in determining crop and livestock vulnerabilities, as well as in researching potential measures to address vulnerabilities (e.g., breeding, pest management), yet farmers’ vulnerabilities to the indirect effects of climate change (e.g., energy prices or market changes) have received much less attention. Examples of agricultural vulnerability assessments include:

- National: U.S. Global Change Research Program, National Climate Assessment — see description under Impact Assessment.
- National: Institute for Agriculture and Trade Policy⁷³ — advocates for continued availability of federal risk management products such as crop insurance contingent upon “climate compliance” and mandatory participation in conservation programs that support adaptation to more climate-resilient systems.
- Regional: The Land Institute⁷⁴, (based in Kansas) — supports perennial grain and oilseed crops and enhances ecology within agriculture. Though climate change is not identified as a primary objective, the institute’s work directly supports climate adaptation.
- State: University of California and the California Energy Commission, California State Assessment — this assessment, Vulnerability and Adaptation to Climate Change in California Agriculture,⁷⁵ supports research on numerous impacts and vulnerabilities of California agriculture, the nation’s largest producer of fruits and vegetables, particularly in relation to water availability, temperature, economics, and the potential for adaptation.
- Local: Dorchester County, Maryland Sea Level Rise Preparedness⁷⁶ — focuses on sea level rise and its impact on major economies (such as agriculture) and includes a vulnerability assessment as part of a proposal for adaptive measures.

Planning

Planning for agriculture and climate change may include drafting impact and mitigation assessments as well as developing tools and strategies for adaptation. One of the challenges associated with planning in the agricultural sphere is ensuring that participation from farmers, who generally bring a deeper understanding of change over time and what adaptation strategies may actually be feasible. Building in a legitimate stakeholder participation process in planning activities will help to build strategies that

⁷² California Natural Resource Agency (CNRA). 2012. California Climate Adaptation Policy Guide. Saramento, California Natural Resources Agency- public draft available June 2012.

⁷³ <http://www.iatp.org/>

⁷⁴ <http://www.landinstitute.org>

⁷⁵ Expected to be posted on the California Energy Commission website (<http://www.energy.ca.gov/publications/index.php>) by summer 2012.

⁷⁶ <http://www.dnr.state.md.us/dnrnews/pdfs/Dorchester.pdf>

address a more complete spectrum of adaptive considerations while reducing redundancy. Some agricultural adaptation planning efforts include:

- National: USDA Climate Change Science Plan⁷⁷ — intends to serve as a guide for the agency and its stakeholders in developing and investing in strategies for adaptation to climate change in the agricultural sector.
- Regional: The Mid-Atlantic Water Program⁷⁸ — uses a collaborative approach to managing water quality and availability for agricultural users (e.g., by hosting a forum of nine regional land grant universities, to address not only impacts, but the need for resources to fill information gaps and generate new tools, as well as the need for additional partnerships).
- Tribal: The Swinomish Climate Change Initiative⁷⁹ — in light of their vulnerable coastal location, the Swinomish Indian Tribe's Office of Planning and Community Development has undertaken a planning process, resulting in an Impact Assessment and Adaptation Plan, both of which include agricultural considerations.
- State: The Wisconsin Initiative on Climate Change Impacts (WICCI)⁸⁰ — The WICCI process created an Agricultural Working Group comprised of diverse interests that convenes to support and conduct research, outreach, and needs assessment necessary to generate successful adaptation to climate change.
- Local: Southeast Florida Regional Climate Change Compact⁸¹ — this four-county partnership works to facilitate mitigation and adaptation planning across numerous sectors including agriculture in Florida's vulnerable southeast region.

Capacity Building

Capacity building for agricultural adaptation refers to any activity that better equips a given actor to make changes that support resilience and sustainability within agricultural systems. In this case, an actor may be any participant in the food system, including farmers and ranchers, food processors or packers, or government institutions, just to name a few.

The ability to conduct successful capacity building relies on the availability of appropriate adaptation strategies and the resources to disseminate them. Given that adaptation strategies are relatively nascent, particularly at the state and local level, capacity building is also an area in need of support. Ensuring that climate planners understand the important role of agricultural adaptation, as well as what that adaptation might look like within their planning area, will help to bring farmers to the table when building climate

⁷⁷ http://www.usda.gov/oce/climate_change/science_plan2010/index.htm

⁷⁸ http://www.mawaterquality.org/capacity_building/documents/Summary-Report_FINAL.pdf

⁷⁹ http://www.swinomish-nsn.gov/climate_change/project/reports.html

⁸⁰ <http://www.wicci.wisc.edu/agriculture-working-group.php>

⁸¹ <http://www.southeastfloridaclimatecompact.org/>

action plans or other such strategies. Historically, the USDA Cooperative Extension⁸² (“Extension”) has served a crucial role bridging the gap between university research on agriculture and food systems, — where much of the current climate adaption work is happening, — and those who will use these research products. Funding for Extension continues to be reduced, along with the ability to help transmit information between these two vital players in the agricultural landscape.

- National: The National Center for Appropriate Technology’s (NCAT), National Sustainable Agriculture Project (ATTRA)⁸³ — provides a wealth of resources, literature, and technical assistance to help farmers move toward alternative energy sources on their farms, thereby increasing resilience in the face of volatile fuel prices, while simultaneously reducing their GHG impact.
- Regional: The Union of Concerned Scientists⁸⁴, Smart Pasture Operations — promotes pasture-based systems for beef cattle as a mitigation technique, but is also considered an adaptation strategy, in light of potential regulatory constraints related to GHG emissions and the rising demand for grass-fed beef. Farmers’ movement away from corn-based finishing will reduce the vulnerability of feed to price swings.
- State: The California Climate Action Network (CalCAN)⁸⁵ — builds a network of mutually supportive actors, including farmers, policy makers and researchers, to build capacity for solutions that enhance farm productivity while providing climate co-benefits and influencing policy decisions.

Resources/Tools

Resources and tools for agricultural adaptation include best management guides; databases of climate data; and decision support tools for nutrient management, irrigation, and cropping decisions. Tools of this nature are often important components of capacity building (training on how to use a given tool or resource) as well as implementing agricultural adaptation. Not surprisingly, these tools and resources often have applicability beyond managing for climate change variability. Given the time and resources necessary to generate these tools and the developing nature of adaptation within agriculture overall, tools are still relatively few. A few examples of the variety of tools available include:

- State: Cornell University, Adapt-N⁸⁶ — helps farmers to more accurately predict the nitrogen requirements of their plants, thereby increasing efficiency in application, minimizing costs, and reducing GHG emissions related to production, transportation, and application.

⁸² <http://www.csrees.usda.gov/Extension/>

⁸³ <http://sustainableagriculture.net/>

⁸⁴ <http://www.ucsusa.org/>

⁸⁵ <http://calclimateag.org/>

⁸⁶ <http://adapt-n.cals.cornell.edu/index.html>

- Regional: The NOAA Regional Climate Center’s⁸⁷ Climate Information for Management and Operational Decisions (CLIMOD) System — powered by the Applied Climate Information System, CLIMOD provides web-based access to daily temperatures, precipitation, and growing degree days, among other metrics, to help farmers adapt their production strategies and planners to better understand climate trends.
- Local: Lodi (California) Rules for Sustainable Winegrape Growing⁸⁸ — contains 75 best management practices for sustainability, including numerous practices which contribute directly to climate adaptation as a self-assessment tool developed by growers, farm advisors, and researchers.

Implementation

The implementation of agricultural adaptation can take many forms, from shifting to more water-saving irrigation techniques, to crop diversification, to concrete policies or regulations for natural resource management that reduce agricultural damages, e.g., to drought or flooding. The adoption of a climate action plan in which specific goals for agriculture are included should also be considered implementation, along with the actualization of those goals. Implementation of explicit “climate-change adaptive” strategies is still relatively limited, but implementation of mitigation strategies that happen to include adaptive capacity (such as less reliance on fossil fuel-based inputs) is more common.

- National: The USDA NRCS Conservation Programs⁸⁹ for resource management — provides incentives or payments to farmers who implement a range of ecological best management practices via programs such as the Environmental Quality Incentive Program (EQIP), the Conservation Stewardship Program (CSP), the Emergency Watershed Protection (EWP) Program, and numerous others, many of which have the co-benefit of facilitating adaptation to climate change. For example, the EWP includes funds to help minimize the risks of run-off and soil erosion, as well as loss of crops and property in the face of increasing flood risks.
- State: Sustainable Conservation⁹⁰ — engages with California farmers to implement various innovative strategies that couple adaptation and mitigation such as creating biomethane from dairy waste, which reduces dependence on petroleum-based fertilizers and fuel⁹¹ or supporting soil carbon storage enhancement practices, which increase soil water holding capacity necessitating less irrigation.⁹²

⁸⁷ <http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html>

⁸⁸ http://www.lodiwine.com/Lodi_Rules_Farming_Practices.pdf

⁸⁹ <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/pr ograms/financial/ewp>

⁹⁰ <http://www.suscon.org/>

⁹¹ see example at <http://suscon.org/cowpower/index.php>

⁹² Hatfield, J.L., K.J. Boote, B.A. Kimball, L.A. Ziska, R.C. Izaurralde, D. Ort, A.M. Thomson and D.W. Wolfe. 2011. Climate impacts on agriculture: Implications for crop production. *Agronomy Journal* 103(2):351-370.

- State: California’s Senate Bill 375, the Sustainable Communities and Climate Protection Act of 2008 — requires Metropolitan Planning Organizations to prepare “sustainable communities strategies,” including farmland preservation and in-fill growth, which help meet GHG-reduction targets due to the much lower GHG emissions per unit area compared to urban sprawl. Farmland preservation is a useful adaptation tool, in which planning organizations and bodies recognize and actively work to preserve agricultural land use as a resilience strategy for food security. It is also a strategy with mitigation potential given the lower GHG emissions per acre of farmland compared to urban land use.

Monitoring and Evaluation

Monitoring and evaluation are essential components of any new management decision and, as such, must be factored into adaptation strategies for agriculture. A significant amount of monitoring is already in progress as a means of informing climate mitigation assessments (e.g., N₂O emissions in crop fields or carbon sequestration potentials in rangeland), but it is rarely combined with the evaluation of adaptation strategies such as managing higher temperatures and less water availability. Some monitoring and evaluation approaches rely on tools which can also be employed in planning and capacity building. Given the limited scope of implementation of climate adaptation strategies, monitoring of such strategies is even more limited. Although sparse there are a few examples of monitoring and evaluation in the agricultural sector:

- National: USDA Natural Resource Conservation Service (NRCS) — conducts numerous monitoring activities with implications for adaptation planning. These include the Natural Resources Inventory⁹³ (NRI), which surveys land use and natural resource conditions on non-federal lands; the Soil Climate Analysis Network (SCAN), which collects soil moisture, temperature, solar radiation, and precipitation data through remote collection systems; and Snowpack monitoring (SNOTEL)⁹⁴.
- Regional: Pennsylvania State PestWatch⁹⁵ — maintains a web-based system for submission of pest trap counts and historical catch summaries as well as resources to support integrated pest management.
- Local: Stockholm Environmental Institute, Water Evaluation, and Planning System (WEAP)⁹⁶ — a modeling platform that enables integrated assessment of a watershed’s climate, hydrology, land use, infrastructure, and water management priorities and, therefore, facilitates the evaluation of various climate change, land-use, and adaptation scenarios using data from global climate change models that are

⁹³ <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri>

⁹⁴ <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/snowsurvey>

⁹⁵ <http://www.pestwatch.psu.edu/>

⁹⁶ <http://www.weap21.org/>

downscaled to local conditions. Various types of jurisdictions around the world⁹⁷ have used WEAP in dozens of assessments.

Entire Arc

Activities that encompass the entire arc are those that undertake the full range of adaptation processes, from impact or vulnerability assessment to planning, capacity building, implementation, and monitoring. Such processes are quite rare given the duration of commitment and scope of resources required.

- State: California Climate Adaptation Policy Guide⁹⁸ — this document and process, slated for completion in 2012, will serve as a guide for California and other states and jurisdictions developing comprehensive adaptation plans that take into account the full range of exposure, vulnerability, impact, adaptive capacity, strategy development, and implementation approaches.
- Regional: University of Arizona, Climate Assessment for the Southwest (CLIMAS), part of the NOAA RISA system — takes a leadership role in conducting participatory research, facilitating knowledge exchange between a range of experts and stakeholders, and developing decision support tools to support resilience and adaptation across a range of sectors including agriculture.

General Observations

At the national, state, and local level the focus of most institutions working on climate change and agriculture remains impact and vulnerability assessment. While such assessment is a fundamental building block to developing successful adaptation strategies, in general, pro-active measures for change remain nascent by comparison. Instead, these increasingly robust assessments of impacts and vulnerabilities are commonly used to develop mitigation strategies, most of which are built around carbon sequestration, reducing N₂O emissions via fertilizer management, and developing and using agriculture-based bio-fuels. Adaptation, when explored, tends to emphasize direct climate impacts on crops and livestock and the economic ripple effect of those impacts.

As many jurisdictions in the U.S. are now actively addressing impacts and vulnerability to climate changes, as well as mitigation options, there is growing need for science-based exploration of tools to help scientists, farmers, policymakers, and the general public better understand the wealth and complexity of adaptation options for increasing agricultural sustainability (i.e., achieving agricultural productivity and profitability, environmental quality, and social well-being).

⁹⁷ <http://www.weap21.org/index.asp?action=205>

⁹⁸ http://resources.ca.gov/climate_adaptation/local_government/adaptation_policy_guide.html

Following are some preliminary observations about agricultural adaptation at a variety of scales in the United States:

- Templates and technical assistance for the development of impact and vulnerability assessments are readily available at a range of scales.
- Vulnerability and impact assessments, as well as the adaptation strategies built from them, must take a finer-grained approach because impacts and vulnerabilities are inherently location-specific, yet conducting detailed assessments requires resources (financial and human) that may be less available at the local level.
 - Many counties have developed climate assessments or action plans which mention agriculture; however few devote much attention to this sector, beyond citing well-established and general risks and impacts.
 - Beyond noting risks associated with food access and food miles, most urban climate plans devote very limited attention to this sector.
- Very few organizations or institutions make agricultural adaptation to climate change their sole focus. More often, it is one of a suite of climate-related issue areas and, even then, work in this area is often new or limited in scope.
 - The California Climate Action Network is rare in its work focusing on advocating for farmers and adaptation, while advancing policy-oriented climate solutions.
- Native American communities are some of the nation's most vulnerable when it comes to climate change.⁹⁹ The number of Native American farmers has grown significantly, with those identifying as full owners increasing by 267 percent from 2002 to 2007.⁶³ However, the focus of tribal governments vis-à-vis climate change remain predominantly on issues related to displacement and sea level rise, salmon and other wildlife viability, and changing access to native foods and medicines.
 - Limited information about tribal initiatives focused on agricultural adaptation may or may not reflect a lower incidence. Instead, discussions and planning may be happening off-line and, as such, are difficult to capture through web-based research.
- The majority of initiatives focus on research, often working to develop new varieties of crops with increasing disease, pest, and drought or flood tolerance or models of future climate impacts.
 - Other common research initiatives, as seen by the Union of Concerned Scientists and Resources for the Future, focus on synthesizing already available data and analysis into new resources for the general public, which often feed into policy reform.

⁹⁹ Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott. 2007. North America. Climate Change 2007: "Impacts, Adaptation and Vulnerability." Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.), Cambridge University Press, Cambridge, UK. pp. 617-652.

- Some field-based research, such as that underway at the Rodale Institute or Land Institute, does not directly focus on climate change adaptation, but rather overall agricultural resiliency and stewardship.
- A handful of web-based adaptation tools have emerged in service of growers from a particular region, such as the Southeast Climate Consortium's AgroClimate or Cornell University's Adapt-N. These tools tend to come from academic institutions.
- Both in light of its leadership on climate change policy and its large agricultural industry, California institutions and agencies have generated a substantial body of work¹⁰⁰ on agricultural adaptation that other states are already using as a template.
- Thus far, there is little emphasis on integrated land use planning that seeks to engage and conserve biodiversity across landscapes as a resilience tactic for provide multiple ecosystem services (including food provision).

Key Opportunities for the MacArthur Foundation in Agriculture

- Leverage and support projects that simultaneously mitigate GHG emissions and adapt to climate change via energy self-sufficiency, lessen dependence on fertilizers and pesticides that are petroleum-based inputs, and manage complex farming systems using renewable/sustainable inputs; and support projects that find ways to facilitate deep, authentic, and ongoing participation from farmers, partly by increasing awareness and buy-in for climate change solutions.
- Support and encourage collaboration between odd bedfellows, such as institutions that are working on adaptation but may not consider it as such (e.g., the Land Institute, county planning departments).
- Work with tribal groups on agricultural adaptation in light of relatively high levels of food insecurity and a growing base of farmers, many of whom may be new to agriculture.
- Explore the potential for using and conserving agrobiodiversity and diversifying farming systems as a source of resilience in an uncertain future.
- Determine how farm labor and environmental justice will be affected by fluctuating energy and water prices, along with different scenarios for immigration policy. These are additional sources of compounded vulnerability to farming that are largely unexplored, therefore, little effort is being made to develop adaptation strategies that address them.
- Pursue farm preservation as a means of increasing United States food security, which can also reduce GHG emissions if combined with land use strategies for in-fill growth rather than suburban sprawl (e.g., American Farmland Trust¹⁰¹).

¹⁰⁰ <http://www.climatechange.ca.gov/adaptation/agriculture.html>,
<http://www.climatechange.ca.gov/state/agriculture.html>,
http://www.climatechange.ca.gov/climate_action_team/agriculture.html

¹⁰¹ <http://www.farmland.org/programs/states/futureisnow/developmentefficiency.asp>

- Consider approaches that will shift the national dialog away from agriculture as a source of GHGs to one that values it also as a sink, particularly by comparison to urban land uses (e.g., the interdisciplinary case study of Yolo County, California).
- Support strategies that facilitate adaptation simultaneously in multiple sectors such as agriculture and natural resources (e.g., the Land Institute).
- Recognize that planning for climate resilient systems which provide environmental and social benefits can also be an opportunity to rebuild a more sustainable American food system.
- Examine adaptation measures that provide potential for enhanced economic opportunities (e.g., National Good Food Network¹⁰²).
- Consider the potential to translate these agricultural adaptation opportunities to aquaculture practice as well.

¹⁰² <http://www.ngfn.org/>

Chapter 4: Preparing Human Communities and the Built Environment for Climate Change

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Climate change poses a variety of risks to human communities and the built environment of the United States, raising challenges for both urban and rural areas. Changes already in place will affect human communities directly by altering environmental conditions such as temperature, precipitation, and sea level; and by altering the energy, water, materials, food, transportation, ecological, and other systems communities depend on.

Human development of the landscape and the ways in which we plan, manage, and operate our cities, communities, and infrastructure is typically based on an assumption that the future climate will resemble that of the (recent) past. We now know, however, that the past is an increasingly poor guide to the future. As the climate increasingly diverges from expected past conditions, plans, policies, infrastructure and expectations about the benefits and services provided by each must be adjusted accordingly to avoid increasingly severe consequences. Many of these adjustments will require significant effort in areas such as knowledge development, institutional and legal adjustments, and the development of political support, among others. Consequently, there is argument that the time to begin preparing for these projected changes is now, if not years ago.

Despite a growing awareness of the need to prepare for a changing climate, existing fiscal challenges make action on adaptation difficult. Communities are increasingly forced to “do more with less,” leveraging existing funds and partnerships and making hard choices among desirable programs, while adjusting to shifting patterns of growth, development, and tax revenue. Many face the need to update existing infrastructure — water and sewer delivery pipes and treatment facilities, roads, and schools that have exceeded their useful life¹⁰⁴ — at high cost. Some require new infrastructure to accommodate economic and population growth while others, facing diminishing populations, must work to realign economic realities with community priorities. Under conditions like these, it may be hard to make adaptation planning a higher priority than other pressing needs — such as critical infrastructure upgrades — even though these upgrades can provide an opportunity for building in resilience as part of asset management.

¹⁰³ The author appreciates the contributions of Lara Whitely Binder to this chapter, as well as input from Josh Foster.

¹⁰⁴ For example, necessary maintenance and upgrades to U.S. drinking- and waste-water treatment systems were estimated at \$91 billion (Environmental Protection Agency. 2010. *Clean watersheds needs survey: 2008 report to Congress*, EPA-832-R-10-002. Washington, DC: EPA).

Despite these fiscal issues and the limited federal leadership and public support that exist for dealing with climate change, progress is being made towards climate change adaptation. The *nature of the problem* that climate change will pose is increasingly well understood. Some government entities are *planning* for these changes, working individually, collectively, and in collaboration with the broader community. Research, education, training, and peer-to-peer and research-to-practice networking efforts are underway to *build the capacity* of individuals and institutions to incorporate climate change into their work. *Implementation* of on-the-ground climate change adaptive actions is beginning. *Resources and tools* are available to support various steps of the climate change adaptation process and a handful of researchers and practitioners are beginning to think about strategies and metrics for *monitoring and evaluating* adaptive actions. This chapter addresses each of these components of adaptation, providing a snapshot of some of the key activities and entities involved in each. We identify some promising ways for building on these initial efforts to catalyze the more considered, comprehensive and wide-spread action urgently needed to deal with the imminent challenges of climate change.

	Impacts Assessment	Vulnerability Assessment	Planning	Capacity Building	Implementation	Resources/ Tools	Monitoring/ Evaluation
Federal	More Activity	Moderate Activity	More Activity	More Activity	Less Activity	Moderate Activity	Absent or Unknown
Tribal	Moderate Activity	Moderate Activity	Moderate Activity	Less Activity	Less Activity	Moderate Activity	Absent or Unknown
Region	More Activity	Moderate Activity	More Activity	Less Activity	Less Activity	Moderate Activity	Absent or Unknown
State	Moderate Activity	Moderate Activity	More Activity	Moderate Activity	Less Activity	Moderate Activity	Absent or Unknown
Local	More Activity	Moderate Activity	Moderate Activity	Moderate Activity	Less Activity	Moderate Activity	Absent or Unknown

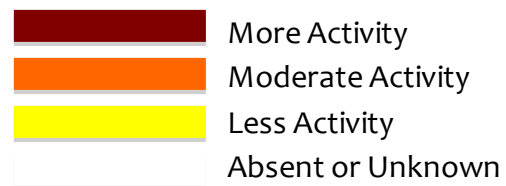


Figure 1. Activity levels vary in the stages of the adaptation process relating to human communities and the built environment in the United States. Significant effort has gone into impact assessments and planning efforts, some effort has gone into vulnerability assessments and tools development, there is less activity in capacity building and implementation, and there is a lack of monitoring and evaluation of adaptation efficacy.

Problem Identification: Impacts and Vulnerability Assessments

Understanding the challenges climate change will pose for human communities requires (in part) understanding (1) how climate is projected to change, how these changes will affect aspects of the natural environment on which people depend, and the likely impacts on human communities [impacts assessment]; and (2) the people, places, and infrastructure likely to be most vulnerable to these impacts [vulnerability assessment].

While impact assessments provide information about where (in which places and/or sectors) and how climate change impacts are likely to unfold, they do not necessarily tell us which impacts are likely to be most important, or of highest concern. Therefore, before planning for climate change, it is useful to consider the relative vulnerability of people, places, or infrastructure to climate change so that response actions can be prioritized toward reducing the risks of the most vulnerable.¹⁰⁵

Because climate change will affect communities through multiple impact pathways and affect various dimensions of society, these assessments must cross many sectors and disciplines of inquiry. They must also be context-specific since the consequences of climate change, as well as the nature of adaptation options, will differ from place to place.

Comprehensive assessments of the consequences of climate change for cities provide synopses of the types of impacts cities may experience, their vulnerabilities to those impacts, and case studies of individual communities or sectors. Key assessments include:

- *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*, which presents a comprehensive Intergovernmental Panel on Climate Change (IPCC)-style assessment of the most significant climate change-related issues for cities.¹⁰⁶
- The UN-Habitat's *2011 Global Report on Human Settlements*, which also focuses on climate change and cities, includes chapters on "hot cities (battlegrounds for climate change), cool cities (pulling back from the abyss), greedy cities (environmental injustice), and active cities (where municipalities and ordinary citizens are making a global difference)."¹⁰⁷
- The IPCC's 2007 Fourth Assessment Report, *Climate Change 2007: Impacts, Adaptation, and Vulnerability*, discusses "industry, settlement, and society," describing current conditions and trends; future impacts and vulnerabilities; and adaptation issues for industry, services, utilities, infrastructure, and human settlements.¹⁰⁸

¹⁰⁵ It is worth noting that many efforts labeled as "vulnerability assessments" do not in fact consider the response capacity of the affected system and should more appropriately be labeled "impacts" or "sensitivity" assessments. In other words, while they detail how climate change might unfold in a particular place for a particular system or community, they do not provide insight into the aspects of future change to which the community is most vulnerable and on which it should therefore focus its risk reduction efforts.

¹⁰⁶ Rosenzweig C., W.D. Solecki, S.A. Hammer and S. Mehrotra (Eds.). 2011. *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*. Cambridge University Press.

¹⁰⁷ United Nations Human Settlements Program. 2011. *Cities and climate change: Global report on human settlements*. London: Earthscan. <http://www.unhabitat.org/content.asp?typeid=19&catid=555&cid=9272>

¹⁰⁸ Wilbanks, T.J., P. Romero Lankao, M. Bao, F. Berkhout, S. Cairncross, J.-P. Ceron, M. Kapshe, R. Muir-Wood and R. Zapata-Marti, 2007. Industry, settlement and society. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 357-390.

- The most recent assessment is *U.S. Cities and Climate Change: Urban, Infrastructure, and Vulnerability Issues*, which was prepared as technical input for the ongoing U.S. National Climate Assessment. This synthesis examines connections between climate change and cities using a system-level perspective that integrates information about climate impacts across sectors with consideration of the social conditions (economic, institutional, political) ultimately shaping both climate impacts and responses.¹⁰⁹

Integrated climate change impact assessments for specific places or systems have been undertaken by numerous local, regional, state, and tribal entities, often in support of climate change adaptation planning activities. Local governments who have engaged in climate impacts assessment were categorized as “(1) those initiated and supported by the Center for Clean Air Policy with funding, since 2008, through the Rockefeller Foundation’s Climate Change Resilience Initiative; (2) those initiated and facilitated by ICLEI-Local Governments for Sustainability; and, finally, (3) independent efforts, several of which are closely related to regional assessments previously conducted as part of the National Assessment (e.g., New York City), regionally based, [National Oceanic and Atmospheric Administration (NOAA)-sponsored Regional Integrated Sciences and Assessments] centers (e.g., King County, Washington), or other regional assessments (e.g., Chicago).”¹¹⁰

Development of the scientific understanding about potential future conditions that underlies assessments such as these has been primarily an academic and federal research effort, funded by federal agencies within the U.S. Global Change Research Program.¹¹¹ Research is aimed at improving our understanding of, and methodologies for assessing, human influence on climate; how changes in global climate affect regional climate; implications for locally-specific environmental conditions that may be sensitive to climate, including snowpack, streamflow, coastal erosion, and ecosystems; and the consequences for human communities and the built environment. This work provides the foundation needed for climate change adaptation efforts, namely “adapting to what, where, and in what time frame?”

¹⁰⁹ Solecki W. and Rosenzweig C., eds. 2012. *U.S. Cities and Climate Change: Urban, Infrastructure, and Vulnerability Issues*. Technical Report in Support of the National Climate Assessment.

¹¹⁰ Moser, S. C., 2009. *Good Morning America! The Explosive Awakening of the U.S. to Adaptation*. Charleston, SC: NOAA and Sacramento, CA: California Energy Commission.

¹¹¹ The USGCRP “coordinates and integrates federal research on changes in the global environment and their implications for society”. The USGCRP began as a presidential initiative in 1989 and was mandated by Congress in the Global Change Research Act of 1990, which called for “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.” USGCRP’s thirteen member departments and agencies are: the Departments of Commerce, Defense, Energy, Interior, State, Transportation, Health and Human Services, and Agriculture, and the National Aeronautics and Space Administration, National Science Foundation, Smithsonian Institution, Agency for International Development and Environmental Protection Agency.

Moving from *impacts* to *vulnerability* requires information about the ability of the affected entity to adapt or adjust in response to projected impacts, which is often much less well understood than the climate impacts themselves. In part, this reflects the relative dearth of social science research into the adaptive capacity of specific systems in specific locations. This gap is partially being addressed through the on-the-ground processes of impact assessments/adaptation planning that draw on practitioner and/or stakeholder knowledge. Examples of recent assessments illustrate some of the different approaches used to define and assess vulnerability:

The *Washington State Department of Transportation* (WSDOT) recently completed a climate impact vulnerability assessment of key local, regional, and state-wide transportation infrastructure as part of a pilot project effort funded by the Federal Highway Administration (FHWA).¹¹² The effort combined a spatially explicit inventory of department-owned assets with information on projected climate change impacts from the University of Washington's Climate Impacts Group with the subject matter expertise of WSDOT staff to qualitatively assess infrastructure susceptibility to damage from climate impacts and the criticality of damaged infrastructure for the state transportation system. WSDOT's efforts resulted in a comprehensive inventory of transportation infrastructure vulnerability in Washington¹¹³ and proposed improvements to the FHWA's conceptual climate risk assessment model for assessing transportation infrastructure vulnerability across the nation.

The *City of Chicago* examined impacts through the lens of economic consequence, commissioning an economic impact analysis of climate change from a corporate risk consulting group, and developed the *Chicago Area Climate Change Quick Guide*, which identifies and ranks risks associated with more than 80 different potential impacts.¹¹⁴

The *City of San Francisco* committed early to including issues of environmental justice in their climate change adaptation plan by assessing the disproportionate impacts climate change will have on low-income neighborhoods.

The *U.S. National Climate Assessment* is in the process of applying a "risk framing" approach to assessing potential climate change impacts on the nation, rather than the

¹¹² This was one of several pilot efforts around the country to test the FHWA conceptual climate risk assessment model (see

http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/index.cfm).

¹¹³ Washington State Department of Transportation. 2011. Climate Impacts Vulnerability Assessment. Report to the Federal Highway Administration. February. <http://www.wsdot.wa.gov/NR/rdonlyres/B290651B-24FD-40EC-BEC3-EE5097E06180/WSDOTClimateImpactsVulnerabilityAssessmentforFHWAFinal.pdf>

¹¹⁴ Parzen, J. (Ed.). 2008. Chicago Area Climate Change Quick Guide: Adapting to the Physical Impacts of Climate Change. Report prepared by MWH for the Chicago Climate Task Force. March. http://www.chicagoclimatereaction.org/filebin/pdf/Chicago_Quick_Guide_to_Climate_Change_Preparation_June_2008.pdf

“impacts framing” used in the past. The assessment is bringing together scientific and practical expertise to provide information about the likelihood and consequences of different climate changes in order to support management and reduction of climate risks.¹¹⁵

Challenges

- A key impediment to climate risk assessment and adaptation planning often cited by local actors is the lack of locally-specific climate change projections and impacts relevant to decision making, as well as the uncertainty associated with available projections. However, locally-specific, decision-relevant information has been developed and made available for various regions of the country and improvements in computing capacity are making fine-scaled regional climate modeling increasingly viable. Furthermore, both research and practical experience indicate that rarely is lack of scientific information the most significant barrier to preparing for a changing climate.
- Despite increasing attention to vulnerability assessment and decision support, research funding remains skewed toward the beginning of the chain (climate science/climate modeling) rather than the end of the chain (developing actionable information for decision makers, including analysis of locally-specific vulnerabilities and adaptation alternatives). Efforts aimed at addressing this gap include NOAA’s Sector Applications Research and RISA programs¹¹⁶ and recent Kresge Foundation support for work examining potential state and local legal and policy frameworks for adaptation.
- The substantial and increasing, interest among Native American tribal communities in understanding the risks and challenges posed by climate change exceeds current tribal capacity for assessing climate impacts and vulnerabilities. Most tribal assessments have been highly dependent on external scientific expertise. Challenges persist in integrating tribal traditional ecological knowledge of changing conditions with western knowledge and projections of future change.
- Despite the development of innovative approaches for linking knowledge development with on-the-ground adaptation efforts, insufficient links remain between the research community and decision makers to fully inform both research and practice with the insights, advances, and needs of the other.

Planning

Along with assessing potential climate impacts, noticeable effort is being directed toward planning for climate change in the human communities/built environment sector.

¹¹⁵ <http://www.globalchange.gov/what-we-do/assessment>

¹¹⁶ Both the Sector Applications Research Program (http://www.cpo.noaa.gov/cpo_pa/sarp/) and the RISA program (http://www.cpo.noaa.gov/cpo_pa/sarp/cpo_pa/risa/) are part of NOAA’s effort to “identify and serve the nation’s needs for climate information to support decision making.”

Adaptation planning is characterized by various levels of stakeholder engagement, from internally focused, government-specific planning processes (the city of Seattle) to government-organized, multi-stakeholder advisory groups (Washington State). An adaptation planning effort by the Swinomish Indian Tribal Community in Washington includes establishment of an “honorable engagement process” that specifically seeks tribal perspectives on climate change issues and active involvement of tribal youth, in addition to more traditional engagement processes with non-tribal entities.

Chapter 2 of this report describes the state of climate change adaptation policy planning at the federal, tribal, state, and local level in the United States, identifying those entities with plans or planning processes. In addition to, and often in advance of, government-wide planning processes, individual government agencies and departments are also planning for climate change. For example climate change analyses by Seattle Public Utilities and Seattle City Light pre-date the engagement of the city as a whole in developing an adaptation strategy.

Planning for climate change is made more difficult by the fact that climate change risks will cross jurisdictional boundaries and the increasing awareness that adaptation efforts will be insufficient unless they are cohesive (or at least complementary) across those same boundaries. Despite this challenge, many adaptation efforts are moving forward with a cross-jurisdictional focus. The following are examples of innovative ways of self-organizing across boundaries to address climate change adaptation:

- The *Southeast Florida Regional Climate Compact* is an agreement undertaken by Broward, Miami-Dade, Palm Beach, and Monroe counties in December 2009 to coordinate their climate change mitigation and adaptation activities, including development of and advocacy for state and federal climate legislation.¹¹⁷
- The *North Cascadia Adaptation Partnership (NCAP)* is an example of federal and other lands management agencies coming together to assess common climate vulnerabilities and adaptation strategies. NCAP is a collaboration between the U.S. Forest Service and the National Park Service on climate change adaptation across two national forests and two national parks, consisting of six million acres in the state of Washington. NCAP is a science/management partnership and participants include other federal agencies, public utilities, and Native American tribal representatives. In addition to assessing climate risks to fish and wildlife, habitat, and vegetation, the NCAP project is examining strategies for coping with climate risks to roads, trails, and infrastructure.¹¹⁸
- The San Francisco Bay Conservation and Development Commission partnered with the NOAA’s Coastal Services Center to work with Bay Area communities in planning for sea level rise. The *Adapting to Rising Tides* project will be a

¹¹⁷ <http://www.broward.org/NATURALRESOURCES/CLIMATECHANGE/Pages/SoutheastFloridaRegionaleCompact.aspx>

¹¹⁸ <http://northcascadia.org/>

collaborative effort in which community officials and stakeholders examine the potential consequences of sea level rise and other climate change impacts for Bay Area communities, ecosystems, infrastructure, and economy; and identify local and regional strategies for addressing those challenges.¹¹⁹

- In 2010, the Swinomish Indian Tribal Community in Washington completed a two-year climate change adaptation planning effort that identified how climate change may affect the 3,000 residents of the reservation and neighboring communities and how the community can adapt to those impacts. Key participants included representatives from neighboring jurisdictions, on-reservation private landholders, and climate impacts and adaptation scientists.¹²⁰

Challenges

Climate change adaptation planning efforts are limited by budget constraints, staff cuts, lack of public support, outright political opposition, lack of urgency, and lack of recognition of adaptation's relevance to broader policy objectives. Entities engaged in planning, however, are raising increasingly sophisticated questions, such as:

- *How should we prioritize adaptation options?* To date, planning processes have typically addressed questions of prioritizing adaptation/response options in an ad hoc fashion, focusing first on climate change risks that exacerbate existing challenges; and climate change responses that align with pre-existing priorities, can be implemented in the near-term, or are relatively inexpensive.
- *What are the implications of various alternative response actions?* Most research to date has focused on identifying local impacts of climate change. Little analysis exists to support the identification and evaluation of alternate response actions in an uncertain and changing climate.
- *How much will this cost?* The relative lack of information regarding economic costs and benefits of adapting (or not adapting) to climate change has limited analysis of risks and trade-offs associated with various adaptation alternatives. This lack of information can preclude inclusion of climate change adaptation considerations in the budget-based governmental decision making processes.
- *How do our climate adaptation efforts support (or hinder) our mitigation efforts?* Climate change adaptation and mitigation efforts have tended to occur independently. Potential synergies and conflicts between these activities at the state to local level are beginning to be observed, but little guidance exists for exploiting the former and avoiding the latter.
- *What can we do without getting sued?* Although there are some scholarships that provide practitioners with guidance on the degree to which existing legal frameworks allow for implementation of various adaptation responses (see Resources/Tools on page 72), much uncertainty remains.

¹¹⁹ <http://risingtides.csc.noaa.gov>

¹²⁰ http://www.swinomish-nsn.gov/climate_change/climate_main.html and http://www.swinomish-nsn.gov/climate_change/Docs/SITC_CC_AdaptationActionPlan_complete.pdf

- *What are we planning for? What would constitute successful adaptation to a changing climate?* Deep recognition of the fundamental shifts climate change is likely to bring makes protecting the status quo increasingly difficult. However, few planning processes go beyond striving to reduce the risk of negative outcomes. What would climate change adaptation plans look like if they, instead, sought to identify strategies for transforming systems to thrive under the changes projected for the future?

Capacity Building

Many different types of groups are working to increase the capacity of local, regional, state, and tribal communities to prepare for climate change. These include environmental, sustainability, and community-oriented non-profit organizations; federal agencies; universities; private foundations; self-organized groups within the public sector; and, increasingly, private consulting companies. Capacity building efforts include:

- Increasing general climate change awareness through outreach and communication campaigns;
- Providing training on methods of climate impacts assessment and adaptation planning;
- Facilitating network development amongst climate change adaptation practitioners for peer-to-peer learning, knowledge sharing and support;
- Developing and delivering resources to support adaptation efforts (see Resources/Tools on page 72); and
- Working with communities, resource managers, planners, and policymakers in an iterative fashion to support the application of climate change information, resources and tools.

This part of the adaptation field is highly in flux, with new players entering the arena regularly, new programs being developed, and old programs being retired. With some players operating at a national scale, assisting states across the country, for example, and others working with local communities in specific sub-regions of the United States, it is impossible to catalog them all here. Some examples of capacity building efforts and players include:

Non-Profit Organizations

Through its *Climate Solutions University*, the Model Forest Policy Program delivers a multi-year training program, combined with support for professional network development, that enables rural communities across the United States to assess local forest, water, climate, and economic vulnerabilities and opportunities; and design and implement climate adaptation plans to protect local forest and water resources.¹²¹

¹²¹ <http://www.mfpp.org/csu/>

ICLEI-USA's *Climate Resilient Communities Program* provides ICLEI member communities access to tools, information, and guidance, including an online Adaptation Database and Planning Tool that guides users through the "Five Milestones for Climate Adaptation" established by the Climate Impact Group and King County in the 2007 ICLEI-published guidebook, *Preparing for Climate Change: A Guidebook for Local Governments*.¹²²

Clean Air-Cool Planet is working to "strengthen the ability of northeast communities to adapt to impending climate-induced change" through such activities as educational outreach; half-day workshops on assessing impacts, vulnerabilities, and existing planning frameworks relevant to climate adaptation planning; and network development.¹²³

The Institute for Sustainable Communities (ISC) gathers city and regional adaptation practitioners from around the United States for its annual *Climate Leadership Academy* where practitioners can "share "their challenges and successes and work together to develop new ways of adapting to a changing climate in their own cities." More recently, ISC has offered regional and "metro" scale versions of these workshops.¹²⁴

Federal Programs

NOAA's *Coastal Training Program* provides shoreline planners with a template for a climate change planning workshop, including materials, presentations, and other resources.¹²⁵ The workshop lays a foundation in science and focuses on actions that can be taken to prepare and adapt to climate change, derived in large part from the guidebook, *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*.¹²⁶

The U.S. Environmental Protection Agency (EPA) currently has regional networks in Region 1 (New England), Region 4 (Southeast), and Region 5 (Midwest). These networks focus on best practice sharing and ensuring that local communities have access to federal resources. An early adaptation focus of the EPA is on water utility vulnerability assessment and planning.

¹²² Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. 186 pp.

http://www.iclei.org/fileadmin/user_upload/documents/Global/Progams/CCP/Adaptation/ICLEI-Guidebook-Adaptation.pdf

¹²³ http://www.cleanair-coolplanet.org/climate_preparedness/

¹²⁴ <http://www.sustainablecommunitiesleadershipacademy.org/>

¹²⁵ <http://nerrs.noaa.gov/CTPIndex.aspx?ID=455>

¹²⁶ Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. 186 pp.

http://www.iclei.org/fileadmin/user_upload/documents/Global/Progams/CCP/Adaptation/ICLEI-Guidebook-Adaptation.pdf

Academic Boundary Organizations

The Climate Impacts Group at the University of Washington works with natural resource managers, planners, and policymakers to build understanding of the role climate plays in shaping both the local environment and management outcomes, to identify where and how climate information can be brought to bear in management and planning, to develop decision-relevant information about local climate impacts, to support the application of this information in decisions, and to co-develop processes for assessing and reducing climate vulnerabilities in management and planning. For example, the CIG is working with the city of Seattle to develop a transferable framework for assessing the degree to which municipal plans enhance or reduce climate resilience.¹²⁷

The Georgetown Climate Center (“the Center”) at the Georgetown Law School assists a number of states and communities with addressing legal and policy issues that arise as a result of climate change. For example, the Center is working with officials in Washington, D.C. and Milwaukee to review existing authorities and recommend options for addressing the urban heat island effect and other climate change impacts; draft a model sea level rise overlay zone to assist local governments in Maryland (as well as tailoring this analysis to suit other jurisdictions based on their unique circumstances); and advise New York and California in evaluating their authority to manage coastal development differently but still in accordance with federal requirements [of such entities as the U.S. Army Corps of Engineers and the Federal Emergency Management Agency (FEMA)] and funding restrictions (of such entities as the U.S. Department of Transportation).¹²⁸

NOAA’s RISA program aims to “help build the nation’s capacity to prepare for and adapt to climate variability and change by providing cutting-edge scientific information to public and private user communities.” The RISA program supports eleven regional, university-based efforts directed toward climate science and outreach.¹²⁹ The Northeast RISA, the Consortium for Climate Risk in the Urban Northeast, focuses specifically on climate risks associated with densely populated, highly interconnected urban areas within the Philadelphia-New York-Boston urban corridor.¹³⁰

Northern Arizona University’s *Institute for Tribal Environmental Professionals (ITEP)* was formed to act as a catalyst and supporter of tribal governments’ work toward the environmental protection of Native American natural resources. ITEP provides training, assistance, and educational resources to tribes on climate change issues.¹³¹

¹²⁷ <http://cse.washington.edu/cig>

¹²⁸ <http://www.georgetownclimate.org/>

¹²⁹ http://www.climate.noaa.gov/cpo_pa/risa/

¹³⁰ <http://ccrun.org/>

¹³¹ <http://www4.nau.edu/itep/climatechange/>

Public Sector

Water utilities are a leader in self-organizing to strengthen individual utility and sector-wide climate change adaptation capacity. Activities include engaging with the academic and federal research community to develop utility-specific climate change/impacts projections; partnering with other water suppliers (via the Water Utility Climate Alliance,¹³² for example) to increase the capacity of water utilities to access and influence the development of climate information and share methods for risk assessment and adaptation planning; and developing internal capacity by hiring staff scientists skilled in climate modeling, downscaling, hydrologic modeling, and reservoir impacts assessment.

Private Foundations

The *Kresge Foundation's* recent grant making in the arena of climate change adaptation has included a focus on developing place-based climate adaptation strategies and informing and promoting climate-wise policies and practices. Support for some of the entities listed above, as well as many others, has led to a wide variety of capacity-building activities in large and small communities across the United States.¹³³

The *Surdna Foundation* also supports adaptation capacity-building efforts through its Sustainable Environments program.¹³⁴

Networks

As part of their capacity building efforts, many of the programs and entities identified above have supported the development of networks of their participants to enable peer-to-peer learning. The following networks are also worth noting:

The *American Society of Adaptation Professionals (ASAP)*, represents the first effort to organize and support the needs of climate change adaptation professionals — in academia, public and non-profit sectors, and the private sector — working on the challenges of adaptation at various scales (national to local), within or across multiple sectors (such as transportation or water supply), and within or across multiple vectors of climate change impacts (such as drought or sea level rise). ASAP network participants have developed an agenda for specific actions needed to consolidate efforts across the emerging, but still diffuse, adaptation profession to prepare the nation for a changing climate.

¹³² <http://www.wucaonline.org/>

¹³³ <http://www.kresge.org/programs/environment/adaptation-climate-change>

¹³⁴ <http://www.surdna.org/>

The Pacific Northwest Tribal Climate Change Network (“the Network”, established in 2009) serves as a forum for sharing information on climate change programs and policies and developing resources and profiles of innovative tribal efforts to address climate change. The Network also focuses on identifying and exploring key research needs, including the role of traditional ecological knowledge in understanding climate change and the impact of climate change on tribal culture and sovereignty. Organizations in the Network have cited a critical need for coordination and collaboration between agencies and organizations to meet tribal needs in accessing climate change resources and information.¹³⁵

The Association for Climate Change Officers, a non-profit aimed at advancing “the knowledge and skills of those dedicated to developing and directing climate change strategies in the public and private sectors,” has a working group focused on adaptation.¹³⁶

Private Consulting Firms

Finally, several private consulting companies are also active in this area, including Susanne Moser Research & Consulting,¹³⁷ Stratus Consulting,¹³⁸ Cascadia Consulting Group,¹³⁹ and Adaptation International.¹⁴⁰ Some of the larger beltway firms, such as ICF-International,¹⁴¹ are beginning to engage as well.

Challenges¹⁴²

Major challenges to building and sustaining capacity include the impacts of limited funding and communication challenges:

- *Funding limitations make it difficult to sustain needed efforts.* As awareness of adaptation has grown, so have the number of public and non-profit entities seeking to fill the demand of practitioners, resource managers, planners, and policymakers for adaptation-related information relevant to their field. The number of websites and social networking sites seeking to deliver that information is also increasing; however, limited resources for sustained operations and ongoing maintenance often threaten the efficacy of the most valuable resources and organizations, or lead to premature termination before consolidation and reorganization can occur.

¹³⁵ <http://tribalclimate.uoregon.edu/network/>

¹³⁶ <http://www.aacoonline.org/ccls/adaptation2011/>

¹³⁷ <http://www.susannemoser.com>

¹³⁸ <http://stratusconsulting.com/>

¹³⁹ <http://www.cascadiaconsulting.com/>

¹⁴⁰ <http://www.adaptationinternational.com/>

¹⁴¹ <http://www.icfi.com/>

¹⁴² Many of these challenges are courtesy of the American Society of Adaptation Professionals community.

Interest in adaptation science is growing within the research community but the demand for adaptation science is growing more rapidly. At the same time, cuts to federal research budgets (especially with respect to climate) are making it more difficult to fund the research necessary for answering emerging questions. Small grant awards (on the order of \$50,000-\$150,000) make it difficult to address complex, inter-disciplinary impacts that more accurately reflect “real world” system interactions and responses. A general lack of adaptation research funding at state levels or from private foundations compounds these problems.

Research on causes, consequences, and effective strategies for managing climate change is often done by boundary organizations such as those listed above, who also deliver this information and support its use in decision making. These organizations are often located at universities (and stakeholders are turning to universities as a source of expertise on this topic), yet typical sources of university funding and typical university reward structures are often unsupportive of the type of research and the development of external relationships necessary for successful engagement with practitioners.

- *Budget challenges reduce practitioner capacity.* Budget cuts and layoffs are combining to reduce the number of staff working on adaptation in state and local government, often leading to the loss of the most experienced adaptation practitioners.
- *Best strategies for communicating adaptation unknown.* How best to communicate the challenges and urgency of climate change adaptation to the broader public has only recently emerged as a necessary complement to the mitigation policy agenda and is yet largely unknown. Basic questions about framing and messaging have been relatively unexplored and it is hard to find research and training in this area.

Implementation

Most activity associated with preparing human communities and the built environment to climate change has been directed at defining the problem (impacts/vulnerability assessment) or planning a response. Fewer communities have started implementing adaptation actions. This reflects the relatively new status of adaptation planning efforts, the fact that adaptation plans often require additional steps to translate them into action, and the fiscal and personnel limitations facing many communities and government agencies. Those actions that have been taken are most often in the category of “no” or “low regrets.”¹⁴³ Often they derived financial or political feasibility from existing initiatives or funding sources, or could be implemented because of opportunities presented by infrastructure replacement or upgrade. It is important to note that many

¹⁴³ A “no regrets” action provides benefits in current and future climate conditions even if no climate change occurs. “Low regrets” preparedness actions provide important benefits at relatively little additional cost or risk, again regardless of whether the projected climate change occurs.

activities that are adaptive in nature may not be explicitly identified as climate change adaptation, either because it is considered politically unwise to label them as climate change-related activities or because the actions are being done for other reasons, such as responding to existing threats or challenges. Examples of adaptive actions include:

Coastal Village Relocation

- The Native Village of Shishmaref is located on Sarichef Island in the Chukchi Sea. This barrier island is highly vulnerable to coastal erosion, thawing permafrost, and flooding. Relocation efforts have been underway since 2001; however, a lack of funding has delayed the process and the people and infrastructure remain at risk.¹⁴⁴
- A February 2012 law provides for the transfer of 772 acres of Olympic National Park land in Washington to the Quileute Nation. This will provide higher ground for a Native American village that currently averages only 10-15 feet above sea level (the school is one foot above sea level) and is at frequent risk of flooding and inundation from tsunamis, rising seas, and coastal river flooding and migration.¹⁴⁵

Adjustments to Infrastructure

- In one of the earliest known actions, Boston, Massachusetts officials took projected sea level rise into account in 1993 when constructing the Deer Island sewage treatment plant, at both a higher elevation and higher cost than first planned.¹⁴⁶
- King County, Washington officials designed and constructed a new wastewater treatment facility (needed because of population growth) to support wastewater treatment and distribution for re-use to provide “insurance” against projected decreases in regional water supply due to climate change. The county’s Wastewater Treatment Division is assessing the impact of saltwater intrusion into its wastewater system.¹⁴⁷
- King County, Washington officials also used information about projected increases in flood risk to revamp its approach to funding flood control projects, consolidating a patchwork of small districts within the county to a county-wide Flood Control District, and generating public support for a new property tax. The change dramatically increased the level of funding available for levee repair and

¹⁴⁴ Gregg, R. M. 2010. *Relocating the Native Village of Shishmaref, Alaska Due to Coastal Erosion* [Case study on a project of the Shishmaref Erosion and Relocation Coalition]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2770> (Last updated December 2010)

¹⁴⁵ indiancountrytodaymedianetwork.com/2012/02/28/quileute-is-moving-to-higher-ground-100321

¹⁴⁶ Feifel, K. 2010. *Proactive Incorporation of Sea Level Rise into the Design of the Deer Island Wastewater Treatment Plant* [Case study on a project of the Massachusetts Water Resources Authority]. Product of EcoAdapt's [State of Adaptation Program](#). Retrieved from CAKE: <http://www.cakex.org/case-studies/2791> (Last updated December 2010)

¹⁴⁷ http://www.nerrs.noaa.gov/doc/pdf/training/strategies_king_county.pdf

acquisition of chronically flooded property and enhanced King County's ability to receive federal and state matching funds. The county is also replacing existing “short span” river bridges with longer spans designed to withstand higher peak flows as part of its regular asset management cycle.¹⁴⁸

Green Infrastructure

- As a result of recent floods and projected increases in extreme precipitation events, Chicago is expanding the area of permeable surfaces within the city (including green alleys and rooftop gardens), assessing its drainage infrastructure, and preparing a drainage-solutions strategy.¹⁴⁹
- Milwaukee is also using swales and rain gardens to slow stormwater run-off and ameliorate its negative impacts on water quality.¹⁵⁰
- Los Angeles, Chicago, and New York City are investing in tree planting to offset the urban heat island effect.^{151,152,153}

Institutionalization of Risk Assessment and Planning

- Planning and budgetary processes in Keene, New Hampshire ensure that climate change is considered in capital development and operations efforts because climate change adaptation is part of Keene’s master plan and, because capital projects and operations must link to the master plan, both proposed capital development and operations efforts must consider climate change adaptation.¹⁵⁴
- Officials in the city of Chula Vista, California have an implementation plan for 11 adaptation action areas that includes performance metrics for each action area and budgeting information.¹⁵⁵
- Seattle’s Department of Transportation uses a decision support tool (CIMPACT-DST)¹⁵⁶ to identify major capital infrastructure projects that might be at risk from projected regional climate change.

Challenges

Moving from the planning to implementation phase poses several challenges, including:

¹⁴⁸ http://www.nerrs.noaa.gov/doc/pdf/training/strategies_king_county.pdf

¹⁴⁹ www.cityofchicago.org/city/en/depts/cdot/provdrs/alley/svcs/green_alleys.html

¹⁵⁰ <http://city.milwaukee.gov/ManagingYourStormwater>

¹⁵¹ http://bss.lacity.org/UrbanForestry/index_policies.htm

¹⁵² http://www.cityofchicago.org/city/en/depts/streets/provdrs/forestry/svcs/tree_planting.html

¹⁵³ <http://www.dec.ny.gov/lands/4957.html>

¹⁵⁴ Headwater Economics. 2012. Implementing Climate Change Adaptation: Lessons Learned From Ten Examples. Headwater Economics, Bozeman Montana. http://headwaterseconomics.org/wphw/wp-content/uploads/Climate_Adaptation_Lessons_Learned.pdf

¹⁵⁵ http://www.chulavistaca.gov/clean/conservation/Climate/documents/ClimateActionPlanUpdate_Oct11ProgressReport_FINAL.pdf

¹⁵⁶ Developed by Cascadia Consulting, Seattle.

- How to translate the broad strategies typical of climate adaptation plans into specific, implementable actions.
- How to coordinate and sequence actions across multiple relevant departments, agencies, and/or levels of government.
- How to prioritize specific actions for implementation from the long lists developed in planning.
- How to work with limited resources and little public/political support for action.
- How to work with distributed ownership and operation and/or regulation of critical urban infrastructure in some communities. New York City, for example, does not own or operate its energy generation or transmission infrastructure, telecommunication networks, or mass transit and rail freight systems,¹⁵⁷ in contrast to Los Angeles, which does.

Resources & Tools

Resources and tools to assist climate change adaptation efforts include guidance on the process of impacts/vulnerability assessment and adaptation planning; resource guides; case studies, reports, and other literature; databases; and decision support tools. Many of these are identified and/or made available via climate change adaptation clearinghouses.

Clearinghouses

Climate Adaptation Knowledge Exchange (CAKE) is a joint project of Island Press and EcoAdapt aimed at building a shared knowledge base for climate change adaptation. Through its online portal, CAKE provides a virtual library; a directory of practitioners; case studies of adaptation projects; an interactive online platform for community development; and links to freely available data, tools and information on other sites.¹⁵⁸

Georgetown Climate Center's Adaptation Clearinghouse seeks to assist state policymakers, resource managers, academics, and others who are working to help communities adapt to climate change by providing materials, links, policy briefs, legislative trackers, and other information about progress and tools for climate change adaptation.¹⁵⁹

Guidebooks and Models for Impacts/Vulnerability Assessment and Adaptation Planning

Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments: Published in September 2007, *Preparing for Climate Change* was created via a unique partnership between specialists in regional climate impacts science, vulnerability assessment, and adaptation planning (the Climate Impacts Group); local government

¹⁵⁷ Solecki W. and Rosenzweig C., eds. 2012. U.S. Cities and Climate Change: Urban, Infrastructure, and Vulnerability Issues. Technical Report in Support of the National Climate Assessment.

¹⁵⁸ <http://www.cakex.org/>

¹⁵⁹ <http://www.georgetownclimate.org/adaptation/clearinghouse>

staff responsible for adaptation planning and implementation (King County, Washington); and a non-profit connecting thousands of communities involved in climate change and sustainability issues (ICLEI). The guidebook remains one of the foundational pieces in a growing body of literature on climate adaptation planning. Content includes information on raising and maintaining internal and external support for adaptation planning; conducting a climate change vulnerability assessment; and developing, implementing, and evaluating adaptation plans.¹⁶⁰

Adapting to Climate Change: A Planning Guide for State Coastal Managers:

This guidebook, produced by NOAA's Office of Ocean and Coastal Resource Management, offers a framework for state coastal managers to follow as they develop and implement climate change adaptation plans in their own states.¹⁶¹

Center for Climate Strategies: Adaptation Guidebook: This guidebook, released by the Center for Climate Strategies in 2011, includes a catalogue of adaptation actions, a detailed review of state and local adaptation plans and comprehensive methodology, and supporting templates for sub-national adaptation planning.¹⁶²

EPA: Adaptation Strategies Guide for Water Utilities: This guide assists drinking water and wastewater utilities in understanding the climate-related impacts they may face in their region and adaptation strategies they can use to prepare their systems for those impacts. The guide includes a worksheet to assist the user in the adaptation planning process and examples of utilities implementing adaptation options for their systems.¹⁶³

New York City Panel on Climate Change: Adaptation Assessment Guidebook: This guidebook lays out a multi-step process to help stakeholders create an inventory of their at-risk infrastructure and develop adaptation strategies to address identified risks. The steps outlined are designed to be incorporated into the risk management, maintenance and operations, and capital planning processes of the agencies and organizations that manage and operate critical infrastructure and are discussed in detail throughout the guidebook.¹⁶⁴

¹⁶⁰ Snover, A.K., L.C. Whitely Binder, J. Lopez, E. Willmott, J.E. Kay, D. Howell, and J. Simmonds. 2007. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. University of Washington Climate Impacts Group and King County, Washington, in association with and published by ICLEI - Local Governments for Sustainability, Oakland, CA.

<http://cse.washington.edu/cig/fpt/guidebook.shtml>

¹⁶¹ National Oceanic and Atmospheric Administration (NOAA). 2010. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. NOAA Office of Ocean and Coastal Resource Management.

<http://coastalmanagement.noaa.gov/climate/adaptation.html>

¹⁶² <http://www.climatestrategies.us/library/library/view/908>

¹⁶³ <http://water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k11003.pdf>

¹⁶⁴ Major, D. C. and M. O'Grady. 2010. Adaptation Assessment Guidebook. *Annals of the New York Academy of Sciences* 1196: 229–292. doi: 10.1111/j.1749-6632.2010.05324.x.

<http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05324.x/full#ss15>

FHWA: Conceptual climate risk assessment model for transportation infrastructure: The FHWA’s conceptual climate risk assessment model for transportation infrastructure has been piloted by numerous transportation departments in states around the country, including Washington and New Jersey. The model helps state agencies identify facilities vulnerable to the effects of climate change, evaluate risks, and determine possible strategies to reduce risk.¹⁶⁵

Resource Guides

Many of the guidebooks listed above provide information about and links to sample climate adaptation plans, policies, and ordinances, as well as sector-specific climate change adaptation strategies. A few additional resource guides stand out:

Promising Practices in Adaptation & Resilience: A Resource Guide for Local Leaders: This resource guide, produced by the Institute for Sustainable Communities for their Climate Leadership Academy, showcases promising practices in climate adaptation and resilience, through case studies discussing local government progress on climate adaptation. It also provides detailed resource lists by topic, including general resources on climate change adaptation; online portals and peer exchanges; adaptation planning examples, case studies, and guidelines; risk assessment examples and guidelines; resources for climate adaptation strategies by sector; and resources for communication and community engagement.¹⁶⁶

Georgetown Climate Center Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: The tool kit explores eighteen different planning, regulatory, spending, and tax- and market-based land-use tools that can be used to preemptively respond to the threats posed by sea level rise. Each tool is analyzed by (1) the type of power exercised to implement it (planning, regulatory, spending, or tax and market-based tools); (2) the policy objective that it facilitates (protection, accommodation, planned retreat, or preservation); and (3) the type of existing or potential land uses to which it can be applied (critical infrastructure, existing development, developable lands, and non-developable lands).¹⁶⁷

Decision Support Tools

A variety of “tools” for visualizing and/or accessing climate change scenarios exists, including one of the most recently released, the Cal-Adapt online tool¹⁶⁸ for accessing

¹⁶⁵ http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/index.cfm

¹⁶⁶ http://www.iscvt.org/who_we_are/publications/Adaptation_Resource_Guide.pdf

¹⁶⁷ Grannis, J. 2011. Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use. Georgetown Climate Center. Georgetown Law, Washington, DC.
http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf

¹⁶⁸ <http://cal-adapt.org/>

state- and local-level climate change projections for temperature, precipitation, snowpack, sea level rise, and wildfire risk in California. Tools designed to support specific adaptation decision processes are more limited.

A tool for assessing climate risk for capital projects, “CIMPACT-DST,” was developed by the private consulting group, *Cascadia Consulting*. This spreadsheet-based tool addresses primary and secondary climate impacts related to projected changes in temperature, sea level, and precipitation on major infrastructure types. Capital improvement project managers can use the tool to identify key climate impacts early in the planning process. Seattle’s Department of Transportation currently uses this tool, which is being modified by Cascadia for use in other cities in the western United States and southeast Asia. CIMPACT-DST represents an emerging type of climate adaptation decision tool, one that is developed and delivered, for a fee, by the private sector.

Challenges

- Funds for developing new resources, such as clearinghouses or guidebooks, are often easier to come by than funds to support their continued maintenance, development, and delivery, yet persistence and development of a trusted reputation over time is essential for these resources to meet the evolving needs of the adaptation community.
- Decision support tools for assessing or alleviating climate risk require local specificity that tools for calculating greenhouse gas emissions (or potential emission reductions of various alternatives) do not. In many cases, successfully localizing a tool requires the development of locally-specific climate change projections. This makes transferring tools among users, sectors, and locations much more difficult.

Monitoring and Evaluation

Monitoring of environmental conditions and the outcomes associated with management actions aimed at preparing for climate change are essential for evaluating progress toward climate change adaptation. Information about observed changes in climate and in natural and human systems can be used to realign climate change adaptation strategies to the actual rates of change being experienced or trigger alternative adaptation actions (such as those planned for implementation at different levels of experienced change). Monitoring of desired conditions in human communities and the built environment is required to stimulate any necessary modifications to adaptation actions. Finally, adaptation practitioners must “monitor” new knowledge (of projected climate change, locally relevant climate impacts, and strategies and trade-offs associated with adaptation options) in order to develop and implement the most appropriate adaptation actions.

Beyond the climate science arena, few entities are engaged in monitoring climatic or other conditions for the purposes of informing their climate change adaptation efforts. Some early efforts include:

- New York City’s Plan for Climate Change, which identifies goals for a climate change indicator and monitoring system, including creation of a mechanism for alerting stakeholders to emerging climate change data and related risk information, warning of certain thresholds, and providing decision triggers for altering adaptation choices.¹⁶⁹
- Some entities are preparing for less predictable future conditions by developing adjustable management strategies informed by ongoing monitoring of environmental conditions. Seattle RainWatch is a new technology developed to help Seattle Public Utilities better prepare for and respond to incidents of extreme precipitation and urban flooding. This technology provides operators and decision makers with enhanced, targeted weather alerts to inform resource management and crew deployment during weather events.
- As part of its establishment of an ongoing assessment process, the National Climate Assessment intends to develop a set of physical, ecological, and societal indicators that communicate key aspects of the physical climate, climate impacts, vulnerabilities, and preparedness. Work on these is preliminary.

Challenges

Where adaptation policy and projects are being developed and implemented, efforts to systematically evaluate relative success and capture the knowledge being generated are lagging. A fundamental challenge to the monitoring and evaluation required to continually re-orient management outcomes in a changing climate is the lack of consensus on the metrics by which progress towards adaptation should be measured. With few exceptions, neither climate change adaptation guides nor actual climate change plans specify endpoints or criteria for success. They provide little in the way of setting expectations for outcomes, establishing performance measures, or, thereby, indicating appropriate targets for monitoring and evaluation.

Gaps & Opportunities

Despite the diversity of progress toward climate change adaptation detailed in this and other chapters of this report, the fact remains that relatively little has been done to date to prepare communities in the United States for a changing climate. In 2011, roughly 40 of ICLEI’s 600 member communities had taken up adaptation planning.¹⁷⁰ This amounts to less than 0.2 percent of the total counties, cities, and incorporated areas in the nation. To

¹⁶⁹ Jacob, K., R. Blake, R. Horton, D. Bader and M. O’Grady. 2010. Chapter 7: Indicators and monitoring. *Annals of the New York Academy of Sciences*, 1196: 127–142. doi: 10.1111/j.1749-6632.2009.05321.x

¹⁷⁰ M. Stultz, personal communication, 2011.

meet the climate change challenge, rapid, widespread forward progress that transcends the current piecemeal approach is urgently needed.

Support and Sustain Adaptation Leaders

Lack of sufficient and stable funding has put at risk many of the innovative and successful efforts described above to develop the knowledge and to stimulate and support the action needed to prepare for climate change. In many cases, what is needed for true progress toward climate resilience is less a re-invention of methods, tools, or approaches than a sustained effort at distributing, localizing, applying, evaluating, and learning from them. This means:

- *Supporting successful adaptation facilitation programs, such as those described in the capacity building section above.*
- *Supporting the maintenance and continued development of existing tools, resources, and clearinghouses.*
- *Supporting and replicating successful boundary organizations that work with stakeholders to develop and translate scientific, legal, and policy information and identify input pathways for climate information in planning and decision processes.*
- *Supporting successful networks, such as the nascent American Society of Adaptation Professionals that links members of academia, non-profits, government entities, and the private sectors in order to advance the state of practice by linking advances and efforts in research, practice, and policy.*

Advance the Leading Edge

The leading edge of climate change adaptation is in implementing the adaptation plans and policies that have been developed—in other words, moving from paper to practice. Putting adaptation plans into practice often requires translating general adaptation strategies into specific adaptation tactics, evaluating and prioritizing those tactics, determining how to sequence their implementation across departments and time periods, and addressing their legal and fiscal implications. In this time of limited public resources and scarce public support, however, few communities have taken these steps. *Supporting communities ready to put their plans into practice would greatly advance the state of adaptation, not only by resulting in adaptation actions on the ground, but by providing leadership and example to the rest of the nation.*

Some of the most exciting recent advancements in climate adaptation planning have been multi-jurisdictional collaborations developed to assess risk, craft adaptation responses, pool resources and knowledge, and advocate for climate policy, such as the Southeast Regional Florida Climate Compact. *Supporting the development of regional collaborations and their links to climate impacts and adaptation expertise would advance the necessary multi-jurisdictional planning to address cross-cutting risks (e.g., flooding, sea level rise, fire risk) and the development of coordinated response strategies.*

Learn from Experience

Despite numerous reports on the plans, programs, and policies developed by leading adaptation communities and various forums that exist to facilitate sharing information about the processes, outcomes, and tools for climate change adaptation planning efforts, less attention has been paid to how well existing guidance meets the needs of communities. Is existing guidance practical and actionable for communities just embarking on adaptation planning efforts? What aspects of the adaptation planning process are the most challenging and how could guidance be improved so that these challenges are reduced? How well does existing guidance satisfy the increasingly sophisticated needs of communities thinking about moving from planning to implementation? Given that various forms of adaptation guidance and adaptation efforts have been in existence and used by dozens of communities, for at least five years, it is now possible to *evaluate and update existing guidance so that it both meets the needs of communities engaged in adaptation and reflects current understanding of successful approaches to assessing and ameliorating climate risk.*

Catalyze New Change

Those community and governmental entities identified as leaders in assessing and preparing for climate risks have been characterized as those with access to locally-specific, decision-relevant information to support planning and management efforts and those who participated in programs specifically aimed at assessing impacts/vulnerability or reducing hazard risks. Therefore, *supporting the development and delivery of locally-specific information and the entities that support its use in impacts assessment/planning activities would provide the foundation for climate change adaptation planning by additional communities and sectors.*

For adaptation to take root and spread across the United States, however, a more fundamental barrier needs to be overcome — the lack of public and political support for climate change preparation. Although much research has been done on the topic of communicating climate change and motivating behavior change with respect to greenhouse gas emissions reductions, little attention has been paid to the challenge of communicating climate change adaptation. *Research and training are needed on how best to effectively communicate the challenges, necessity and urgency of climate change adaptation to the broader public.*

Identify and Eliminate Climate Rigidities

The mismatch between society's expectations about climate (embedded in its plans, policies, and infrastructure) and the actual result of climate change will challenge human communities and the built environment. Many of these mismatches are institutionalized in our laws, policies, and regulations. For example, FEMA is not legally allowed to

consider the changing climate when updating the flood plain maps that underlie local development and insurance decisions, despite clear scientific evidence that climate change will increase flood risk in many locations. *Identifying and publicizing these institutionalized rigidities and their social, ecological, and economic consequences could be used to galvanize public support and governmental action on adaptation.*

Answer Emerging Questions

As communities have moved from climate awareness into impacts assessment and action, their needs have become more sophisticated, requiring information not typically included in current adaptation planning guidance. Communities are increasingly requesting guidance on how to:

- Align adaptation efforts across the built and natural environment;
- Integrate climate change adaptation and mitigation efforts;
- Coordinate adaptation efforts with urban sustainability, community development, and environmental justice initiatives;
- Evaluate adaptation actions and outcomes;
- Prioritize adaptation actions identified in planning processes;
- Decide when climate adaptation actions should be “mainstreamed” and when stand-alone programs should be developed;
- Value adaptation actions for the purpose of cost/benefit analysis and make the business case for adaptation in competitive funding environments; and
- Avoid social/legal gridlock with respect to trade-offs and inevitable losses.

Mining current research and practice to develop guidance that answers these emerging questions would significantly advance adaptation theory and practice.

Focus: Climate Change and Human Health

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Identifying and preparing for the impacts of climate change on human health is an essential component of adapting human communities to climate change. Climate change consequences of the highest concern for human health include extreme heat events (direct impacts on morbidity and mortality), reductions in air and water quality, physical and mental health consequences of climate hazards such as storms and flooding, and changes in vector-borne and infectious diseases and food-borne illnesses. Some analyses examine projected impacts through the lens of race and social justice to identify potentially hard-hit populations or those without resources to adapt, as was seen during the 2007 Chicago heat wave. Many local and state governments have included human health impacts in their climate risk assessment and adaptation planning efforts.

Climate change impacts on human health are increasingly being framed as a public health issue. Of significant concern for adaptation, however, are the dwindling capacity of the overall public health system and the loss of basic public health programs that would support climate change preparation and response. The Centers for Disease Control's (CDC) Climate-Ready States and Cities Initiative addresses this challenge by providing assistance to local governments preparing for the health effects of climate change.¹⁷¹ The initiative is helping 10 states and cities apply climate science, predict health impacts, prepare climate change programs, and develop the capacity to implement climate change programs and adaptation actions. Through this initiative, for example, Oregon is training local public health partners to make sure that local agencies understand the risks posed by a changing climate and have the capacity to respond to local changes.¹⁷²

Key resources related to climate change and human health include the CDC's Resources on Climate Change & Public Health website,¹⁷³ the American Public Health Association's *Climate Change Guidebook*,¹⁷⁴ and the Resource Innovation Group's *Public Health and Climate Change: A Guide for Increasing the Capacity of Local Public Health Departments*.¹⁷⁵

¹⁷¹ http://www.cdc.gov/climatechange/climate_ready.htm

¹⁷² <http://public.health.oregon.gov/HealthyEnvironments/climatechange/Pages/index.aspx>

¹⁷³ <http://www.cdc.gov/climatechange/>

¹⁷⁴ http://www.apha-environment.org/pdf/APHA_ClimateChg_guidebook.pdf

¹⁷⁵ http://www.theresourceinnovationgroup.org/storage/public-health-materials/Public%20Health%20Guide_FINAL.pdf

Chapter 5: How Climate Savvy is Natural Resource Management in the United States?

Lara J. Hansen, Ph.D., *Chief Scientist and Executive Director*
and

Rachel M. Gregg, M.M.A, *Lead Scientist*¹⁷⁶
EcoAdapt

Like the other sectors identified in this report, natural resources will be affected by the full spectrum of climate change manifestations, including increasing air and water temperatures, altered precipitation patterns, and altered environmental chemistry (such as pH and dissolved oxygen). These changes will result in second order changes including:

- Altered flow patterns, runoff, drought
- Biodiversity loss
- Decreasing snowpack
- Erosion
- Fire
- Fishery harvest
- Flooding
- Habitat alteration
- Hypoxia
- Ocean acidification
- Phenological shifts
- Range shifts
- Sea level rise
- Storms/extreme weather events
- Water quality
- Water quantity

The effects of climate change are further compounded by a suite of existing environmental stressors that affect both natural resources and human communities. This includes things like pollution, pests/diseases, invasive species, overharvest/overexploitation, and habitat fragmentation/destruction (including encroachment by human development and resource extraction). There is a robust literature demonstrating that the adverse effects of these stressors generally exacerbate or are the types of environmental changes associated with climate change.¹⁷⁷ While there are a few examples of ameliorating effects, they are few and far between and often cease to have these effects with either an increase in the non-climate stressor or with more advanced climate change.

In general it will be how management of these non-climate stressors is adjusted that will dominate the suite of activities undertaken to address the effects of climate change in the natural resource sector. This is because existing regulatory and management structures exist for addressing these other factors, meaning there are existing a)

¹⁷⁶ The authors appreciate the contribution of Jessica Hitt to the research of this chapter.

¹⁷⁷ Hansen, L.J. and J.R. Hoffman. 2010. *Climate Savvy: Adapting Conservation and Resource Management to a Changing World*. Island Press, Washington DC.

mechanisms that can justify action, b) management and regulatory goals that will be affected by climate change that still need to be met, and c) tools and approaches that managers, planners, and others use in standard practice. This affords an array of opportunities for action within existing management frameworks while exploring additional approaches for future adaptation action; however, it is important to note there are limitations in this approach. Many existing approaches to addressing non-climate stressors have often been inadequate in the absence of climate change effects, designed for stationarity and, therefore, likely not adaptable to changing conditions and limited by legal or regulatory hurdles.

There is an array of activities already underway that take advantage of existing mechanisms, as well as some new innovations, all of which this chapter explores. While these examples include activities from the local to the national level, they are just the tip of the iceberg in terms of what we need to be doing in the United States to address the effects of climate change on natural resource management and protection. There is a large opportunity to improve how this issue is addressed in the United States.

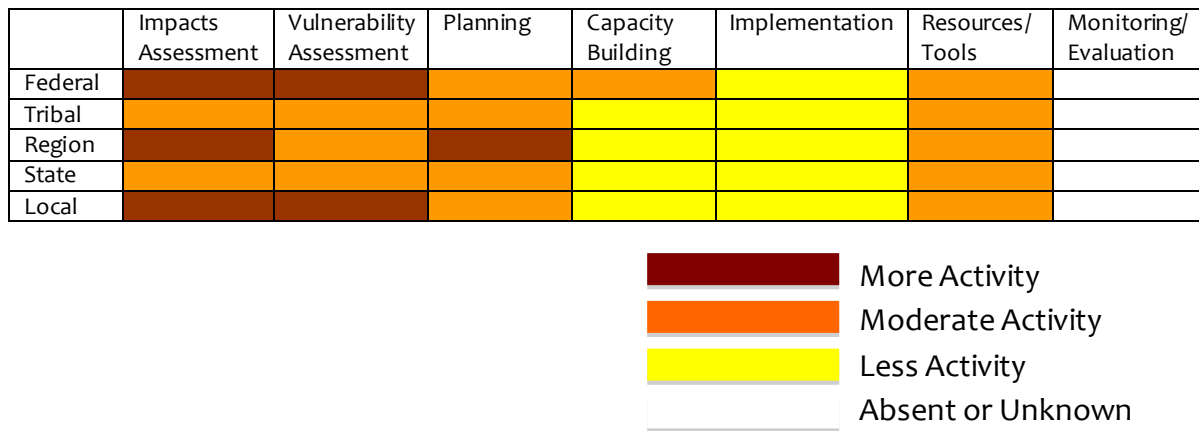


Figure 1. Activity levels vary in the stages of the adaptation process relating to natural resources in the United States. Significant effort has gone into problem identification (particularly impact assessments), some effort has gone into planning and tools development, there is insufficient effort toward capacity building and implementation, and there is essentially an absence of monitoring and evaluation of adaptation efficacy.

Problem Identification: Impacts and Vulnerability Assessments

Understanding the implications of climate change for natural resources has been an active area both in terms of knowing what change is afoot (Impact Assessments) and understanding the potential implications of that change (Vulnerability Assessments). The basic research that works to understand changes in the physical world (temperature, hydrological cycle, sea level rise, ocean acidification), has allowed for a clearer

understanding of the changes we can expect in the biological world, which in turn have allowed for consideration of the vulnerabilities of those aspects that are valued by human interests.

Quantifying Change (Impacts Assessment)

Over the past several decades, assessing potential future and actual impacts of climate change, either through modeling or empirical study, has been the dominant activity in the climate change community. This has included individual research studies (such as temperature monitoring, species range shifts, environmental tolerance) innovative model development and refinement (General Circulation Models¹⁷⁸ and downscaling), and intergovernmental global assessments of the effects of climate change (e.g., Intergovernmental Panel on Climate Change).

At the national level, the U.S. Global Change Research Program (USGCRP) has supported national assessments that include natural resource impacts. The current National Climate Assessment is nearing completion and includes chapters on terrestrial (Biodiversity, Ecosystems, and Ecosystem Services) and marine (Coastal and Ocean) habitats. In 2008 the Climate Change Science Program created a simplified assessment, but it also included a natural resource-based product, *The effects of climate change on agriculture, land resources, water resources, and biodiversity*.¹⁷⁹ Much of the research for these products is supported by the USGCRP's 13 agencies and their climate work. This includes modeling and monitoring by National Aeronautics and Space Administration and National Oceanic and Atmospheric Administration (NOAA) and ecosystem monitoring and research by the U.S. Department of Interior (DOI), U.S. Department of Agriculture [including the U.S. Forest Service (USFS)], and the U.S. Environmental Protection Agency (EPA).

Many federal holdings (parks and reserves) are either part of impact assessment monitoring networks or have taken on their own impact assessments. Voyageurs National Park staff members are collaborating with the University of Minnesota's Natural Resources Research Institute and the U.S. Geological Survey to track moose movement within the park's boundaries using GPS collars that provide location and temperature data. The results will inform research needs and help identify potential climate refugia.¹⁸⁰

¹⁷⁸ General Circulation Models (GCMs) are numerical simulation models depicting the response of the global climate to increasing greenhouse gas concentrations.

¹⁷⁹ CCSP. 2008. *The effects of climate change on agriculture, land resources, water resources, and biodiversity*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. P. Backlund, A. Janetos, D. Schimel, J. Hatfield, K. Boote, P. Fay, L. Hahn, C. Izaurralde, B.A. Kimball, T. Mader, J. Morgan, D. Ort, W. Polley, A. Thomson, D. Wolfe, M. Ryan, S. Archer, R. Birdsey, C. Dahm, L. Heath, J. Hicke, D. Hollinger, T. Huxman, G. Okin, R. Oren, J. Randerson, W. Schlesinger, D. Lettenmaier, D. Major, L. Poff, S. Running, L. Hansen, D. Inouye, B.P. Kelly, L. Meyerson, B. Peterson, R. Shaw. U.S. Environmental Protection Agency, Washington, DC, USA, 362 pp

¹⁸⁰ Hitt, J. & Windels, S. 2010. *Identifying Climate Refugia for Moose Populations in Voyageurs National Park (VOYA) Using GPS Telemetry*. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/2389> (Last updated May 2011)

The National Estuarine Research Reserve System has a few examples, including Elkhorn Slough where scientists are examining tidal dynamics, accretion rates, and salt marsh elevation to identify and manage marsh sites that may be resilient to sea level rise.¹⁸¹

At the regional, state, and local level there are also quite a few endeavors underway. Some states have very advanced research programs to assess the effects of climate change on their state, such as California. Through California Energy Commission funding, the state has done extensive work to assess the impacts of climate change (projected and realized) that it could experience. Recently officials have refocused this funding to more exclusively examine renewable energy development, but much of the infrastructure that program created still exists (see Cal-Adapt in the Resources/Tools section on page 94). Most states rely on regional federal efforts to provide climate science. Through NOAA's Regional Integrated Sciences and Assessments (RISAs), to the new DOI Climate Science Centers and Landscape Conservation Cooperatives, funds or information are being made available to support regional impact assessments.

Some specific endeavors at the regional scale include:

- The St. Petersburg Coastal and Marine Science Center's Coral Reef Ecosystem Studies (CREST) project in which Florida's coral reef health and resilience are examined with respect to forecasting future ecosystem changes to more accurately guide management decisions even in the face of climate change¹⁸²;
- The North Pacific Climate Regimes and Ecosystem Productivity Program that examines ecosystem responses and provides tools and data to support the incorporation of climate variability into fishery and marine resource management in the Bering Sea and Gulf of Alaska¹⁸³; and
- Regional studies that monitor species changes, such as:
 - An assessment of climatic changes (e.g., stream temperatures, high flows) on four western trout species¹⁸⁴;
 - A study of climate change threats to wolverine alpine habitat in the Columbia, Upper Missouri, and Upper Colorado River basins to determine if an Endangered Species Act (ESA) listing was warranted¹⁸⁵;

¹⁸¹ Gregg, R. M. 2010. *Designing Salt Marsh Conservation Strategies in Elkhorn Slough National Estuarine Research Reserve* [Case study on a project of the Elkhorn Slough NERR]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/2808). Available on CAKE: <http://www.cakex.org/case-studies/2808> (Last updated Dec. 2010)

¹⁸² Gregg, R. M. 2010. *Coral Reef Ecosystem Studies (CREST) Project* [Case study on a project of the U.S. Geological Survey's St. Petersburg Coastal and Marine Science Center]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/1008). Available on CAKE: <http://www.cakex.org/case-studies/1008> (Last updated April 2010)

¹⁸³ Gregg, R. M. 2010. *North Pacific Climate Regimes and Ecosystem Productivity Program* [Case study on a project of the National Oceanic and Atmospheric Administration (NOAA)]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/1041). Available on CAKE: <http://www.cakex.org/case-studies/1041> (Last updated April 2010)

¹⁸⁴ Wenger, S.J., D.J. Isaak, C.H. Luce, H.M. Neville, K.D. Fausch, J.B. Dunham, D.C. Dauwalter, M.K. Young, M.M. Elsner, B.E. Rieman, A.F. Hamlet, and J.E. Williams. 2011. Flow regime, temperature and biotic interactions determine winners and losers among trout species under climate change. *Proceedings of the National Academy of Sciences*. August 23; 108(34): 14175–14180, doi: 10.1073/pnas.1103097108.

- An analysis of climatic changes on pika habitat in order to determine if an ESA listing was needed¹⁸⁶; and
- An assessment of climate change effects on Pacific Northwest salmon.^{187,188}

There is a good tribal example in the Yurok Tribe's Climate Change Impacts Assessment and Prioritization Project, funded with an EPA Environmental Justice Small Grants Program award. The project focuses on building adaptive capacity for one of the largest and poorest tribes in California; the tribe is developing an impact assessment that will inform broader research and planning efforts.¹⁸⁹

In addition to California's varied impact assessments, Florida has the Shelf (FLaSH) Ecosystem Project¹⁹⁰ and Delaware has its own Sea Level Rise Adaptation Initiative.¹⁹¹ Finally, at the local level a combination of municipal and private entities have become concerned enough about climate change to undertake their own impact assessments, including the Pacific Coast Shellfish Growers Association's Oyster Emergency Project, an effort of several oyster farms to assess the effects of acidification on oyster development¹⁹²; and the Lamprey River Watershed flood assessment, a collaborative study of flood risks associated with land use and climate change scenarios intended to inform the development of new 100-year flood risk boundary maps.¹⁹³

¹⁸⁵ McKelvey, K.S., J. P. Copeland, M. K. Schwartz, J. S. Littell, K. B. Aubry, J. R. Squires, S. A. Parks, M. M. Elsner, G.S. Mauger. 2011. Climate change predicted to shift wolverine distributions, connectivity, and dispersal corridors. *Ecological Applications*, 21(8): 2882–2897.

¹⁸⁶ Ray, A.J., J.J. Barsugli, K. Wolter, and J. Eischeid. 2010. Rapid-Response Climate Assessment to Support the FWS Status Review of the American Pika. Prepared for the U.S. Fish and Wildlife Service and NOAA Earth System Research Laboratory. http://www.esrl.noaa.gov/psd/news/2010/pdf/pika_report_final.pdf

¹⁸⁷ Mantua, N., I.M. Tohver, and A.F. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change*, DOI: 10.1007/s10584-010-9845-2.

¹⁸⁸ Wu, H., J.S. Kimball, M.M. Elsner, J. Stanford, N. Mantua, and R.F. Adler. 2012. Projected Climate Change Impacts on the Hydrology and Temperature of Pacific Northwest Rivers. *Water Resources Research* (in preparation)

¹⁸⁹ EPA. 2010. Environmental Justice Small Grants Recipients – FY2010.

<http://www.epa.gov/compliance/environmentaljustice/grants/ej-smgrants-recipients-2010.html>

¹⁹⁰ Gregg, R. M. 2010. *Response of Florida Shelf Ecosystems to Climate Change: The FLaSH Project* [Case study on a project of the U.S. Geological Survey's St. Petersburg Coastal and Marine Science Center]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/1014). Available on CAKE: <http://www.cakex.org/case-studies/1014> (Last updated May 2011)

¹⁹¹ Gregg, R. M. 2010. *Delaware Sea Level Rise Adaptation Initiative* [Case study on a project of the Delaware Coastal Management Program]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/835). Available on CAKE: <http://www.cakex.org/case-studies/835> (Last updated March 2010)

¹⁹² Feifel, K. 2010. *Responding to Ocean Acidification: The Oyster Emergency Project* [Case study on a project of the Pacific Coast Shellfish Growers Association]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/50). Available on CAKE: <http://www.cakex.org/case-studies/50> (Last updated February 2010)

¹⁹³ Gregg, R. M. 2010. *Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Climate Change and Land Use* [Case study on a project of the Great Bay National Estuarine Research Reserve, University of New Hampshire, and Antioch University New England]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/840). Available on CAKE: <http://www.cakex.org/case-studies/840> (Last updated March 2010)

Opportunities

While there is always value in additional information, this is likely the area least in need of support. There are several existing resources, such as Cal-Adapt and Data Basin (see both below in Tools), attempting to make impact assessment information more readily available, but despite strong efforts by both neither is a “household” name for the potential user community. Perhaps more important than new impact assessment information is developing ways to make sure that information is getting to potential user communities in an understandable and usable format that can be applied to their own workflow.

Understanding the Implications of Change (Vulnerability Assessment)

Vulnerability assessments are critical tools that allow practitioners to evaluate the exposure, sensitivity, and adaptive capacity of their goals or actions. These assessments are used broadly across the natural resources sector at a wide range of jurisdictional scales, though activity appears to be highest at the local level. Vulnerability assessments take a variety of formats — there is no “one-size-fits-all” approach. Some assessments are stand-alone reports while others are integrated into broader adaptation planning processes.

Currently there is a Presidential Executive Order (E.O. 13514 — see Chapter 2 for more details) that mandates the need for vulnerability assessment to be part of federal practice. This has had widespread implications and has led to the creation of many of the processes and tools described in this document. Agency actions to implement this include an effort by the National Park Service (NPS) to conduct assessments at 23 coastal parks using a coastal vulnerability index based on existing conditions and historic sea level rise rates.¹⁹⁴ The USFS has undertaken some regional efforts, including the Pacific Northwest Vulnerability Assessment and Action Plan for national forests in western Washington State.¹⁹⁵ Tied to this has been the North Cascadia Adaptation Partnership, which has been a collaboration of the USFS and NPS to assess the vulnerability of natural and cultural resources on federal lands.¹⁹⁶

Tribes have created their own vulnerability assessments relevant to their lands and resources. The Swinomish Climate Change Initiative includes a vulnerability assessment that explores the climate implications for salmon, shellfish, and shorebirds; coastal,

¹⁹⁴ Gregg, R. M. 2010. *Assessing the Relative Coastal Vulnerability of National Park Units to Sea Level Rise* [Case study on a project of the National Park Service - Geologic Resources Division and the U.S. Geological Survey - Woods Hole]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/2815). Available on CAKE: <http://www.cakex.org/case-studies/2815> (Last updated December 2010)

¹⁹⁵ Aubry, C., W. Devine, R. Shoal, A. Bower, J. Miller, and N. Maggiulli. 2011. *Climate Change and Forest Biodiversity: A Vulnerability Assessment and Action Plan for National Forests in Western Washington*. USDA Pacific Northwest Region. <http://ecoshare.info/wp-content/uploads/2011/05/CCFB.pdf>

¹⁹⁶ North Cascadia Adaptation Partnership: <http://www.northcascadia.org/>

marine, and estuarine habitats; freshwater and groundwater resources; and forest resources.¹⁹⁷

At the state level, the Massachusetts Division of Fisheries and Wildlife worked with the Manomet Center for Conservation Sciences to conduct a vulnerability assessment of twenty key habitats in the state using an expert panel's rankings and confidence scores; the results are being incorporated into the State Wildlife Action Plan and applied to the division's land acquisition strategy.¹⁹⁸ The Washington Department of Natural Resources integrated a pilot assessment of the state's highly valued geoduck fishery into its adaptation planning process to provide an example of how the department could improve its climate preparedness efforts on state-owned aquatic lands.¹⁹⁹

While many large cities have taken on different versions of the vulnerability assessment (New York City, Chicago, Los Angeles), even small cities such as New Castle, Delaware,²⁰⁰ Satellite Beach, Florida,²⁰¹ and Hayward, California,²⁰² are finding this approach useful.

A very useful guidance document titled *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment* was developed in 2011 to help in the vulnerability assessment process and has been eagerly adopted by state and federal agencies.²⁰³

Opportunities

Vulnerability assessments are a useful tool for effective adaptation planning; however they are not universally employed. While this is, in part, due to a lack of understanding

¹⁹⁷ Swinomish Indian Tribal Community. 2009. Swinomish Climate Change Initiative: Impact Assessment Technical Report. La Conner, WA.

¹⁹⁸ Gregg, R.M. 2010. *Integrating Climate Change into the Massachusetts State Wildlife Action Plan Using an Expert Panel-based Vulnerability Assessment* [Case study on a project of the Massachusetts Department of Fish and Game and Manomet Center for Conservation Sciences]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/981> (Last updated April 2010)

¹⁹⁹ Gregg, R. M. 2010. *Preparing for Climate Change on State-Owned Aquatic Lands in Washington State* [Case study on a project of the Washington Department of Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/1078> (Last updated April 2010)

²⁰⁰ Gregg, R. M. 2010. *City of New Castle, Delaware Coastal Resiliency Action Plan* [Case study on a project of the Delaware Coastal Management Program]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/850> (Last updated March 2010)

²⁰¹ Gregg, R. M. 2010. *Indian River Lagoon and City of Satellite Beach, Florida Adaptation Project* [Case study on a project of the Indian River Lagoon National Estuary Program]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/843> (Last updated March 2010)

²⁰² Kershner, J. 2010. *Adapting to Sea Level Rise in Hayward, California* [Case study on a project of ESA PWA]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/2738> (Last updated December 2010)

²⁰³ Glick, P., Stein, B. A., & Edelson, N. A. (Eds.). 2011. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. Washington, DC: National Wildlife Federation. <http://www.nwf.org/~media/PDFs/Global-Warming/Climate-Smart-Conservation/NWFScanningtheConservationHorizonFINAL92311.ashx>

regarding their utility, there is also a general lack of funding to undertake them. Many adaptation activities can become part of other funded mandates as they are just modifications of existing responsibilities, but a vulnerability assessment generally requires a new outlay of funds. Given the present economic situation for most state and local governments there are few such funds. Creating support for vulnerability assessments in terms of funds, guidance, and expertise would be quite valuable.

Planning

Once the problems caused by climate change have been identified and quantified, the next step is generally to develop a plan to address the problem. Such plans can be designed to be anticipatory, reactive, or both. There are many examples of processes used to develop plans as well as completed plans. While creation of an adaptation plan can be a solid step in the right direction, it can also be a step in place if it is never implemented.

These processes are evident at all jurisdictional levels. Different strategies are used to facilitate adaptation planning, ranging from internal processes to stakeholder engagement to scenario planning.

Internal Processes

The internal approach is sometimes favored by high-level planners as well as small-scale efforts, such as those on private lands. A high-level example is the Interagency Climate Change Adaptation Task Force, which is the effort of federal agencies to implement federal mandates regarding climate change.²⁰⁴ The Swinomish Climate Change Initiative was created in 2008 to assess impacts on the Swinomish Indian Tribal Community, located on lands in Washington State, and develop recommended adaptation actions.²⁰⁵ The planning process followed a phased approach. Phase 1 included securing funding and partnerships, initial outreach and stakeholder engagement meetings, and impact assessments. Phase 2 involved the actual development of the adaptation action plan. Phase 3 will include implementation, monitoring, and updates to the impact assessments.

Stakeholder Engagement

Engaging stakeholders through in-person or online interactions can be critical to ensuring the success of adaptation. Many federal and state processes include stakeholder collaboration, or at least public comment. The National Fish, Wildlife, and Plants

²⁰⁴ Gregg, R. M. 2010. *Creating a National Adaptation Strategy for the United States: The Interagency Climate Change Adaptation Task Force* [Case study on a project of the White House Council on Environmental Quality]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/2750). Available on CAKE: <http://www.cakex.org/case-studies/2750> (Last updated December 2010)

²⁰⁵ http://www.swinomish.org/climate_change/climate_main.html

Adaptation Strategy includes not only federal agencies, but also state and tribal representatives of natural resource management agencies.²⁰⁶ The goal of that process is to develop a plan that will be agreeable to and implementable by all of these levels of government to improve management in the face of climate change. It sets out a framework that will require additional detail to implement. This process also includes public comment periods and expert review. The Climate Change Action Plan for the Florida Reef Tract was created through a multi-year stakeholder engagement process that included representatives from federal, state, and local government, as well as conservation organizations and local businesses (tourism, fishing, development).²⁰⁷ The result was a plan containing 40 defined actions that address the implications of climate change for the reef system to meet the needs of the various sectors involved. The Nature Conservancy's Alaska chapter developed the *Alaskan Marine Arctic Conservation Action Plan for the Chukchi and Beaufort Seas* to guide the organization's management and conservation efforts in the region.²⁰⁸ An expert panel helped guide the selection of six primary conservation targets, including bowhead whales, ice-dependent marine mammals (such as polar bears), seabirds, boulder patch communities, benthic fauna, and fish.

Workshops are commonly used to educate participants and solicit stakeholder input for planning purposes. The Padilla Bay National Estuarine Research Reserve (NERR) developed and piloted the *Planning for Climate Change* workshop in Washington, which provides tools, data, strategies, and practical exercises for engaging shoreline managers in climate change planning.²⁰⁹ The materials are customizable and have since been used for trainings at other NERRs. Another good example of stakeholder engagement through workshops was a NOAA's Center for Sponsored Coastal Ocean Research project that convened stakeholders from North Carolina to help plan for sea level rise and increased storm activity.²¹⁰ Workshop leaders solicited input on the design of products (e.g., mapping tools, modeling tools) to facilitate a planning process.

²⁰⁶ <http://www.wildlifeadaptationstrategy.gov>

²⁰⁷ Florida Reef Resilience Program. 2010. Climate Change Action Plan for the Florida Reef System. http://ecoadapt.org/data/library-documents/FL_Reef_Action_Plan.pdf

²⁰⁸ Gregg, R. M. 2010. *Alaskan Marine Arctic Conservation Action Plan for the Chukchi and Beaufort Seas* [Case study on a project of The Nature Conservancy - Anchorage]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/1538> (Last updated July 2010)

²⁰⁹ Gregg, R. M. 2010. *The National Estuarine Research Reserve's "Planning for Climate Change" Workshop* [Case study on a project of the Padilla Bay National Estuarine Research Reserve and Washington Sea Grant]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/849> (Last updated March 2010)

²¹⁰ Kershner, J. 2010. *North Carolina Sea Level Rise Project* [Case study on a project of NOAA's Center for Sponsored Coastal Ocean Research]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/2787> (Last updated December 2010)

Scenario Planning

Finally, scenario planning allows users to identify scenarios, create adaptation responses, and evaluate options. The National Park Service, using the Global Business Network's methodology, has been conducting scenario planning exercises for many of its park units, including Joshua Tree²¹¹ and Kaloko-Honokōhau²¹² National Parks. The *Rising Waters* scenario planning workshops in the Hudson River Valley of New York allowed communities to develop four different scenarios to inform recommendations for mitigation and adaptation responses.²¹³

Opportunities

Most of the opportunities around planning fall in the areas of capacity building and implementation. Getting to good plans requires having an informed group of people to develop them, which requires the creation of opportunities to inform people through educational materials and trainings (see the *Opportunities* section of Capacity Building on page 92 for more on this issue). Plans are not valuable if they are not implemented. Presently far more effort is being focused on plan creation than implementation (see the *Opportunities* section of Implementation on page 93 for more on this issue).

Capacity Building

One of the greatest challenges to adaptation is that it is a new idea and most people have no idea how to incorporate it into what they do. This has resulted in a tremendous need for education and training. Presently very few academic institutions include adaptation in their core curriculum around natural resource management (or any other subject for that matter). Additionally there are decades of graduates in the work force who also have no formal training in adaptation. There have been efforts made to fill these gaps but they are few compared to the need.

There is a growing effort to develop adaptation training materials. These include textbooks and other educational books (*Climate Savvy: Adapting Natural Resource Management to a Changing World*, or the *Earthscan Reader on Adaptation to Climate Change*), guidebooks (previously mentioned *Scanning the Conservation Horizon*), and

²¹¹ Kershner, J. 2011. *Scenario Planning in Joshua Tree National Park* [Case study on a project of Joshua Tree National Park]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/2904). Available on CAKE: <http://www.cakex.org/case-studies/2904> (Last updated January 2011)

²¹² Feifel, K. 2010. *Scenario Planning Pilot Study for Kaloko-Honokōhau National Historical Park* [Case study on a project of the National Park Service]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/1583). Available on CAKE: <http://www.cakex.org/case-studies/1583> (Last updated July 2010)

²¹³ Gregg, R. M. 2010. *Rising Waters: Helping Hudson River Communities Adapt to Climate Change* [Case study on a project of The Nature Conservancy - Eastern New York]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/2731). Available on CAKE: <http://www.cakex.org/case-studies/2731> (Last updated December 2010)

workbooks (Freshwater Future is developing an adaptation workbook for natural resource advocacy and management). The U.S. Fish and Wildlife Service's National Conservation Training Center (NCTC), in their collaboration on creation of the *Scanning the Conservation Horizon* document, has created a vulnerability assessment training course that has been wildly popular.²¹⁴ This course was initially offered at the NCTC campus in West Virginia but has been repeated in locations around the country at the invitation of regional and state entities, generally in collaboration with federal efforts. The Southern Maine Regional Planning Commission and Maine Geological Survey have partnered to conduct outreach workshops to encourage local communities to consider regulatory responses to sea level rise and extreme coastal storms.²¹⁵

There are a variety of other trainings that occur in either an *ad hoc* or less structured manner. All of NOAA's RISA programs (in regions around the country) have either funded or directly run training opportunities. Perhaps the longest of these efforts has been the 15 years of training offered through the Climate Impacts Group (formerly the Pacific Northwest RISA) for regional land and resource managers. NOAA's Coral Reef Program, in collaboration with The Nature Conservancy and other partners, has run training for coral reef managers in coordination with their Coral Reef Watch Program and The Nature Conservancy's Reef Resilience Program. These occur largely on the international stage but have included trainings in the United States (Florida, Hawaii, and American Samoa). The Institute of Tribal Environmental Professionals offers capacity building workshops specific to climate change impacts and adaptation.²¹⁶

Several groups run capacity building as part of their organizational mandate, including EcoAdapt's Awareness to Action workshops (formerly known as Climate Camps), the Geos Institute's ClimateWise Program, and the National Center for Ecological Analysis and Synthesis Climate Change and Wildlife Conservation working group Climate Change Adaptation for Conservation Targets (ACT) Framework.

There are several universities that are incorporating adaptation into their curriculum as part of conservation biology, wildlife management, and planning courses; and a smaller number that have courses specifically devoted to adaptation.

Universities, government agencies, and NGOs have all employed webinars as a means of trying to spread adaptation education. Some of these efforts are individual trainings, but others can be a series, such as the National Park Service's Climate Change in America's National Parks, the California Landscape Conservation Cooperative webinar series, or smaller NGO training courses. The webinar is a nice model to consider, along with other

²¹⁴ http://training.fws.gov/CSP/Resources/climate_change/vul_trng.html

²¹⁵ Gregg, R. M. 2010. *Municipal Adaptations to Create Resilient Beach Communities in Southern Maine: The Coastal Hazard Resiliency Tools Project* [Case study on a project of the Southern Maine Regional Planning Commission and Maine Geological Survey]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/2779> (Last updated December 2010)

²¹⁶ <http://www4.nau.edu/itep/climatechange/>

online training, as it offers a new technology/lower carbon approach that will almost certainly become the dominant format as we learn to address climate change at a societal level.

Opportunities

If knowledge is power, then much could be done to empower people to start integrating climate change into their work in the form of adaptation. This could mean increasing awareness of existing outlets for training or building on those existing outlets, without any fear of overlap, or creating new training opportunities. Empowerment could also come from developing and promoting training/educational materials.

Training as part of formal educational courses on natural resource adaptation is rare and there are few continuing education or professional development trainings that provide adaptation teaching. Support of such efforts in general or for specific efforts is a wide-open opportunity.

Lack of capacity has severely hindered the ability of those trying to fund adaptation efforts. When the Wildlife Conservation Society hosted their inaugural round of adaptation project funding (a re-granting program for the Doris Duke Charitable Foundation) they received few grants for climate change adaptation. The same was true for Freshwater Future (running a re-granting program for the Kresge Foundation) in their pilot adaptation grants for the Great Lakes region. In both cases they determined their need to develop an associated training effort to educate grantees on the basics of adaptation and how it could apply to their work in order to help them develop fundable projects. EcoAdapt has been providing training support in both of these efforts. Based on these experiences, it appears that channeling more money into adaptation that does not include targeted training is unlikely to garner rapid returns.

Implementation

The underlying goals of the previous steps are to move efforts to the point of implementation — where management, planning or other activities are modified and tangibly enacted with an aim toward achieving better outcomes given the reality of climate change. As with the other sectors, the majority of activity is still not arriving at the implementation phase. Perhaps we are still in a learning phase with regard to climate-smart natural resource management, or perhaps there are other barriers (perceived uncertainty, lack of political will). Despite the relatively smaller suite of efforts invested in implementation there are still quite a few implementation activities occurring at different scales. Some of these implementation activities already have legs, while others are just being initiated.

One of the most often cited examples of adaptation in action is the Alligator River National Wildlife Refuge on the Albemarle-Pamlico Peninsula of North Carolina.²¹⁷ This is an ongoing adaptive management study, being conducted in collaboration by the U.S. Fish and Wildlife Service and The Nature Conservancy, to determine how to make the area more resilient to the effects of sea level rise. The project includes oyster reef construction, hydrological restoration, and revegetation. Some implementation has been due to extreme circumstance that could not be ignored. A classic example is Arctic native village relocation, such as what is happening in the coastal village of Newtok, Alaska. The village is being forced to relocate further inland to a former part of the Yukon Delta National Wildlife Refuge to avoid massive river and shoreline erosion; moving from these historic lands has meant abandoning traditional hunting and growing grounds.²¹⁸

Some projects that started as efforts to create new guidance frameworks or regulatory rules are beginning to see the light of implementation. In 2012, the USFS recommended a new National Forest System Land Management Planning rule, intended to help forest managers incorporate climate change into forest unit management. Beginning later this year they will begin implementation of this new rule in the first set of forests, including the Inyo, Sequoia, and Sierra National Forests (California); the Nez Perce-Clearwater National Forest (Idaho); the Chugach National Forest (Alaska); the Cibola National Forest (New Mexico); and the El Yunque National Forest (Puerto Rico).²¹⁹

State and local projects have also been implemented. The Rhode Island Coastal Resources Management Council (“the Council”) regulates shoreline activities in the state. In January 2008, Section 145 of the Coastal Resources Management Program (*Climate Change and Sea Level Rise*) was adopted, authorizing the Council to develop regulations to manage the shoreline with respect to rising sea levels. In new development guidelines, the Council will accommodate a 3-5 foot rise in sea level for freeboard calculations; the Council acknowledges this range is modest and that they must revise the estimates with new information.²²⁰

Opportunities

Moving people from identifying problems toward planning and taking action is a critical step. Unfortunately it also tends to be a stumbling block. Groups frequently see the risk

²¹⁷ Gregg, R.M. 2010. *Alligator River National Wildlife Refuge/Albemarle-Pamlico Peninsula Climate Adaptation Project* [Case study on a project of The Nature Conservancy - Nags Head Woods and the U.S. Fish and Wildlife Service - North Carolina]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/682). Available on CAKE: <http://www.cakex.org/case-studies/682> (Last updated August 2011)

²¹⁸ Feifel, K. & Gregg, R. M. 2010. *Relocating the Village of Newtok, Alaska due to Coastal Erosion* [Case study on a project of the Newtok Planning Group]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/1588). Available on CAKE: <http://www.cakex.org/case-studies/1588> (Last updated July 2011)

²¹⁹ <http://www.fs.usda.gov/detail/planningrule/home/?cid=stelprdb5359471>

²²⁰ Gregg, R. M. 2010. *Planning for Sea Level Rise in Rhode Island's Coastal Management Program* [Case study on a project of the Rhode Island Coastal Resources Management Council]. Product of EcoAdapt's [State of Adaptation Program](http://www.cakex.org/case-studies/1546). Available on CAKE: <http://www.cakex.org/case-studies/1546> (Last updated July 2010)

of implementation as large, overlooking the risk of inaction. Creating mechanisms to help people overcome this hurdle and begin to change their practices to reflect what they learn from assessments and planning is a tremendous need. This may be done through creating mechanisms to share lessons and case studies (see examples in the Resources/Tools section below), directing capacity building to empower constituencies (see examples in the Capacity Building section on page 90), developing new guidance to clarify the risks of inaction in the face of climate change, or creating financial mechanisms to make adaptation implementation less of a financial risk in cases where costs cannot be incorporated into existing management endeavors. This last item could be lower interest loans or bonds that support actions that have included climate change assessments and responses in their funded efforts.

Resources/Tools

Many tools and resources are available to help practitioners process climate change information and make adaptation decisions. These tools include those that help with planning processes or decision support, modeling and analysis (e.g., environmental, socioeconomic), or visualization. In addition, this category includes climate change or adaptation portals. Challenges for those who might need these resources is that they are not always easy to find, often hard to understand for the lay user, and sometimes require technical capacity not possessed by potential users. These resources are almost all available online and come in the form of guidebooks, online tools, and information portals, including data.

Guidebooks

It is quite likely that the most popular guidance document out there today is *Scanning the Conservation Horizon* (2011),²²¹ designed to support natural resource practitioners in conducting vulnerability assessments.

Two long-standing resources that have been used around the world are the World Wildlife Fund's *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change and Natural Systems*²²² and *Preparing for Climate Change: Guidebook for Local, Regional, and State Governments* from the Climate Impacts Group, King County and ICLEI.²²³ The latter, created in collaboration with King County, Washington officials and

²²¹ Glick, P., Stein, B. A., & Edelson, N. A. (Eds.). 2011. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. Washington, DC: National Wildlife Federation. <http://www.nwf.org/~media/PDFs/Global-Warming/Climate-Smart-Conservation/NWFScanningtheConservationHorizonFINAL92311.ashx>

²²² Hansen, L.J., J.L. Biringer, J.R. Hoffman (editors). 2003. *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*. WWF. 242pp. http://assets.panda.org/downloads/buyingtime_unfe.pdf

²²³ Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and

the University of Washington's Climate Impacts Group, was designed for use primarily by human communities; however given the reliance of human communities on natural resources it can be quite useful for those working at the interface of the natural and built environment as they try to envision adequate adaptation efforts to meet those often seemingly conflicting needs. Due to progress in the field since each of these resources was created, their author teams have updated (*Buying Time* has been updated as *Climate Savvy*) or are in the process of updating (University of Washington Climate Impacts Group is endeavoring to update the ICLEI document) their resources.

As the application of adaptation increases more specific, guidebooks have emerged to address specific regional or sectoral interest. One of the most explored tools for adaptation is habitat restoration; however restoration often looks to the past with an aim of achieve some past state. Since climate change will likely make past conditions obsolete, effective restoration must take change into account and support function in the face of change. *Restoring the Great Lakes' Coastal Future: Technical Guidance for the Design and Implementation of Climate-Smart Restoration Projects*²²⁴ was developed by the National Wildlife Federation and EcoAdapt with funding from NOAA to provide a process and ideas for making restoration adaptive.

The Western Governors' Association has been working to coordinate state efforts in the west relating to climate change. In addition to having an Adaptation Work Group, they are also creating guidance on water resources, wildlife connectivity, and forest health relative to climate change and management.²²⁵

Data Sources and Planning Tools

The NOAA Coastal Services Center has an array of useful tools and data sets for adaptation planners, including:

- The Coastal Inundation Toolkit – users can identify exposure and sensitivity, map potential inundation extent to visualize impacts, and read case studies.²²⁶
- CanVis – users can visualize the impacts of sea level rise and coastal development.²²⁷

published by ICLEI – Local Governments for Sustainability, Oakland, CA. 186pp.

http://www.iclei.org/fileadmin/user_upload/documents/Global/Programs/CCP/Adaptation/ICLEI-Guidebook-Adaptation.pdf

²²⁴ Glick, P., J. Hoffman, M. Koslow, A. Kane, and D. Inkley. 2011. *Restoring the Great Lakes' Coastal Future: Technical Guidance for the Design and Implementation of Climate-Smart Restoration Projects*. National Wildlife Federation, Ann Arbor, MI. [http://ecoadapt.org/data/library-documents/NWF-Restoring the Great Lakes%27 Coastal Future-090211.pdf](http://ecoadapt.org/data/library-documents/NWF-Restoring%27%20Coastal%20Future-090211.pdf)

²²⁵ <http://www.westgov.org/initiatives/climate>

²²⁶ <http://www.csc.noaa.gov/digitalcoast/inundation/>

²²⁷ <http://www.csc.noaa.gov/digitalcoast/tools/canvis/>

- Sea Level Rise and Coastal Flooding Impacts Viewer — users can visualize possible effects of sea level rise on coastal communities in Alabama, Florida, Georgia, Mississippi, and Texas.²²⁸

NOAA also has the Coral Reef Watch,²²⁹ perhaps one of the best examples of an online resource for getting climate information to the relevant players, so they can make informed, real-time decisions on how to improve resource management. This is one of the earliest resources of its kind yet it goes virtually unreplicated in other fields. Why? No one knows.

Several states that are more heavily engaged on climate change adaptation have been developing their own tools. California has created Cal-Adapt where users can identify impacts (e.g., temperature, wildfire, precipitation, sea level rise) throughout the state at local scales.²³⁰ Given Florida's particular vulnerability to climate change, there are a few resources specifically targeted to that state. The South Florida Regional Planning Council created inundation maps for seven coastal counties.²³¹ The Maryland Department of Natural Resources is incorporating climate change as a data layer into the GreenPrint mapping tool, which helps identify land acquisition and conservation priorities, to include a climate change vulnerability layer.²³² The South Florida Regional Planning Council created a *Climate Change Community Toolbox* to assist the Miami-Dade Climate Change Advisory Task Force plan for and adapt to climate change; it provides resources for decision makers to inform planning and implementation of adaptation strategies, including fact sheets of projected climate change impacts, sea level rise maps, and a compendium of adaptation resources from around the world.²³³ The indigenous residents of Kotzebue, Alaska, the Qikiktagrugmiut, developed a study to collect traditional ecological knowledge from tribal members regarding observed environmental changes from the 1950s to 2002; the final report serves as a baseline from which to measure future environmental changes and consequences of climate variability in the region.²³⁴

²²⁸ <http://www.csc.noaa.gov/digitalcoast/tools/slrviewer>

²²⁹ <http://coralreefwatch.noaa.gov/satellite/index.html>

²³⁰ www.cal-adapt.org

²³¹ <http://www.sfrpc.com/gis/slr.htm>

²³² Feifel, K. 2010. *Integrating Climate Change Adaptation Strategies into Maryland's Coastal Land Conservation Targeting* [Case study on a project of the Maryland Department of Natural Resources]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/1707> (Last updated July 2010)

²³³ Gregg, R. M. 2010. *Florida's Climate Change Community Toolbox* [Case study on a project of the South Florida Regional Planning Council]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/998> (Last updated March 2010)

²³⁴ Feifel, K. 2010. *Documenting Traditional Ecological Knowledge in Northwest Alaska* [Case study on a project of Kotzebue IRA]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/1580> (Last updated July 2010)

Data Basin's Climate Center²³⁵ provides an online resource to use and share spatial (and some other) data through an open access GIS tool. Many adaptation planning groups have worksites on Data Basin where they share common data layers and analysis. Additionally, it is a repository of data layers relevant to climate change planning.

The Georgetown Climate Center's Sea Level Rise Adaptation Tool Kit²³⁶ can help governments consider law and policy questions for choosing adaptation strategies, while balancing the impact of human community activities with coastal resource management.

Two tools that were largely developed for human community adaptation but are relevant for the natural resource/human community interface are the RAND Corporation's Robust Decision Making tool²³⁷ and ICLEI's Adaptation Database for Planning Tool (ADAPT)²³⁸ which allows users to assess vulnerabilities, design goals, and develop strategies. Both are proprietary, however they are something to be aware of.

Modeling/Analysis

The Sea Level Rise Affecting Marshes Model (SLAMM)²³⁹ simulates the effects of sea level rise (e.g., inundation, erosion, overwash) on coastal areas. Climate Wizard²⁴⁰ allows users to visualize temperature and precipitation data over time (the past 50 years, the mid-century [2050's], and the end-century [2080's]) around the world.

Climate Change or Adaptation Portals

- NOAA Coastal Services Center's Digital Coast²⁴¹ provides easy access to a suite of tools and data that cover land use, conservation, coastal hazards, and climate change.
- CAKE²⁴² is billed as an online adaptation destination which provides the adaptation practitioner community with a georeferenced database to find and share case studies and key resources and tools, as well as a directory to locate other adaptation practitioners and a community forum to share advice and opportunities.

²³⁵ <http://databasin.org/climate-center>

²³⁶ <http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea-level-rise-and-coastal-land-use>

²³⁷ Feifel, K. 2010. *Using Robust Decisionmaking as a Tool for Water Resources Planning in Southern California* [Case study on a project of the RAND Corporation]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/1029> (Last updated April 2010)

²³⁸ http://www.iclei.org/climate_and_energy/Climate_Adaptation_Guidance/adaptation-database-and-planning-tool-adapt

²³⁹ <http://warrenpinnacle.com/prof/SLAMM/>

²⁴⁰ <http://www.climatewizard.org>

²⁴¹ <http://www.csc.noaa.gov/digitalcoast>

²⁴² <http://www.cakex.org>

- USFS Climate Change Resource Center²⁴³ is a website for resource managers requiring basic information about climate change impacts and more detailed support for mitigation and adaptation strategies.
- Georgetown Climate Center's Adaptation Clearinghouse²⁴⁴ can help local government identify other plans, vulnerability assessments, policy responses to variety of climate impacts, with a focus on law and governance. This resource is relevant for natural resources and the other sectors discussed in this paper.
- The Gulf of Mexico Climate Community of Practice²⁴⁵ website provides local decision makers, extension professionals, and educators with the climate science and resources needed to incorporate climate change and coastal hazards into community plans.

Opportunities

Clearly there are a lot of resources and tools waiting for users. It is not clear how many of these tools are used, and how effective they are. A useful endeavor would be to conduct an assessment of user community awareness and use (including efficacy) of the various tools in order to determine how to provide or at least advertise the most effective tools currently available and make suggestions about what tools are still needed.

Monitoring and Evaluation

While many adaptation activities are being planned or are in progress, relatively few are being monitored for success. Successful adaptation will require appropriate evaluation to determine what is and is not working. Unfortunately, there has been very little activity to develop monitoring and evaluation practices with regard to climate change. A lack of monitoring and evaluation is not unique to the issue of climate change adaptation; funding for and commitment to monitoring and evaluation are rarely included in management budgets and their utility is often underappreciated. The implications are, perhaps, more acute with regard to adaptation in that it is a new concept being employed under rapidly changing conditions and the need for lessons to improve practice for better outcomes is particularly urgent. Recently there have been some efforts to begin to assess monitoring and evaluation practice including a chapter in the U.S. National Climate Assessment, several international endeavors (predominantly relating to development projects rather than natural resources), and a few smaller scale projects led by NGOs in the United States.

There are a few examples of how monitoring and evaluation has been incorporated. In Northern California, the South Bay Salt Pond Restoration Project aims to restore and enhance wetland habitat, provide flood protection, buffer the area against sea level rise

²⁴³ <http://www.fs.fed.us/ccrc/>

²⁴⁴ <http://www.georgetownclimate.org/adaptation/clearinghouse>

²⁴⁵ <http://masgc.org/climate/cop/index.html>

and flooding, and improve water quality.²⁴⁶ The project team created an Adaptive Management Plan to guide implementation; lessons learned from each phase will inform future phases and help determine the final habitat configuration of the area. This process includes evaluation of the effects of changes such as sea level rise as they occur so that management can be modified in response.

The California MPA Monitoring Enterprise, in collaboration with EcoAdapt, has developed a monitoring framework specifically for assessing climate change manifestations relevant to temperate marine protected area management.²⁴⁷ While there are many protocols for monitoring coral reefs during bleaching events, this framework is unique in that it includes longer-term management issues.

Opportunities

Along with capacity building this is probably the most needed component for building adaptation in the United States, and probably globally. We have not been incorporating monitoring and evaluation into adaptation mechanisms, which means we are missing out on opportunities to improve our approaches. Even those efforts underway that include monitoring and evaluation are yet to garner any lessons. As a result, we are really still making best guesses when it comes to adaptation practice; however this is the reality for most natural resource management even without climate change. Providing funding mechanisms that require inclusion of monitoring and evaluation, supporting the development of monitoring and evaluation methodologies so interested parties could learn how to incorporate such approaches, or supporting capacity to synthesize monitoring and evaluation information in order to develop next generation guidance, would all be solid investments.

Key Opportunities for the MacArthur Foundation in this Sector

In some ways the natural resource management sector has been overtly grappling with the challenges of climate change longer than either agriculture or human communities, although those sectors have almost certainly been unknowingly adjusting their systems to the manifestations of climate change for quite a while as well. Natural resource management officials, in areas such as coral reefs, have developed adaptation efforts from the bottom up, rather than waiting for regulatory mechanisms or federal mandates. Despite all of these activities, however, there is still a dramatic need for a) capacity building mechanisms, b) monitoring and evaluation, c) integration into planning with other sectors to avoid maladaptation (for natural resources as well as the other sectors), and d) less *ad hoc* approaches to adaptation.

²⁴⁶ Kershner, J. 2010. South Bay Salt Pond Restoration Project [Case study on a project of the California Coastal Conservancy]. Product of EcoAdapt's [State of Adaptation Program](#). Available on CAKE: <http://www.cakex.org/case-studies/2876> (Last updated February 2011)

²⁴⁷ *Monitoring climate effects in temperate marine ecosystems*. MPA Monitoring Enterprise, California Ocean Science Trust, Oakland, CA. February 2012.

Appendix A: Key Players by Affiliation

Players	Agriculture	Human Communities	Natural Resources	Policy
Federal				
Environmental Protection Agency (EPA) (www.epa.gov)		X	X	
EPA Climate Ready Estuaries Program (www.epa.gov/cre)			X	
EPA Climate Ready Water Utilities (water.epa.gov/infrastructure/watersecurity/climate)		X		
Interagency Climate Change Adaptation Task Force (www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation)	X	X	X	X
National Climate Change and Wildlife Science Center (nccwsc.usgs.gov)			X	
National Estuarine Research Reserve Coastal Training Program (nerrs.noaa.gov/Training.aspx)		X	X	
National Ocean and Atmospheric Administration (www.noaa.gov)			X	
The Centers for Disease Control and Prevention (www.cdc.gov)		X		
U.S. Department of Agriculture (USDA) (www.usda.gov)	X		X	
USDA Agricultural Marketing Service (www.ams.usda.gov)	X			
U.S. Department of the Interior (www.doi.gov)			X	
U.S. Fish and Wildlife Service (www.fws.gov)			X	
U.S. Forest Service (www.fs.fed.us)			X	
U.S. Geological Survey (www.usgs.gov)			X	
U.S. Global Change Research Program (www.globalchange.gov)	X	X	X	
Regional				
DOI Climate Science Centers (www.doi.gov/csc/index.cfm)			X	
DOI Landscape Conservation Cooperatives (www.fws.gov/science/shc/lcc.html)			X	

Players	Agriculture	Human Communities	Natural Resources	Policy
National Ocean and Atmospheric Administration Regional Climate Centers <ul style="list-style-type: none"> High Plains Regional Climate Center (www.hprcc.unl.edu) Midwestern Regional Climate Center (mrcc.isws.illinois.edu) Northeast Regional Climate Center (www.nrcc.cornell.edu) Southeast Regional Climate Center (www.sercc.com) Southern Regional Climate Center (www.srcc.lsu.edu) Western Regional Climate Center (www.wrcc.dri.edu) 	X		X	
Tribal				
Coquille Tribe (www.coquilletribe.org)			X	
Fond du Lac Band of Lake Superior Chippewa Reservation (www.fdlrez.com)			X	
Menominee Nation (www.menominee-nsn.gov)			X	
Swinomish Indian Tribal Community (www.swinomish-nsn.gov/climate_change)	X	X	X	
State				
Sea Grant Climate Network (sgcnetwork.ning.com)			X	
Sea Grant Programs (www.seagrant.noaa.gov)			X	
State Environment and Wildlife Agencies			X	
Western Governors Association (www.westgov.org)				X
Local				
City of Chicago (www.cityofchicago.org)		X		
City of New York (www.nyc.gov)		X		
King County, WA (www.kingcounty.gov)		X		
Southeast Florida Regional Climate Change Compact <ul style="list-style-type: none"> Broward County (www.broward.org) Miami-Dade County (www.miamidade.gov) Palm Beach County (www.pbcgov.com) Monroe County (www.monroecounty-fl.gov) 		X		
Water Utility Climate Alliance (www.wucaonline.org) <ul style="list-style-type: none"> Denver Water Metropolitan Water District of Southern California New York City Department of Environmental Protection Portland Water Bureau San Diego County Water Authority San Francisco Public Utilities Commission Seattle Public Utilities 		X		

Players	Agriculture	Human Communities	Natural Resources	Policy
• Southern Nevada Water Authority				
Yolo County, CA (www.yolocounty.org)	X			
Private Sector				
Stratus Consulting (stratusconsulting.com)		X		
Susanne Moser Research & Consulting (www.susannemoser.com)		X		
NGO				
American Farmland Trust (www.farmland.org)	X			
American Society of Adaptation Professionals		X	X	
Association of Fish and Wildlife Agencies (www.fishwildlife.org)			X	
Center for Clean Air Policy (www.ccap.org)				X
Center for Climate and Energy Solutions (C2ES) (www.c2es.org)				X
Center for Climate Strategies (www.climatestrategies.us)				X
Clean Air-Cool Planet (www.cleanair-coolplanet.org)		X		
Defenders of Wildlife (www.defenders.org)			X	
EcoAdapt (www.ecoadapt.org)			X	
Ecological Society of America (www.esa.org)			X	
Geos Institute (www.geosinstitute.org)			X	
ICLEI – Local Governments for Sustainability (www.iclei.org)		X		X
Institute for Sustainable Communities' Climate Leadership Academy (www.iscvt.org)		X		X
Institute for Tribal Environmental Professionals (www4.nau.edu/itep)		X	X	
Kresge Foundation (www.kresge.org)		X	X	
Manomet Center for Conservation Sciences (www.manomet.org)			X	
Mid-Atlantic Water Program (www.mawaterquality.org)	X			
Model Forest Policy Program (www.mfpp.org)		X		
National Farmers Union (www.nfu.org)	X			
National Good Food Network – Wallace Center at Winrock (www.wallacecenter.org)	X			
National Sustainable Agriculture Coalition (sustainableagriculture.net)	X			
National Wildlife Federation (www.nwf.org)			X	
NatureServe (www.natureserve.org)			X	
Resources for the Future (www.rff.org)	X			
Rockefeller Foundation (www.rockefellerfoundation.org)				X
Rodale Institute (www.rodaleinstitute.org)	X			

Players	Agriculture	Human Communities	Natural Resources	Policy
Surdna Foundation (www.surdna.org)		X		
Sustainable Conservation (www.suscon.org)	X			
The Nature Conservancy (www.tnc.org)			X	
The Wilderness Society (www.wilderness.org)			X	
Union of Concerned Scientists (www.ucsusa.org)	X		X	
Academia				
Climate Impacts Group (ces.washington.edu/cig)	X	X	X	
Cornell University (Adapt-N) (adapt-n.cals.cornell.edu)	X			
Georgetown Climate Center (www.georgetownclimate.org)		X	X	X
NOAA Regional Integrated Sciences and Assessments: <ul style="list-style-type: none"> Alaska Center for Climate Assessment and Policy (ine.uaf.edu/accap) California-Nevada Applications Program (meteora.ucsd.edu/cap) Carolinas Integrated Sciences and Assessments (www.cisa.sc.edu) Climate Assessment for the Southwest (www.climas.arizona.edu) Climate Impacts Research Consortium (pnwclimate.org) Consortium on Climate Risk in the Urban NE Great Lakes Regional Integrated Sciences and Assessments Center (www.graham.umich.edu/centers/glisa.php) Pacific RISA (www.pacificrisa.org/cms) Southeast Climate Consortium (www.seclimate.org) Southern Climate Impacts Planning Program (www.southernclimate.org) Western Rural Development Center (wrdc.usu.edu) Western Water Assessment (wwa.colorado.edu) 	X	X	X	
Oregon Climate Change Research Institute (occri.net)	X	X	X	
Regional Approaches to Climate Change in Pacific Northwest Agriculture (reacchpna.uidaho.edu)	X			
University of California-Davis (www.ucdavis.edu)	X			
Philanthropy				
Doris Duke Charitable Foundation (www.ddcf.org)			X	
Kresge Foundation (www.kresge.org)	X	X	X	X
Gordon and Betty Moore Foundation (www.moore.org)			X	
Surdna Foundation (www.surdna.org)		X		
Wilburforce Foundation (www.wilburforce.org)			X	

Appendix B: Annotated Bibliography of Key Documents by Sector

Agriculture

Antle, J.M. and S.M. Capalbo. 2010. Adaptation of agricultural and food systems to climate change: an economic and policy perspective. *Applied Economic Perspectives Policy* 32: 386-416.

- This paper presents an analytical framework for examining public and private investment decisions related to climate change adaptation measures in agricultural and food systems.

California Emergency Management Agency and California Natural Resources Agency. 2012. *California Climate Adaptation Policy Guide*. Draft. Saramento, CA.

http://resources.ca.gov/climate_adaptation/docs/APG_-_PUBLIC_DRAFT_4.9.12_small.pdf

- This guide was created to support the adaptation efforts of local and regional policymakers in California. The document provides a decision-making framework that presents users with the means to interpret and evaluate climate impacts, assess vulnerability, and develop and implement adaptation measures.

Center for Climate and Energy Solutions. 2012. *Climate Change Adaptation: What Federal Agencies Are Doing*. <http://www.c2es.org/publications/report/climate-change-adaptation-what-federal-agencies-are-doing>*

- This report surveys the climate change adaptation policies of each major federal department and several cabinet agencies and interagency initiatives.

Climate Change Science Program. 2008. *The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. P. Backlund, A. Janetos, D. Schimel, J. Hatfield, K. Boote, P. Fay, L. Hahn, C. Izaurralde, B.A. Kimball, T. Mader, J. Morgan, D. Ort, W. Polley, A. Thomson, D. Wolfe, M.G. Ryan, S.R. Archer, R. Birdsey, C. Dahm, L. Heath, J. Hicke, D. Hollinger, T. Huxman, G. Okin, R. Oren, J. Randerson, W. Schlesinger, D. Lettenmaier, D. Major, L. Poff, S. Running, L. Hansen, D. Inouye, B.P. Kelly, L. Meyerson, B. Peterson, R. Shaw. U.S. Department of Agriculture, Washington, DC., USA, 362 pp

<http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm>

- This report is an assessment of climate change impacts on agriculture (cropping systems, pasture and grazing lands, animal management), land and water resources (forests, arid lands, water quantity, availability, accessibility, and quality), and biodiversity (species diversity, rare and sensitive ecosystems) in the United States. It addresses sensitivity and vulnerability, indicators of change, and monitoring and observation systems that may be used to detect change.

* Also appears in Policy.

Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott. 2007. *North America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (editors) Cambridge University Press, Cambridge, UK. pp. 617-652. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch14.html

- A chapter in the 2007 IPCC Impacts, Adaptation, and Vulnerability report that is focused on the United States and Canada. It addresses impacts, vulnerabilities, and levels of adaptive capacity.

Hatfield, J.L., K.J. Boote, et al. 2011. Climate impacts on agriculture: Implications for crop production. *Agronomy Journal* 103(2):351-370.

- This article addresses likely climate change impacts on crop production (e.g., corn, soybean, wheat, rice, sorghum, cotton, peanuts, tomatoes), including changes in temperature, CO₂, and precipitation; non-climate stressors, such as increased pests and diseases, are addressed as well.

Lal, R., J. A. Delgado, P.M. Groffman, N. Millar, C. Dell, and A. Rotz. 2011. Management to mitigate and adapt to climate change. *Journal of Soil and Water Conservation* 66: 276-285.

- This paper addresses mitigation and adaptation options for management of carbon, nitrogen, manure, and agricultural and grazing lands. Increasing soil and water conservation measures will enhance sustainable agriculture and increase food security.

Lobell, D., M.B. Burke, C. Tebaldi, M.D. Mastrandrea, W.P. Falcon, and R.L. Naylor. 2008. Prioritizing climate change adaptation needs for food security in 2030. *Science* 319: 607-610.

- This article includes an analysis of climate risks to agricultural practices in 12 food-insecure regions. South Asia and Southern Africa were identified as the regions that will suffer the most if adaptation measures are not enacted.

Rosenzweig, C. and F. N. Tubiello. 2007. Adaptation and mitigation strategies in agriculture: an analysis of potential synergies. *Mitigation and Adaptation Strategies for Global Change* 12: 855-873.

- This article addresses likely climate change impacts on crop production and disproportionate effects in different regions of the world. The authors consider measures to increase local adaptive capacity and the use of agriculture as a means to mitigate greenhouse gas emissions.

Smith, P. and J. E. Olesen. 2010. Synergies between the mitigation of, and adaptation to, climate change in agriculture. *The Journal of Agricultural Science* 148: 543-552.

- This paper focuses on the cost-effectiveness and mitigation potential of agriculture. It also addresses some possible adaptation options that can enhance mitigation, such as reducing soil erosion, reducing leaching, conserving soil moisture, increasing crop diversity, and changing land use practices.

Stöckle, C., R.L. Nelson, S. Higgins, J. Brunner, G. Grove, R. Boydston, M. Whiting, and C. Kruger. 2007. *Assessment of Climate Change Impact on Eastern Washington Agriculture*. *Washington Climate Change Impacts Assessment*. Climate Change Impacts Group, Seattle, Washington. <http://cses.washington.edu/db/pdf/wacciach5ag648.pdf>

- A chapter in the broader Washington Climate Change Impacts Assessment focused on agriculture. The assessment focused on economically viable crops for the state in selected representative regions.

Wall, E. and B. Smit. 2008. Climate change adaptation in light of sustainable agriculture. *Journal of Sustainable Agriculture* 27(1) <http://www.mendeley.com/research/climate-change-adaptation-light-sustainable-agriculture>

- This article identifies adaptation strategies currently used in agricultural practices as they relate to climate and weather. It discusses a range of options for combining climate change adaptation measures with traditional sustainable agriculture practices.

Human Communities and Built Environment

Center for Climate Strategies. 2011. *Center for Climate Strategies Adaptation Guidebook: Comprehensive Climate Action*. <http://www.climatestrategies.us/library/library/view/908>

- The guidebook includes a catalogue of adaptation actions, a detailed review of state and local adaptation plans, and comprehensive methodology and supporting templates for sub national adaptation planning.

Clean Air Partnership. 2007. *Cities Preparing for Climate Change: A Study of Six Urban Regions*. Toronto, Ontario, Canada.

http://www.cleanairpartnership.org/pdf/cities_climate_change.pdf

- This study presents lessons learned from six cities that have taken on climate change adaptation — London, New York, Boston, Halifax, Vancouver, and Seattle. Using the lessons, the report recommends a process for adaptation and provides examples of adaptation actions and measures.

Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network. 2011. C. Rosenzweig, W.D. Solecki, S.A. Hammer, and S. Mehrotra (editors). Cambridge University Press, UK.

- This report examines the climate-related risks faced by cities in developed and developing countries and potential mitigation and adaptation options for urban planning. It provides examples and analysis for twelve cities, including Athens,

Dakar, Delhi, Harare, Kingston, London, Melbourne, New York City, São Paulo, Shanghai, Tokyo, and Toronto.

Grannis, J. 2011. *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use — How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise*. Georgetown Climate Center.

http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf

- The tool kit explores 18 different land-use tools that can be used to preemptively respond to the threats posed by sea level rise. Each tool is analyzed by (1) the type of power exercised to implement it (planning, regulatory, spending, or tax and market-based tools); (2) the policy objective that it facilitates (protection, accommodation, planned retreat, or preservation); and (3) the type of existing or potential land uses that the tool can be used to adapt (critical infrastructure, existing development, developable lands, and non-developable lands).

Institute for Sustainable Communities Climate Leadership Academy. 2012. *Promising Practices in Adaptation & Resilience: A Resource Guide for Local Leaders*.

http://www.iscvt.org/who_we_are/publications/Adaptation_Resource_Guide.pdf

- This document provides a synthesis of how practitioners are addressing climate change adaptation in planning processes. It includes case studies of local examples and topic-specific resource lists to guide readers to the best available information.

Lowe, A., J. Foster, and S. Winkelman. 2009. *Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions*. A Report by the Center for Clean Air Policy Urban Leaders Adaptation Initiative.

http://www.ccap.org/docs/resources/674/Urban_Climate_Adaptation-FINAL_CCAP%206-9-09.pdf

- This document focuses on the importance of local government involvement in implementing climate change adaptation action and increasing local resilience. The authors provide ten examples from partners in the Urban Leaders Adaptation Initiative — Chicago, King County (WA), Los Angeles, Miami-Dade County, Milwaukee, Nassau County (NY), New York City, Phoenix, San Francisco, and Toronto — and lessons learned regarding process, information needs, planning, implementation, and outreach and stakeholder engagement.

Major, D. C. and M. O’Grady. 2010. *Adaptation Assessment Guidebook*. Annals of the New York Academy of Sciences, 1196: 229–292. DOI: 10.1111/j.1749-6632.2010.05324.x

<http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05324.x/full#ss15>

- This guidebook lays out a multi-step process to help stakeholders create an inventory of their at-risk infrastructure and develop adaptation strategies to address those identified risks. The steps outlined are designed to be incorporated into the risk management, maintenance and operations, and capital planning

processes of the agencies and organizations that manage and operate critical infrastructure and are discussed in detail throughout the guidebook.

Moser, S.C. 2009. *Good Morning America! The Explosive U.S. Awakening to the Need for Adaptation*. With support from the California Energy Commission and the National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center. <http://www.csc.noaa.gov/publications/need-for-adaptation.pdf>

- This report focuses on an overview of progress on climate change adaptation in the United States over the last decade, ranging from discussions of climate change in the media and the policy realm to a presentation of the state of adaptation research and efforts at federal, state, and local levels.

Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI — Local Governments for Sustainability, Oakland, CA. <http://ces.washington.edu/cig/fpt/guidebook.shtml> *

- This guidebook was created via a unique partnership between specialists in regional climate impacts science, vulnerability assessment and adaptation planning (the Climate Impacts Group), local government staff responsible for adaptation planning and implementation (King County, WA), and ICLEI-Local Governments for Sustainability. The guidebook remains one of the foundational pieces in a growing body of literature on climate adaptation planning, with more than 3,000 copies distributed nationally and internationally. Content includes information on raising and maintaining internal and external support for adaptation planning; conducting a climate change vulnerability assessment; and developing, implementing, and evaluating adaptation plans.

U.S. Environmental Protection Agency. 2012. *Climate Ready Water Utilities: Adaptation Strategies Guide for Water Utilities*. <http://water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k11003.pdf>

- This interactive guide assists drinking water and wastewater utilities in gaining a better understanding of what climate-related impacts they may face in their region, and what adaptation strategies they can use to prepare their system for those impacts. A worksheet is provided to assist the user in the adaptation planning process. The guide also includes examples of utilities implementing adaptation options at their systems.

U.S. Government Accountability Office (GAO). 2009. *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions*. GAO-10-113. <http://www.gao.gov/assets/300/296526.pdf> †

* Also appears in Policy

† Also appears in Policy

- This report to Congress describes the likely impacts of climate change, with particular emphasis on federal government functions. It surveys existing state and local climate adaptation measures and makes recommendations for improving federal policy and enhancing federal-state coordination.

United Nations Human Settlements Programme. 2011. *Global Report on Human Settlements 2011 — Cities and Climate Change*. United Nations.

<http://www.unhabitat.org/content.asp?cid=9599&catid=7&typeid=46>

- This report examines the effects of climate change on urban environments and populations around the world. Chapters focus on “hot cities” (battlegrounds for climate change), “cool cities” (pulling back from the abyss), “greedy cities” (environmental injustice), and “active cities” (where municipalities and ordinary citizens are making a global difference).

Washington State Department of Transportation. 2011. *Climate Impacts Vulnerability Assessment*. Prepared by the Washington State Department of Transportation for submittal to the Federal Highway Administration. Olympia, WA.

<http://www.wsdot.wa.gov/NR/rdonlyres/B290651B-24FD-40EC-BEC3-EE5097ED0618/o/WSDOTClimateImpactsVulnerabilityAssessmentforFHWAFinal.pdf>

- This report tests the conceptual climate risk methodology developed by the Federal Highway Administration on the Washington State transportation system by assessing the projected vulnerability of state transportation infrastructure to climate change impacts (sea level rise, flooding, wildfires, and temperature and precipitation changes). It provides a detailed report on the process used to assess vulnerabilities and recommends improvements to the conceptual model/approach for use in other locations.

Wilbanks, T.J., P. Romero Lankao, M. Bao, F. Berkhout, S. Cairncross, J.-P. Ceron, M. Kapshe, R. Muir-Wood and R. Zapata-Marti, 2007: Industry, settlement and society. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 357-390.

http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch7.html

- A chapter in the larger 2007 Intergovernmental Panel on Climate Change (IPCC) report that focuses on the vulnerabilities of human communities and industry to climate change and associated extreme weather events. The chapter discusses non-climate stressors that compound climate change impacts and the economic and social effects on high-risk locations or sectors (e.g., coastal regions, developing countries, tourism, agriculture) that typically minimize adaptive capacity.

Natural Resources

Glick, P., Stein, B. A., & Edelson, N. A. (editors). 2011. *Scanning the conservation horizon: a guide to climate change vulnerability assessment*. Washington, DC: National Wildlife Federation. <http://www.nwf.org/~media/PDFs/Global-Warming/Climate-Smart-Conservation/NWFScanningtheConservationHorizonFINAL92311.ashx>

- This is a guide to assist fish and wildlife practitioners in understanding the utility and application of climate change vulnerability assessments. Seven case studies are presented on vulnerability assessments, including NatureServe's Climate Change Vulnerability Index for Species in Nevada, U.S. EPA's Threatened and Endangered Species Vulnerability Framework, Species Vulnerability Assessment for the Middle Rio Grande, New Mexico, Vulnerability of Massachusetts Fish and Wildlife Habitats to Climate Change, Vulnerability to Sea-Level Rise in the Chesapeake Bay, An Integrated Climate Change Assessment Framework in the Four Corners Region, and the Pacific Northwest Climate Change Vulnerability Assessment.

Hansen, L.J., J.L. Biringer, and J.R. Hoffman (editors). 2003. *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*. World Wildlife Fund (WWF). http://assets.panda.org/downloads/buyingtime_unfe.pdf

- This manual covers climate impacts, assessments, and adaptation strategies in seven different ecosystems – grasslands, forests, alpine/montane, arctic, temperate marine, tropical marine, and freshwater.

Hansen, L.J. and J.R. Hoffman. 2010. *Climate Savvy: Adapting Conservation and Resource Management to a Changing World*. Island Press, Washington DC.

<http://www.amazon.com/Climate-Savvy-Adapting-Conservation-Management/dp/159726685X>

- Climate change experts Drs. Lara J. Hansen and Jennifer Hoffman consider the implications of climate change for key resource management issues of our time — invasive species, corridors and connectivity, ecological restoration, pollution, and many others. This book offers a wide-ranging exploration of how scientists, managers, and policymakers can use the challenge of climate change as an opportunity to build a more holistic and effective philosophy. Based on collaboration with a wide range of scientists, conservation leaders, and practitioners, the authors present general ideas as well as practical steps and strategies that can help cope with this new reality.

The Heinz Center. 2008. *Strategies for Managing the Effects of Climate Change on Wildlife and Ecosystems*. Washington, DC, 43 pp.

http://www.heinzctr.org/Major_Reports_files/Strategies%20for%20Manageing%20the%20Effects%20of%20Climate%20Change%20on%20Wildlife%20and%20Ecosystems.pdf

- This is a literature review of climate change adaptation resources, including adaptation plans related to biodiversity conservation and wildlife management.

Eighteen strategies are identified and summarized related to land protection and management, direct species management, monitoring and planning, and legislative and regulatory policy.

Heller, N.E. and E.S. Zavaleta. 2009. *Biodiversity management in the face of climate change: A review of 22 years of recommendations*. *Biological Conservation* 142:14-32.

- This paper includes a literature review of over 20 years worth of climate change adaptation measures. Recommendations from the literature are grouped into three options — regional planning, site-scale management, and modification of existing plans. The authors identify information gaps and needs, including practical adaptation examples, planning processes, and integration of social science.

Hopkins, J.J., H.M. Allison, C.A. Walmsley, M. Gaywood, and G. Thurgate. 2007. *Conserving biodiversity in a changing climate: guidance on building capacity to adapt*. Department for Environment, Food and Rural Affairs, London, UK.

<http://www.ukcip.org.uk/wordpress/wp-content/PDFs/CBCCGuidance.pdf>

- This guide is intended for managers engaged in biodiversity conservation in terrestrial ecosystems; it was designed to guide the implementation of the UK Biodiversity Action Plan. The document lists the following guiding principles for climate-smart conservation action:
 - Conserve existing biodiversity, including protected areas and a wide range of ecosystems and species
 - Reduce non-climate stressors
 - Conserve resilient and diverse landscapes
 - Create and enhance connectivity and networks through protection and restoration
 - Monitor in order to differentiate climatic-driven changes
 - Use adaptive management techniques to evaluate conservation targets as changes occur
 - Employ both adaptation and mitigation measures in management and planning

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability*

http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm

- This document provides an assessment of climate change impacts, vulnerabilities of natural resources and human communities, and potential adaptation options. Sectors covered include ecosystems, water resources, agriculture, human health, coastal region, and industry in eight regions — Africa, Asia, Australia/New Zealand, Europe, Latin America, North America, polar regions, and small islands.

Millar, C. I., N. L. Stephenson, and S. L. Stephens. 2007. *Climate change and forests of the*

future: *Managing in the face of uncertainty*. *Ecological Applications* 17(8): 2145-2151.

- This paper reviews resistance, resilience, and response strategies specific to forests, although its conclusions can be applied to other ecosystems. It offers a framework for managing forests ecosystems under uncertainty.

Rose, K.A. 2010. *Tribal Climate Change Adaptation Options: A Review of the Scientific Literature*. U.S. EPA.

http://www.tribesandclimatechange.org/documents/nccc/nccc20110105_0008.pdf

- This paper provides an overview of climate change impacts and adaptation relevant to U.S. tribes. Impacts covered include increasing air temperatures, changes in precipitation and runoff, extreme weather events and storms, decreasing snowpack and ice, and changes in sea levels and pH.

U.S. Global Change Research Program. 2008. *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources (SAP 4.4)*. U.S. Environmental Protection Agency, Washington, DC <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=180143>

- This document examines climate change impacts, adaptation approaches, and strategies to achieve successful implementation of adaptation in natural resource management of federally managed areas. These areas include National Forests, National Parks, National Wildlife Refuges, Wild and Scenic Rivers, National Estuaries, and Marine Protected Areas. Case studies are presented from each of these areas:
 - *National Forests*: Tahoe National Forest, Olympic National Forest, Uwharrie National Forest
 - *National Parks*: Rocky Mountain National Park
 - *National Wildlife Refuges*: Alaska and the Central Flyway
 - *Wild and Scenic Rivers*: Wekiva River
 - *National Estuaries*: The Albemarle-Pamlico Estuarine System
 - *Marine Protected Areas*: Florida Keys National Marine Sanctuary, Great Barrier Reef Marine Park, Papahānaumokuākea (Northwestern Hawaiian Islands) Marine National Monument, Channel Islands National Marine Sanctuary

U.S. EPA. 2009. *Synthesis of Adaptation Options for Coastal Areas*. Washington, DC, U.S. Environmental Protection Agency, Climate Ready Estuaries Program. EPA 430-F-08-024, January 2009.

- This document provides an overview of climate change impacts and adaptation options for coastal regions. Impacts and adaptation options are evaluated by a series of management goals, including: Maintain/Restore Wetlands, Maintain Sediment Transport, Preserve Coastal Land/Development (Including Infrastructure), Maintain Shorelines Utilizing “Soft” Measures, Maintain Shorelines Utilizing “Hard” Measures, Invasive Species Management, Preserve Habitat for Vulnerable Species, Maintain Water Quality, and Maintain Water

Availability. Different examples of adaptation in practice are provided throughout the report.

U.S. Fish and Wildlife Service, National Ocean and Atmosphere Administration (May 17, 2011). *National Fish, Wildlife and Plants Climate Adaptation Strategy*.

<http://www.wildlifeadaptationstrategy.gov/public-review-draft.php>

- A multi-agency (federally led, state and tribal inclusive) effort to “provide a nation-wide unified approach — reflecting shared principles and science-based practices — to safeguard the nation’s biodiversity, ecosystem functions, and sustainable human uses of fish, wildlife and plants in a changing climate.” This document is currently in draft format, having closed for public comment in March 2012. The final version of the strategy is expected in summer 2012.

Policy

Alaska Center for Climate Assessment and Policy. 2010. *Decision-making for at-risk Communities in a Changing Climate*.

<http://www.uaf.edu/accap/documents/DecisionMakingForCommunitiesAtRisk.pdf>

- This report lays out a decision-making matrix for climate change and community relocation, emphasizing uncertainty and the importance of risk management.

California Natural Resources Agency. 2009. *2009 California Climate Adaptation Strategy: A Report to the Governor and the State of California in Response to Executive Order S-13-2008*,

<http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF>

- This report proposes a comprehensive, sector by sector strategy for adapting to climate change in California. For each sector, it describes the impacts and risk from climate change, and assesses potential policy responses.

Center for Climate and Energy Solutions. 2012. *Climate Change Adaptation: What Federal Agencies are Doing*.

<http://www.czes.org/docUploads/federal-agencies-adaptation.pdf>*

- This report surveys the climate change adaptation policies of each major federal department and several cabinet agencies and interagency initiatives.

Chicago Climate Task Force. 2008. *Chicago Climate Action Plan*.

<http://www.chicagoclimateaction.org/filebin/pdf/finalreport/CCAPREPORTFINALv2.pdf>

- This report is the result of a stakeholder process designed to create a plan for the city of Chicago to mitigate and adapt to climate change. It assesses the causes and risks of climate change, sets goals for emissions reduction and adaptation, and recommends five key strategies for achieving those goals.

City of Keene, New Hampshire. 2007. *Adapting to Climate Change: Planning a Climate Resilient Community*.

http://www.ci.keene.nh.us/sites/default/files/Keene%20Report_ICLEI_FINAL_v2_o.pdf

* Also appears in Agriculture.

- This document describes the likely impacts of climate change on the city of Keene, sets goals for adaptation and resilience, surveys progress to date, and makes prospective recommendations for the city. It is intended to serve as a model for other communities.

City of Seattle. 2009. *Seattle Climate Protection Initiative*. Progress Report 2009.

<http://www.seattle.gov/climate/docs/CPI-09-Progress-Report.pdf>

- This progress report details Seattle's efforts to mitigate and adapt to climate. It includes detailed breakdowns of greenhouse gas emissions from different sectors and the impact of particular mitigation policies, and assesses the success of measures to directly protect the city's water supply and adjust to sea level rise.

Georgetown Climate Center. 2011. *State and Local Adaptation Plans*:

<http://www.georgetownclimate.org/adaptation/adaptation-plans.php>; see also Georgetown Climate Center's Adaptation Clearinghouse: www.adaptationclearinghouse.org.

- This webpage provides a list of state and local climate change adaptation plans in United States, with links and brief descriptions for each and the adaptation clearinghouse that includes the resources listed here and hundreds of others.

Interagency Climate Change Adaptation Task Force. 2011. *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*.

http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf

- This document provides an overview of the challenges that climate change presents for freshwater resources and details a plan for managing them accordingly. The plan is based on six broad recommendations, ranging from planning processes and information management to improving water usage efficiency and supporting integrated water resources management.

Maryland Commission on Climate Change, Adaptation and Response Working Group. 2008. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change — Phase 1: Sea-level Rise and Coastal Storms*.

<http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf>

- This report describes Maryland's vulnerability to sea level rise and coastal storms and lays out a strategy for protecting the state's people, property, natural resources, and public investments. Key recommendations include integrating expected sea level rise adaptation into existing planning processes; maintaining and expanding forests, wetlands, and beaches to guard against coastal flooding; and committing state and local government resources to develop and implement a set of performance measures for coastal adaptation.

Maryland Commission on Climate Change: Adaptation and Response and Scientific and Technical Working Groups. 2011. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change — Phase 2: Building Societal, Economic, and Ecological Resilience*.

http://www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf

- This report takes a broader approach to climate change adaptation, addressing the impacts and recommending policies related to human health, agriculture, forests and territorial ecosystems, bay and aquatic ecosystems, water resources, and population growth and infrastructure.

National Science and Technology Council: Subcommittee on Global Change Research. 2012. *The National Global Change Research Plan: 2012-2021*.

<http://library.globalchange.gov/u-s-global-change-research-program-strategic-plan-2012-2021>

- This 10-year plan for the U. S. Global Change Research Program is built around four strategic goals: advancing science, informing decisions, conducting sustained assessments, and communicating and educating. The plan also emphasizes the importance of national and international partnerships that leverage federal investments and provide for the widest use of program results.

State of Oregon. 2010. *The Oregon Climate Change Adaptation Framework*.

http://www.oregon.gov/ENERGY/GBLWRM/docs/Framework_Final_DLCD.pdf?ga=t

- This framework describes expected climate-related risks, the adaptive capacity necessary to deal with those risks, short-term priority actions, and several steps that will evolve into a long-term process to improve Oregon's capacity to adapt to variable and changing climate conditions. It represents the coordinated effort of several state agencies and university partners, following up on the work of the Governor's Climate Change Integration Group.

Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI — Local Governments for Sustainability, Oakland, CA. <http://ces.washington.edu/cig/fpt/guidebook.shtml> *

- This guidebook was created via a unique partnership between specialists in regional climate impacts science, vulnerability assessment and adaptation planning (the Climate Impacts Group), local government staff responsible for adaptation planning and implementation (King County, WA), and ICLEI-Local Governments for Sustainability. The guidebook remains one of the foundational pieces in a growing body of literature on climate adaptation planning, with more than 3,000 copies distributed nationally and internationally. Content includes information on raising and maintaining internal and external support for adaptation planning; conducting a climate change vulnerability assessment; and developing, implementing, and evaluating adaptation plans.

U.S. Army Corps of Engineers. 2012. Responses to Climate Change.

<http://corpsclimate.us/adaptationpolicy.cfm>

- The website houses the Corps' adaptation plan as well as a number of other policy resources on climate change impacts and adaptation.

U.S. Department of Agriculture (USDA), Office of the Secretary. 2011. Departmental Regulation 1070-001: Policy Statement on Climate Change Adaptation. <http://www.ocio.usda.gov/directives/doc/DR1070-001.pdf>

- This departmental regulation implements sections of Executive Order 13514 (see below) related to climate change adaptation planning, consistent with the 2010-2015 USDA Strategic Plan and guidance from the Council on Environmental Quality and the Federal Interagency Climate Change Adaptation Task Force. In addition to ordering the development of a department-wide plan, the regulation directs each USDA agency and office to analyze the impacts of climate change on their areas of responsibility and develop adaptation measures.

U.S. Department of the Interior. 2009. Secretarial Order 3226 Amendment No. 1 — Climate Change and the Department of Interior.

http://www.blm.gov/pgdata/etc/medialib/blm/wy/programs/science.Par.46189.File.dat/SO_3226A1.pdf

* Also appears in Human Communities and Built Environment

- This secretarial order reaffirms ongoing efforts within DOI to address climate change and provides new instructions to individual bureaus and offices on climate change adaptation.

U.S. EPA. 2006. *Excessive Heat Events Guidebook*, EPA 430-B-05-005.

http://www.epa.gov/heatisd/about/pdf/EHEguide_final.pdf

- This guidebook is designed to provide local health and public safety officials with the information they need to evaluate the potential health impacts of excessive heat events and craft appropriate responses. It identifies and attempts to quantify the various risks associated with excessive heat events, analyzes case studies of current notification and response programs, and makes recommendations for future program design.

U.S. EPA. 2012. *National Water Program 2012 Strategy: Response to Climate Change, Public Comment Draft*. <http://water.epa.gov/scitech/climatechange/2012-National-Water-Program-Strategy.cfm>

- This document proposes a national strategy for addressing the impact of climate change on water resources in general and the EPA's National Water Program in particular. It identifies a range of new water resource challenges and explains how the EPA and other federal and state agencies must modify their policies to overcome them.

U.S. EPA's Office of Enforcement and Compliance Assurance, U.S. Army Corps of Engineers' Construction Engineering Research Laboratory, and the Office of the Federal Environmental Executive. 2012. *FedCenter: Climate Change Adaptation*. <http://www.fedcenter.gov/programs/climate/>

- This website hosts federal and state policy actions, including executive orders and their implementing instructions, progress reports, strategic plans, etc. It also offers background information and guidance on adaptation policy.

U.S. Forest Service. 2010. *National Roadmap for Responding to Climate Change*.

<http://www.fs.fed.us/climatechange/pdf/roadmap.pdf>

- [This report describes the Forest Service's plans to assess the risks associated with climate change, engage internal and external partners to seek solutions, and manage ecosystems and human communities to promote resilience.](#)

U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration. 2012. *National Fish, Wildlife, and Plants Climate Adaptation Strategy, Public Review Draft*.

http://www.wildlifeadaptationstrategy.gov/pdf/public_review_draft.pdf

- This report details how climate change is expected to affect the eight major ecosystem types in the United States and proposes a strategy for addressing these impacts. The seven major goals of the strategy are conserving and connecting habitats, managing species and habitats, enhancing management capacity, supporting adaptive management, increasing knowledge, increasing awareness and motivating action, and reducing stresses not caused by climate change.

U.S. Government Accountability Office (GAO). 2009. *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions*. GAO-10-113.

<http://www.gao.gov/assets/300/296526.pdf> *

- This report to Congress describes the likely impacts of climate change, with particular emphasis on federal government functions. It surveys existing state and local climate adaptation measures and makes recommendations for improving federal policy and federal-state coordination.

U.S. Government Accountability Office. 2009. *Climate Change Adaptation: Information on Selected Federal Efforts to Adapt to a Changing Climate*. GAO-10-114.

<http://www.gao.gov/products/GAO-10-114SP>

- This report supplements GAO-10-113 with information obtained from thirteen federal departments and agencies on their current and planned climate change adaptation efforts. The agency submissions were not modified by GAO.

Washington State Department of Ecology. 2012. *Preparing for a Changing Climate: Washington State's Integrated Climate Response Strategy*.

<http://www.ecy.wa.gov/pubs/1201004.pdf>

- This report describes the potential negative effects of climate change as well as the benefits of taking early action on adaptation. It then lays out a comprehensive strategy for adapting to the full range of climate risks and impacts.

White House. 2010. Exec. Order No. 13514, 3 C.F.R. 13514.

http://www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf.

- This executive order from President Obama establishes a national policy that directs federal agencies to: promote energy efficiency; measure, report, and reduce their greenhouse gas emissions from direct and indirect activities; conserve and protect water resources through efficiency, reuse, and stormwater management; eliminate waste, recycle, and prevent pollution; leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; design, construct, maintain, and operate high-performance sustainable buildings in sustainable locations; strengthen the vitality and livability of the communities in which federal facilities are located; and inform federal employees about and involve them in the achievement of these goals.

White House Council on Environmental Quality. 2011. Federal Agency Climate Change Adaptation Planning Support Document.

http://www.whitehouse.gov/sites/default/files/microsites/ceq/adaptation_support_document_3_3.pdf

- This support document provides instructions for federal departments and agencies to implement Executive Order 13514 (see above). It includes background information on adaptation planning as well as detailed instructions from implementing the planning requirements.

* Also appears in Human Communities and Built Environment

White House Council on Environmental Quality, *Federal Actions for a Climate Resilient Nation*: Progress Report of the Interagency Climate Change Adaptation Task Force.

http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_adaptation_progress_report.pdf

- This progress report provides an update on implementation of Executive Order 13514, based on five key goals established by the Interagency Climate Change Adaptation Task Force. These include Integrating Adaptation into Federal Government Planning and Activities; Building Resilience to Climate Change in Communities; Improving Accessibility and Coordination of Science for Decision Making; Developing Strategies to Safeguard Natural Resources in a Changing Climate; Enhancing Efforts to Lead and Support International Adaptation.

Wisconsin Initiative on Climate Change Impacts. 2011. *Wisconsin's Changing Climate: Impacts and Adaptation, The First Report of the Wisconsin Initiative on Climate Change Impacts*. http://www.wicci.wisc.edu/report/2011_WICCI-Report.pdf

- This report surveys a broad range of potential effects of climate change on the state of Wisconsin and provides brief recommendations for adaptation measures.