Climate Change Adaptation across the Landscape

A survey of federal and state agencies, conservation organizations and academic institutions in the United States

Survey Synthesis
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Executive Summary

Climate change is proceeding at a rate at which there will be unavoidable impacts to natural systems and fish and wildlife habitat. Even with the most rigorous emissions reductions we need to plan climate adaptation measures to help natural systems persist in the face of changing climate conditions. Such climate change adaptation is a new challenge for natural resource managers who are grappling with what it will entail in the context of conservation.

To develop a clear definition and statement of need for adaptation we conducted 68 interviews of federal and state agency staff, non-governmental organization conservationists, and academic scientists who are thinking about or working on climate change adaptation. We asked these experts to define climate change adaptation, to discuss ongoing adaptation planning efforts, to provide us with examples of adaptation techniques and practices, and to list costs associated with these techniques. We also asked participants to discuss the challenges to planning for and implementing adaptation, the metrics associated with adaptation project monitoring, partnership opportunities, and communication strategies.

Most participants defined climate change adaptation to encompass anticipating, preparing for, and responding to the expected impacts of climate change in order to promote ecological resilience in natural systems, and to allow these systems to respond to change. A significant minority of participants expressed concern about the use of the term, noting that it could be easily confused with the scientific definition, and some offered alternatives. These concerns provide further support for the need to adopt a widely accessible definition of climate change adaptation.

Many participants are involved in adaptation planning, revision of existing conservation and management plans and reprioritization of conservation and restoration efforts based on climate change. Few examples of specific adaptation techniques or strategies, costs associated with strategies or metrics to measure the effect of techniques are available at this time. Participants identified several barriers to planning for and implementing adaptation strategies: a lack of resources and funding, the need for place-based adaptation strategies and available case studies to guide planning efforts, and further development of adaptation tools, models and guidance.

Despite these challenges, the survey responses suggest that progress is being made to plan and implement adaptation strategies, develop tools and models for adaptation planning, and to help build capacity in state and federal agencies that do not currently have the resources to take on the challenge alone. In particular, promising partnerships are developing within and among the federal and state agencies, conservation organizations and the academic sector. However, without increased funding to support adaptation efforts these partnerships will not be enough to prevent natural system collapse and biodiversity loss. The survey participants made it clear that the agencies responsible for managing the lands and waters of the United States and the agencies, organizations and institutions that support their work are in desperate need of new funding to fully understand, plan for, and address the challenges ahead.

I. Introduction

Climate change is proceeding at a pace at which there will be unavoidable impacts to natural systems and fish and wildlife habitat. Approximately 20-30 percent of the world's plant and animal species are likely to be at increasingly high risk of extinction if global mean temperatures exceed a warming of 2.7 to 4.5ºF. Resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances such as flooding, drought, wildfire, insects and ocean acidification, and other stressors such as land-use changes, pollution and the over-utilization of resources.[1] The effects of climate change are already being felt by wildlife and natural systems, and even with immediate action to reduce greenhouse gas emissions those effects will continue for decades to come. Natural resource managers are just coming to grips with what this means for the future of conservation strategies.

Current conservation priorities and past investments by federal, state, local, tribal, and private entities are at risk because of climate change. The federal government manages over 600 million acres of land – almost 30 percent of the land area in the United States – and more than 150,000 square miles of protected waters. Federal land management and resource agencies are still in the early stages of developing policy direction and enhanced scientific capabilities to address climate change impacts to these lands. States have principal authority for the management and sustainability of fish and wildlife within their borders as well as of state game lands and forests. The newly-finalized State Wildlife Action Plans (SWAPs) provide comprehensive frameworks for management of wildlife and habitat in each state, and can be revised and expanded to establish policy direction and technical guidance for addressing the impacts of climate change on those resources. Tribal governments also have significant responsibility for management and protection of natural resources on tribal lands that will be adversely affected by climate change. Finally, private landowners, land trusts and municipalities have made significant investments in land and species conservation across the nation that will be put at risk by climate change.

In the face of a changing climate, the development and implementation of complementary federal, state and tribal climate adaptation strategies will be necessary to ensure that fish and wildlife species, natural resources, and ecosystems are able to become resilient to and adapt to climate change. Adaptation strategies may include acquisition, protection, management and enhancement of a nation-wide network of conserved lands and waters that will serve as the buffers, corridors, and refugia necessary to make natural systems more resilient to the impacts of climate change; restoration and the rehabilitation of ecosystems that have been lost or compromised; the reduction of other non-climate stressors such as harmful invasive species, pollution, and habitat fragmentation that hinder the ability of species and ecosystems to withstand climatic events; and management options such as maximizing

[1] Fischlin, A., G.F. Midgley, J.T. Price, R. Leemans, B. Gopal, C. Turley, M.D.A. Rounsevell, O.P. Dube, J. Tarzona, A.A. Velichko, 2007: Ecosystems, their properties, goods, and services. *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, 211-272.

stream flow, prescribed burning and other efforts to protect key ecosystem features that represent important "keystones" and "underpinnings" of the overall system.

To better define the term, and to assess the current status of adaptation planning and implementation with the U.S. conservation community, we completed 68 interviews of federal and state agency staff, non-governmental organization conservationists, and academic scientists who are thinking about or working on climate change adaptation. Participants represented 19 state agencies, eight federal agencies, one fisheries commission, one participant from the Canadian Department of Fisheries and Oceans, nine non-governmental conservation organizations (NGOs), and six academic institutions (Appendix A). Using a survey guide and standard methodology (Appendix B and C) we asked these experts to define climate change adaptation, to discuss ongoing adaptation planning efforts, to provide us with examples of adaptation techniques and practices, and to list costs associated with these techniques. We also asked participants to discuss the challenges to planning for and implementing adaptation, the metrics associated with adaptation project monitoring, partnership opportunities, and communication strategies. Results from each of the different sectors are summarized in Appendices D-G and synthesized results are presented below.

II. Defining Adaptation

The term *adaptation* has been used loosely to describe an approach to natural resource management that will help species and ecosystems to persist under changing climate conditions. However, we still lack a broad consensus definition for the term. We asked survey participants to define climate change adaptation and to discuss some of the activities that fall under the adaptation heading.

There were a range of definitions given for the term adaptation, and responses fit into several general definition categories (Table 1). Slightly more than half (53% or 36 participants) of participants said that climate change adaptation involves some type of **(1) responses made to address projected or current climate change impacts to reach some goal**. Seventeen participants, or 25 percent, noted that (1a) adaptation responses will be geared towards moderating or diminishing the impacts of climate change to conserve natural ecosystem integrity, functions and services in the face of climate change. These participants focused on using management as a way to manage the impacts of climate change and build resilient and resistant natural systems. Building resilience (the ability of a system to recover to a functional state following disturbance) was mentioned more frequently (by 14 participants) than building resistance (the ability of a system to withstand a disturbance event without significant loss of function) (three participants).

Thirteen of the 36 participants using the above definition described adaptation as (1b) responses taken to allow natural systems and/or wildlife to change in response to altered climate while maintaining essential functions, resiliency, and integrity. These participants explicitly noted that management goals should not be focused only on resisting a change of state, or maintaining resilience to allow a system to recover from disturbance. Rather successful adaptation includes strategies to help natural systems change in response to climate change but keep all components necessary to retain their function and support biodiversity (even if that diversity is compositionally different).

Eight participants (12 percent) employed the recently proposed definition of adaptation from the Intergovernmental Panel on Climate Change's Fourth Assessment Report or a similar definition. This definition states that (2) adaptation is "**adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderate harm or exploits beneficial opportunities**." Participants who used this term mainly were in the federal sector of our survey and had participated in creation of the Final Report, Synthesis and Assessment Product 4.4 on adaptation options for climate sensitive ecosystems.[2] This definition was the only one used that notes the possible beneficial impacts of climate change to some systems or functions.

Three participants defined adaptation by (3) describing an adaptation process. Process-based definitions included steps one must take to accomplish adaptation. For example, one participant said that adaptation was a process of working to reduce risks and improve resiliency by proactively identifying areas that are particularly vulnerable to climate change impacts, monitoring for changes, and developing or implementing adaptation plans.

Another nine participants (13 percent of the total) listed specific or general actions to describe adaptation, such as strategic habitat conservation, hydrologic restoration, alleviating other stressors, connecting landscapes, making decisions, changing management goals, providing safety nets, and creating long-term sustainability.

Among survey participants adaptation was most often used to describe *proactive* measures taken by managers and conservationists. Twenty-one out of 24 federal agency participants, 16 of 23 state agency participants, all 15 non-governmental organization (NGO) participants, and two out of seven academics said that adaptation involved taking new actions, making decisions, and planning for or managing natural systems under climate change.

Finally, some participants proposed alternative terms to describe adaptation, and raised concerns that adaptation was an inappropriate term to use to describe actions taken to manage natural resources under climate change. One NGO respondent prefers the term "preparation" to describe "action taken to manage ecological systems for long-term persistence under climate change," while others suggested "accommodation" and "adjustment." One participant noted that the lack of a consistent definition for adaptation is a challenge in working to implement adaptation practices. Other than proposing alternative terms, participants suggested that climate change adaptation needs a more agreed upon definition and should be used with caution to avoid confusion.

Participants also expressed concern that the term adaptation may be readily confused with the scientific use of the term. The Oxford Dictionary of Science defines adaptation as "Any change in the structure or functioning of an organism that makes it better suited to its

[2] CCSP, 2008: *Preliminary review of adaptation options for climate-sensitive ecosystems and resources.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Julius, S.H., J.M. West (eds.), J.S. Baron, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott. U.S. Environmental Protection Agency, Washington, DC, USA, 873 pp.

environment." This was also the definition used by 5 out of 7 academics interviewed as well as 3 participants from other sectors. The scientific use of adaptation describes a process that occurs at an evolutionary time-scale, in direct contrast with the time-scales of rapid human responses to help manage and plan for change. Participants noted that the confusion between the terms is dangerous, particularly among the media who may conflate the two meanings. One participant noted that the lack of a consistent definition for adaptation is a challenge in working to implement adaptation practices.

Based on our survey results, we propose the following definition: **Climate change adaptation for natural systems is a dynamic management strategy that involves identifying, preparing for, and responding to expected climate change in order to promote ecological resilience, maintain ecological function, and provide the necessary elements to support biodiversity and sustainable ecosystem services.**

III. Best Practices

Because of the relatively recent emphasis on climate change adaptation, very little resource management is underway that has been planned in the context of climate change. Broad scientific theory and generalized guidance for managers exists, but examples of ongoing adaptation projects or place-based strategies to help a natural resource manager develop and implement an adaptation plan are scarce. In an effort to understand the early state of the field of adaptation we asked survey participants to describe programmatic changes within their agencies or organizations, to discuss adaptation planning efforts, and to provide examples of ongoing adaptation projects and strategies used on the ground.

Programmatic changes

Federal and state participants indicated that the first step in addressing adaptation to climate change is making climate change a part of program priorities, securing increased funding to reflect that new focus, modifying management plans to reflect climate change, forming internal and external working groups, and increasing internal capacity to address adaptation. For example, 24 percent of state agencies (4 out of 17 agencies: FL, NM, NY,WY) are engaged in training programs to help agency staff deal with climate change adaptation and 53 percent (9 out of 17) of state agencies have added staff or reassigned an existing staff member, other than the wildlife planning program manager, to improve capacity to deal with climate change and planning adaptation. Participants from half of the federal agencies interviewed (4) said that their agencies have made addressing climate change a part of their overall agency strategies or program areas, while two agencies reported that there has been no official change to their programs. Two participants are from programs within their agencies that were created solely for the purpose of dealing with climate change such as the Climate Ready Estuaries Program, while many other participants noted that they are now evaluating existing programs to determine how to address climate change through these programs or refocus their efforts in light of climate change. The U.S. Department of Transportation (DOT), United States Geological Survey (USGS), U.S. Forest Service (USFS), U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), National Park Service (NPS) and U.S. Fish and Wildlife Service (USFWS) now have information about climate change on their websites and some have recently released climate change planning tools available online.

Conservation NGO participants reported that organizations have made internal changes to programs in the last several years, developed new programs to deal with climate change, and engaged in helping management agencies and other organizations plan for climate change. Almost all NGO staff interviewed said that their organizations had recently evaluated how their programs operate, restructured or re-allocated funds to address the impacts of climate change, applied for grant funds addressing climate change, or created new programs to deal with climate change adaptation work. One NGO was recently created explicitly to address climate change adaptation.

Many participants noted that efforts to address climate change adaptation have spurred more intra- and inter-agency efforts, collaborative projects and partnerships, information sharing, and innovative thinking.

Planning

A significant amount of planning, revision of existing plans, reprioritization of restoration or conservation actions, identification of new management goals, and development of monitoring protocols will precede implementation of adaptation projects. Interview participants recognized and commented on the tremendous up-front investment in planning for adaptation, and some noted the need to "get it right" and invest the necessary time and effort in planning activities. State and federal agencies are largely involved in the early stages of adaptation planning, often with support from conservation NGO and academic partners (Table 3).

Chief among planning activities mentioned by participants was the **revision of existing management or conservation plans to incorporate climate change, or creating stand-alone adaptation plans**. More than half of the federal agencies reported that they are taking climate change into consideration when drafting management plans, such as management plans for National Park Service units. Fifty-nine percent (10 out of 17) of state fish and wildlife agencies interviewed have elected to use their State Wildlife Action Plan (SWAP) as a vehicle to accommodate planning for climate change adaptation. For example, the state of Nevada engaged partners to develop an adaptation strategy to incorporate into the Nevada SWAP using $400,000 in state bond fund monies. Nevada has engaged partners who helped to develop the original SWAP to assist with the effort, and have contracted with the University of Nevada-Reno to draft a white paper detailing climate change impacts on fish and wildlife to guide the revision process. Using the SWAPs as a vehicle to address climate change will allow agencies to take advantage of the significant effort that went into preparing these comprehensive conservation plans for species of greatest conservation need.

Fifty-three percent (9) of state agency participants also report that they will include climate change adaptation in other plans. For example, in addition to revising the SWAP to address climate change adaptation, the state of Massachusetts is currently incorporating climate change considerations into habitat acquisition planning, landowner incentive program (LIP) planning, and habitat management planning for state owned or managed lands.

New planning efforts rely on a variety of new tools and model outputs. The most frequently mentioned planning tools included vulnerability assessments, scenario-based planning, and

linked species-climate models. Vulnerability assessments can be used to identify climate sensitive ecosystems or habitat-types and climate resilient habitat-types. Refugia are areas that are likely to remain relatively stable as the climate changes, therefore acting as a refuge for native species. Scenario-based planning is usually a qualitative process that allows the user to explore a wide set of alternative futures and design a range of management strategies to address some finite number of scenarios. Finally, participants are also using linked species population-climate forecasting models to understand the impacts of climate change on species distributions and abundance.

Forming working groups, partnerships and facilitating adaptation plan development was another common strategy among state, federal and conservation NGO participants. One such collaborative partnership which has evolved on the Albemarle Peninsula in North Carolina includes the Alligator River National Wildlife Refuge Complex, The Nature Conservancy, Duke University, the U.S. Department of Defense and the U.S. Environmental Protection Agency. The group is working to address salt-water intrusion and future sea level rise, by developing a hydrologic model of the region to guide restoration efforts, considering a number of adaptation strategies including planting of more salt tolerant species, and developing monitoring protocols to track project results.

Conservation NGOs often serve in an organizing role, helping to bring together different sectors and partners to work on adaptation planning. Twelve out of 15 conservation NGO participants (80 percent) noted that they are involved in convening working groups or focus groups to plan for climate change adaptation. One such effort is led by the Wildlife Conservation Society (WCS) in collaboration with the Center for Large Landscape Conservation that has convened a working group at the National Center for Ecological Analysis and Synthesis (NCEAS). The group is charged with bringing together scientists and conservation planners to develop strategies for conservation planning under future climate conditions and to apply that strategy in several locations in the Intermountain West.

Developing tools, predictive science, models, guidance documents, and planning information was an important component of the conservation organization and academic communities' work, as well as federal agencies including USGS, NOAA and EPA. This work is often used to support state and federal agencies whose primary goal is resource and species management. For example, the Massachusetts Department of Fish and Wildlife is working with The Nature Conservancy and the Manomet Center for Conservation Sciences to employ a tool called the Climate Wizard to complete a comprehensive analysis of climate change impacts at fine scales. The state is also completing vulnerability assessments of habitat in the Massachusetts to identify climate sensitive habitat and climate refugia. This assessment will be used to re-prioritize state conservation spending on land acquisitions. One example from the federal sector comes from the Environmental Protection Agency which recently developed the Climate Ready Estuaries Program to help the National Estuary Program (NEP) and coastal communities become 'climate ready' by providing tools and assistance to assess climate change vulnerability and to plan for adaptation.[3] The Program provides a web-based toolkit (www.epa.gov/cre/toolkit.html) with information, data, planning tools, webinars, workshops, adaptation options, and technical assistance for NEP sites and coastal managers. The program is also providing targeted assistance to a small

[3] http://www.epa.gov/cre/

group of NEP sites in the first 12-18 months to identify climate change vulnerabilities, develop adaptation plans, and begin to implement selected adaptation strategies.

On-the-Ground Strategies

Participants identified climate change adaptation strategies to maintain or improve ecosystem resistance, resilience, and strategies that enable a species or ecosystem to change in response to climate change, rather than resisting or recovering from change. For the purposes of this survey we have divided adaptation strategies into the following five areas based on general principals:

1. Reduce other elements of human-caused environmental change;
2. Manage for ecological function and protection of biodiversity;
3. Establish habitat buffer zones and wildlife corridors;
4. Implement "proactive" management and restoration strategies; and
5. Increase monitoring and adaptive management practices [4]

While most agencies and organizations are involved in the planning phase of adaptation efforts, participants did suggest specific techniques they are considering, and several provided examples of ongoing adaptation projects.

1. Reduce other elements of global environmental change: Climate change is one component in a larger collection of human-caused changes that threaten biodiversity and natural systems. Such human-driven changes include increased concentrations of carbon dioxide in the atmosphere and resultant climate change, land use and land cover change, alteration of the world's freshwater systems, global pollution, and alteration of the nitrogen cycle, over-harvest of species, biological invasions by non-native species, light pollution and loss of biodiversity. While climate change is perhaps the greatest impending conservation challenge, other elements of global environmental change continue to wreak havoc on natural systems. In conjunction with climate change, components of global environmental change will act synergistically, intensifying the effects of climate change to further degrade ecological integrity, reduce biodiversity, and impair provisioning of ecosystem services. It is critical that climate change adaptation strategies be designed and implemented in the context of all of these environmental changes, and that these "other stressors" are addressed in order to build resilience and help natural systems and species respond to climate change.

Participants from all sectors recognized that reducing other stressors or components of global environmental change is an essential component of any effort taken to help natural systems adapt to climate change. Twenty-two of 23 or 96 percent of federal agency participants and all conservation NGO participants said that managing other stressors including habitat fragmentation, sprawl, invasive species, human recreation, intense fires, and altered hydrologic cycles is already ongoing and in some cases a part of the agency's overall management strategy. State agencies are also managing other elements of global environmental change. Participants from six state agencies (35 percent) listed specific management activities they are already involved in that they believe will help their agencies address the challenges brought on by climate change. Ongoing activities include restoration

[4] Glick, P., A. Staudt, and B. Stein. 2009. A New Era for Conservation: Review of Climate Change Adaptation Literature. Reston, VA: National Wildlife Federation

of riparian corridors and buffers, stream restoration, habitat acquisitions, using adaptive management to target invasive species, and adjusting deer harvest strategies to reflect lower winterkill resulting from milder winters. However, only now are state agencies as well as their federal counterparts beginning to plan management of these other stressors with climate change in mind. As an NGO participant pointed out, all efforts to reduce existing stressors are important, but strategic re-prioritization of existing stressors will be a necessary component of managing under climate change. One strategy that is currently being employed specifically as an adaptation technique to reduce other stressors comes from coral reef ecosystems where areas of the reefs are being closed to human activity when the risk from bleaching events is high.

Several federal and conservation NGO participants noted that habitat loss and degradation is currently a very serious component of global environmental change and that if habitat loss is not addressed there is little hope of helping natural systems adapt to climate change.

2. Managing for ecologic function and protection of biodiversity: Maintaining ecological function and promoting biodiversity is tied to increased ecosystem resilience. Building resilience was a key component of adaptation strategies identified by participants across sectors and 13 participants (19 percent of the total) used the term in their definitions of adaptation. Conservation NGO participants cited restoration efforts across the country aimed at maintaining or restoring ecological function including riparian restoration, restoring natural fire cycles, and increasing ecological complexity in stream systems. Most of these projects are ongoing and only recently have these efforts begun to plan for management under climate change. Several participants noted that managing in a more holistic manner to address ecological function and biodiversity as well as all scales of heterogeneity in an ecosystem is an important "bet-hedging" strategy to help systems adjust to climate change.

State agency and federal agency participants frequently manage to enhance species population numbers. Participants indicated that there is growing recognition that species management plans will need to incorporate detailed climate change information and model outputs. With this in mind, the New York Department of Environmental Conservation has been assessing bird population changes in spruce grouse and other boreal bird communities that reside in habitat that may be significantly altered by climate change. Participants from the California Department of Fish and Game said they recognize that climate change must be addressed in the development of conservation for sensitive species, such as bats and the western pond turtle.

3. Establish habitat buffer zones and wildlife corridors: Improving habitat connectivity and establishing habitat buffers to facilitate species migration and range shifts in response to climate change was also a strategy discussed by participants, though most efforts are in the early stages of planning. The Wildlife Conservation Society's Corridor Conservation Initiative is using scientific guidelines to promote the development of connectivity policy. For example, WCS Canada and the Adirondack Program are engaged in planning for the northern Appalachian region through the Two Countries One Forest Project. This project identifies critical at-risk landscape linkages under greatest threat from climate change and other pressures. In Montana, the Center for Large Landscape Conservation is actively involved in a Crucial Areas and Connectivity Assessment. The assessment, led by the

Montana Fish, Wildlife and Parks, will produce a set of conservation planning and information tools to assist local, regional, and statewide decision-makers, developers and agency staff to conserve wildlife corridors and crucial habitat throughout Montana. All information will be incorporated in the Montana SWAP and will be used to develop recommendations and guidelines to help federal, state, county and private sector decision makers better understand how their decisions may impact crucial areas.

A number of participants cautioned that in the rush to take on the challenge of climate change, the importance of protecting and conserving habitat should not be forgotten. One participant said that there must be something to connect when agencies and conservationists plan for connectivity. Others noted that in order to provide ecosystems and species the opportunity to respond to climate change and to continue to function, more intact conservation land needs to be restored and protected. A number of state and federal agencies recognized the importance of existing programs to fostering climate change adaptation through land acquisition. One federal participant said that if the problem of habitat fragmentation and urban sprawl was solved, that would be 90 percent of the way towards adapting to climate change.

Participants also recognized that the question of where to spend limited conservation funds may need to be reframed to reflect projected impacts of climate change. Reprioritization of land for acquisition is ongoing in a number of state agencies and federal programs. For example, the Washington Department of Fish and Wildlife is taking a "stronghold approach," in its planning process to identify areas that are most pristine and least affected by existing stressors and therefore thought to be more resilient to the impacts of climate change. These areas will likely be targeted for conservation efforts in the future. Several federal agencies, including the EPA and the USFWS National Wildlife Refuge Program have employed the Sea Level Affecting Marsh Model (SLAMM) to identify areas that will be most affected by sea level rise. Areas where the relative rate of sea level rise is expected to be quite high may not be targeted for acquisition or restoration in the future.

4. Implement "proactive" management and restoration strategies: Strategies in this category include all *active* facilitation of species, habitats and ecosystems to accommodate climate change impacts. Examples include translocating species to new locations, barrier island expansion, marsh creation and planting climate resistant species. Federal participants suggested a variety of strategies that may be used in the future to proactively manage ecosystems and species. For example, the Bureau of Land Management (BLM) is considering planting southern plant genotypes further north and at higher elevation as part of future restoration efforts and a national wildlife refuge manager noted that more salt tolerant species may be used in marsh restoration efforts to account for rising sea level.

An ongoing example of proactive management and restoration comes from Blackwater National Wildlife Refuge on the coast of Chesapeake Bay in Maryland. The refuge has been losing marsh since the 1930's at a rate of 150-400 acres a year due to sea level rise, coastal subsidence, erosion, saltwater intrusion and invasive species. The Blackwater National Wildlife Refuge's Comprehensive Conservation Plan calls for the refuge to restore the wetlands to 1933 conditions, a challenge in light of the rapidly rising tide and loss of 8,000 acres of land. Already, there have been a number of restoration efforts at Blackwater. In the

early 1980's approximately 12 acres of marsh were restored, while a project in 2003 restored a total of eight acres using native dredge material. The 2003 project cost approximately $333,000 to implement.

Other strategies to reduce coastal loss at Blackwater NWR include the installation of a weir on a canal to reduce salt water intrusion; a highly successful extirpation of over 9,000 invasive nutria; controlling populations of resident Canada geese to protect sensitive vegetation; and installing straw bale wave breaks. More recently, the U.S. Fish and Wildlife Service, the U.S. Army Corp of Engineers, the Maryland Port Administration, and the University of Maryland have partnered to form the Maryland Mid-Chesapeake Bay Restoration Project to restore the wetlands. Future restoration efforts may utilize dredged material taken from the approach channels to the Baltimore Harbor in the Chesapeake Bay. The Maryland Port Administration must remove 3.5 - 4 million cubic yards of dredged material each year, and the dredge could potentially be used to expand Poplar Island, conduct large island restoration in the mid-Chesapeake Bay, or complete wetland restoration in Dorchester County and Blackwater Refuge.[5] The feasibility, practicality, cost, and benefits of the restoration efforts still need to be assessed and the cost is expected to be quite high.

5. Increased monitoring and adaptive management practices: Survey participants recognized monitoring and adaptive management as integral components of a climate change adaptation plan. Examples of monitoring strategies developed specifically to address climate change were provided by all participant groups.

At the Rocky Mountain Biological Laboratory, there are several studies that are monitoring changes in altitudinal distribution of wildflowers and bumble bees, assessing changes in phenological events such as hibernation, and examining alterations at the genetic level due to climate change. This work is aimed at documenting natural adaptation to climate change rather than at facilitating adaptation, but understanding the natural capacity of species to evolve and adapt in response to climate change is an important component of planning for adaptation.

In Montana, the World Wildlife Fund is identifying climate sensitive locations for monitoring to detect the presence of ecological thresholds to climate change. In the Adirondacks, the Wildlife Conservation Society has been collecting baseline data on the distribution of boreal birds. Because climate change is the primary threat to this habitat type, data on the distribution and abundance of these species will help management planning efforts. In the Kenai National Wildlife Refuge active monitoring of variables such as glacial recession and methane outputs in the context of climate change is ongoing. NOAA's Coral Reef Watch Program is also actively engaged in monitoring and assessing the status of coral bleaching events around the world and helping managers to monitor bleaching events.

Some participants are employing existing data sets to detect changes in species populations that may be due to climate change. For example, the Texas Parks and Wildlife Department is using long term monitoring data sets to detect changes in estuarine and coastal fish

[5] http://www.fws.gov/blackwater/restore.html

population abundance and distribution and using this information to drive harvest management and decision-making.

Participants also cited efforts to develop monitoring techniques. For example, the Alligator River National Wildlife Refuge Complex is working with other partners to develop outcome-based monitoring and assumption-driven applied research to monitor on-the-ground strategies for dealing with sea level rise. Similarly, the Climate Ready Estuaries program at EPA is working to help the National Estuaries Program and other coastal areas plan for monitoring the effects of sea level rise in the future.

Adaptive management is a systematic approach to improving management by learning from management outcomes.[6] Adaptive management is not simply monitoring management outcomes, but involves exploring alternative ways to meet management goals, developing predictors for the outcomes of alternative management options based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions. Adaptive management emphasizes learning and adapting throughout the course or management through partnerships of managers, scientists, and other stake-holders who learn together how to create and maintain sustainable resource systems.

The Department of the Interior provides a technical guide to adaptive management and created the interdepartmental adaptation working group in 2005 to develop adaptation guidance and policy.[7] Six out of 23 federal agency participants noted that adaptive management was an important tool for managing ecosystems and species especially in the context of climate change. Others noted that monitoring will be a critical component of adaptive management in the future. Several federal participants said that agencies will need more institutional flexibility to develop adaptive management procedures to deal with climate change. Several state agency participants commented that management under climate change will take place in a dynamic environment and that this challenge requires a paradigm shift from assuming climate is static to understanding and adapting to a dynamic climate. Three state agency participants specifically referenced adaptive management.

The majority of conservation organizations and academics also indicated that adaptive management was an important framework for responding to climate change. Several academics identified the need for greater emphasis on adaptive management, with one adding that more fundamental changes are needed to improve the probability that management will achieve its objectives, including significant improvements in communication among researchers and managers. One example that was provided by an academic participant came from the Chesapeake Bay watershed, where efforts are underway to reduce nutrient inputs from point and non-point sources in an effort to reduce hypoxia. In this case, the system response has not been as predicted, so project managers are revising their strategy to calibrate the system level responses to the degree of change in land use management.

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[6] Sexton, W.T., A. Malk, R.C. Szaro, and N. Johnson (editors). 1999. Ecological Stewardship: A Common Reference for Ecosystem Management, Volume 3: Values, Social Dimensions, Economic Dimensions, Information Tools. Elsevier Science, Oxford, UK.

[7] http://www.doi.gov/initiatives/AdaptiveManagement/documents/SecretarialOrder3270AM030907.pdf

A note on mitigation: Several participants from the conservation NGO community and federal agencies noted that while adaptation is critical because of the inevitable impacts of climate change, the conservation community also needs to focus on mitigation. Participants stressed that reducing green house gas pollution is the only long term fix for climate change and the only permanent solution that will ensure the future of wildlife and natural resources. Two participants noted that some ecosystems, such as those in arctic Alaska and high alpine communities simply may not have any adaptation options available to them. This may be the case in more ecosystems in the future if immediate action is not taken to reduce emissions and curtail future warming and climate change. Two participants from federal agencies said that they were in the process of developing estimates for carbon sequestration due to restoration activities on federal lands.

Metrics

We also asked participants to discuss metrics for measuring "success," or monitoring the effectiveness of different adaptation techniques for meeting their management goals. For many this question was difficult because they are only in the early stages of adaptation planning. However, as several participants noted, it is essential that adaptation plans define clear management goals and design monitoring programs to address progress towards these goals. Metrics can be used to adaptively adjust management actions as more information becomes available. Thirty-five percent of federal agency professionals said that in order to establish metrics, land managers needed to define or modify goals and targets at the onset of adaptation planning and apply ongoing monitoring throughout the project to track progress towards these goals. State agencies are using or will use existing long-term data series to detect the impacts of climate change and eventually measure the effects of adaptation efforts. Both state and conservation NGO participants noted they are involved in developing metrics. For example, the Nevada Department of Wildlife is working to establish performance measures for each of Nevada's major ecosystem in the next six to eight months as part of the climate change revisions that will be incorporated into the SWAP.

Examples of hypothetical metrics suggested by participants included the number of coral bleaching events over a given period of time to determine if efforts are increasing the system's resiliency to bleaching; acres of land acquired or conserved; landscape connectivity; species population metrics; biodiversity metrics; habitat quality; water quality and the provisioning of ecosystem services. Many participants noted that sound science and monitoring will be an important component of successful adaptation work.

Several participants pointed to the challenging question, "how do we define management goals and what will these goals be in a climate change future?" Defining metrics of success is perhaps the biggest challenge to adaptation because it requires the identification of target outcomes. Until agreement is reached on what these outcomes are, adaptation practices can neither be planned nor implemented, nor can progress be monitored. Others expressed concern that it is unknown what an ecosystem's endpoint will be, or how a system will change with climate change, which makes setting goals and measuring success extremely difficult. Currently, managers often work to bring an ecosystem or species population to

historic conditions or population levels. Participants noted that in the future it will be difficult if not impossible to manage for these conditions. Ecosystems of the future will be moving targets, and it may be necessary to work towards preserving ecosystem function rather than managing for goals based on preconceived ideas of what a habitat should look like.

IV. Challenges

Climate change poses an unprecedented threat to natural resources, ecosystems and wildlife, and the challenges resource managers and conservationists face in terms of planning for or implementing an adaptation plan are similarly daunting.

State agencies and conservation NGO participants both ranked a **lack of resources, including funding, staff and institutional capacity as the number one challenge to planning for and implementing climate change adaptation activities.** A number of federal participants also noted that they require increased resources and capacity, while one academic participant said that greater support is required for long-term scientific studies. The need for resources comes as no surprise – fish and wildlife management agencies have long been stressed to the breaking point, and the recent economic downturn has impacted agency budgets. One conservation NGO participant remarked that ironically climate change adaptation became an acceptable strategy right around the time of the economic downturn, making it more difficult for everyone involved to secure the funding they need to start the work they've been waiting to be allowed to do.

Participants also expressed a tremendous need for **place-based adaptation techniques and strategies and examples of ongoing adaptation projects.** The conservation NGO and federal agency groups in particular highlighted the lack of tested approaches and case studies for managers on the ground who want more guidance than simplistic instructions to "increase connectivity," or "manage other stressors."

The need for further **development, revision and access to tools and models** was also identified as a challenge. Downscaled models, better predictive tools, linked ecological process and climate models, standardized monitoring methodology, GIS-compatible data, and vulnerability assessment tools were all identified as critical to the adaptation planning and the implementation process. Forty-eight percent of state agencies (10) indicated a need for models that predict climate change impacts at finer geographic scales and eight state agencies (47 percent) indicated that agencies still need to complete vulnerability assessments. Tools and models might help to address the challenge of planning for adaptation under uncertainty, an issue that weighs heavily on many federal and state agency participants. Several conservation NGO participants noted that they are developing strategies to help managers plan under uncertainty, such as employing scenario-planning.

Other challenges that were mentioned with some frequency included:

- a difficulty in setting goals or defining targets for management;
- lack of robust monitoring programs;
- lack of an agency-wide commitment to work on the issue or a political environment that does not allow or promote open and candid discussion;

- the lack of opportunities for collaboration between scientists and managers;
- the challenges associated with setting management goals and targets in dynamic systems;
- need for consistent definition for adaptation; using a better/different term than adaptation;
- the lack of a centralized climate adaptation clearinghouse or other outlets for information sharing; and
- other issues facing conservationists and managers, such as invasive species and habitat fragmentation are still monumentally challenging.

V. Expenditures

Climate change adaptation is going to require a significant investment of new funding. To characterize the costs associated with different aspects of adaptation, we collected available expenditure data from survey participants. At this time most expenditure data relates to planning costs and program budgets. Very few projects have been implemented on the ground to address adaptation goals and as such the survey revealed only a few cost estimates associated with specific adaptation strategies. Many participants noted that costs for planning and implementation activities vary widely and it may be difficult to get a comprehensive sense of the "cost of adaptation."

Table 4 reports cost figures for adaptation planning, various program budgets, research and monitoring, and restoration activities. Reported **planning costs** cover activities such as developing scenario planning prototypes, facilitating development of adaptation plans, and creating a statewide wildlife action plan. Though the latter was not completed to address climate change, the cost is representative of what a statewide assessment of climate change and wildlife resources might entail. Reported costs for planning activities ranged from $45,000 for the development of conservation tools, to over $800,000 for completion of a State Wildlife Action Plan.

Program budgets currently vary greatly, with a high reported by the USGS for their general climate change work, at approximately $35 million dollars per year. Some programs, such as the National Park Service and the Federal Highways Administration (FHWA) of the Department of Transportation do not currently have any funds designated for climate change work. Many participants who do not currently have budgets for climate change say they likely will in the future. **Reported research and monitoring** efforts ranged from $35,000 to close to $1 million, while **restoration efforts** in one national forest for a year cost approximately $5,000,000.

In the future, we may be able to estimate adaptation costs by looking at the costs of restoration or other management projects that have plans that have been revised to address climate change adaptation.

VI. Partnerships, Outreach and Communication

Partnerships

The importance of building partnerships to facilitate adaptation was universally recognized among survey participants. State, federal and conservation NGO participants noted that developing partnerships to work on adaptation was a key component of their work. Both NGO and federal participants stated that climate change was far too broad a challenge for anyone to take on alone. Participants noted a number of partnerships that have been formed to address climate change adaptation planning and implementation and they called for continued formation of partnerships, especially between scientists and land managers. The federal agencies also noted the importance of the science agencies working with the land management agencies to develop strong adaptation plans, establish sound scientific monitoring regimes, and deal with uncertainty.

Outreach and Communication

Survey participants communicate, share information, conduct outreach to their constituents or member groups, and learn about new adaptation techniques through attending conferences and working groups, informal conversations and email, giving presentations, facilitating panel discussions, or producing peer reviewed papers. A number of federal agencies and all conservation NGO participants interviewed have climate change information available on their websites. Informal internal groups, staff training and capacity development, development of outreach and educational tools, newsletters and other in-house publications were all mentioned as important communication strategies. Several participants noted that the information about adaptation and climate change is scattered and that tracking down the right information can be a challenge. To deal with this participants proposed creating a climate change adaptation online clearinghouse, producing regional guides to adaptation, creating a climate change adaptation multi-state collaborative effort similar to the Regional Greenhouse Gas Initiative, and developing an Adaptation Community of Practice to bring together experts and others working on the issue.

VI. Conclusion

The overwhelming majority of participants from federal and state agencies, non-governmental conservation organizations and the academic community recognized that adaptation measures to help all components of natural systems persist with climate change are urgently needed. Participants used a variety of definitions to explain adaptation, and a minority (12 participants) expressed concern about the term or did not define adaptation in a manner consistent with the idea that adaptation involves actions taken proactively or in response to climate change. We propose that ***adaptation for natural systems is a dynamic management strategy that involves identifying, preparing for, and responding to expected climate changes in order to promote ecological resilience, maintain ecological function, and provide the necessary elements to support biodiversity and sustainable ecosystem services.***

While there were few examples of adaptation projects on the ground now, participants are thinking about and planning for adaptation. All sectors have made programmatic changes within their agencies or organizations to begin preparing for climate change. Federal and state agencies are heavily involved in revising existing management plans, preparing new plans, designing adaptation strategies and monitoring protocols, developing metrics, and building capacity to deal with climate change. State wildlife agencies in Massachusetts,

California, Florida, Oregon and Washington have already made significant strides in the planning arena and several federal land management agencies are beginning to incorporate climate change into existing management plans. Conservation NGO and academic participants as well as some of the research oriented federal agencies tend to play a supporting role in these efforts, providing planning tools, synthesis of existing research and new information, and convening the right partners to guide planning efforts.

All participants reported significant challenges to planning for and implementing adaptation. The most common challenge cited by state agency and conservation NGO participants **is a lack of resources, including funding, staff and institutional capacity**. Participants also expressed a tremendous need for **place-based adaptation techniques** and strategies and **examples of ongoing adaptation projects** and further development, revision and access to **tools and models for adaptation planning purposes**. Other challenges ranged from agency acceptance of the problem to a lack of opportunities for collaboration between scientists and managers.

While the challenges presented are real, the responses from survey participants suggest that progress is being made to plan and implement adaptation strategies, develop tools and models for adaptation planning, and to help build capacity in state and federal agencies that do not currently have the resources to take on the challenge alone. In particular, promising partnerships are developing within and among the federal, state, conservation NGO and academic sectors and these partnerships will go a long way towards developing innovative solutions and implementing strong adaptation strategies. However, without increased funding and other resources to support adaptation efforts these partnerships alone will not be enough to prevent natural system collapse and biodiversity loss. The agencies responsible for managing the lands and waters of the United States and the agencies, organizations and institutions that support their work are in desperate need of new funding to fully understand, plan for and address the challenges ahead.

As Douglas Vincent-Laing, Species Assistant to the Commissioner at the Alaska Department of Fish and Game noted, "This is not all gloom and doom. We have dealt with landscape scale changes in the past; we can deal with this. It's just a matter of getting our best minds and resources focused on it."

Table 1: General categories of adaptation definitions given by interview participants.

Definition Used	**Count**
(1) Responses and proactive decisions made to address projected or current climate change impacts to reach some goal	35
(1a) Responses taken to moderate or diminish the impacts of climate change and conserve ecosystem integrity, function, and services in the face of climate change	18
(1b) Responses taken to allow natural systems and/or wildlife to change but maintain essential functions, resiliency, and integrity in response to an altered climate	13
(2) IPCC or IPCC-like: Adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderate harm or exploit beneficial opportunities	8
(3) Describes a process, examples include: Identifying resources and processes at risk from climate change, defining thresholds and reference conditions, establishing monitoring and assessment programs, and engaging in management action that increase the adaptive capacity and ecological resilience of these resources.	3
Lists actions, examples include: Restoring hydrology; strategic habitat conservation; re-prioritizing management decisions	9
Alternative uses or alternative terms used: Preparation; accommodation and adjustment	5
Scientific definition: Natural ability of a particular species to adjust its behavior, range, physiology, or other characteristics over time to enable it to survive in a new environment	8*

* Adds up to 69 responses, because 1 participant used both the IPCC definition and the scientific definition to discuss adaptation.

Table 2: Ongoing adaptation planning activities in state and federal agencies, non-governmental organizations, and academic settings

Type of Planning Activity	Examples
Revising plans or creating new plans	Evaluating and assessing current management practices Developing agency-wide strategic plan Using climate change information to revise existing management plans Reviewing other stressors Incorporating climate change adaptation into State Wildlife Action Plans Considering installation of adaptation strategies Employing vulnerability assessments to revise plans Using linked species-climate forecasting models Conducting impact assessments for planning purposes Identifying climate refugia for conservation prioritization purposes Identifying climate change thresholds Setting priorities for adaptation efforts based on vulnerability assessments Scenario planning to help define more clear management objectives based on range of model projections and identify critical places for monitoring
Convening working groups	Convening natural resource managers, scientists, and conservationists to develop conceptual framework for addressing climate change (CC) impacts
Developing tools, science, strategies, or guidance material for planning purposes	Developing adaptation strategies for specific management units or regions Developing monitoring protocols Developing conservation planning tools Developing predictive models for species, climate change forecasts or ecosystem responses Synthesizing scientific information to make it applicable for land managers Developing predictive science for climate change impacts on species and ecosystems Developing climate change primers for planning purposes Generating material to be used in planning documents

Table 3: Collected expenditure data from survey participants. Includes expenditures for planning activities, program budgets, research and monitoring to address adaptation needs, and restoration activities taken for the purpose of adaptation. Costs are approximate and represent best estimates from survey participants.

Category	Budget Item	Entity	Cost
Planning	Scenario planning prototype development for one plan over 12 months	NPS	$100,000
	Scenario planning development over 6 month period	World Wildlife Fund	$150,000
	EPA Climate Ready Estuaries Planning Facilitation in 6 estuaries	Environmental Protection Agency	$500,000
	Develop state-wide conservation strategy for sensitive bat species in California.	California Department of Fish and Game	$400,000
	Develop conservation strategy for the western pond turtle in California	California Department of Fish and Game	$250,000
	Develop statewide Comprehensive Wildlife Action Plan (not specific to climate adaptation)	California Department of Fish and Game	$809,000
	Develop State Wildlife Action Plan Implementation and Capacity Building Tools for Amphibian & Reptile Conservation (not specific to Climate Adaptation)	California Department of Fish and Game	$45,000
	Develop adaptation strategy to incorporate into State Wildlife Action Plan	Nevada Department of Fish and Game	$400,000
	Climate change adaptation planning workshops (per workshop)	National Center for Conservation Science and Policy	$100,000
	Develop regional action plan that identifies and prioritizes key habitat corridors that will allow for Species of Greatest Conservation Need migration at multiple scales	Hudson River Valley, New York	$146,000
Annual Program Budgets	NPS climate adaptation budget	NPS	$0
	NOAA coral reef watch program budget	NOAA	$1.5 million
	National Wildlife Refuge budget	USFWS	$0
	Total USGS CC budget	USGS	$35 million
	Climate change program	Manomet Center for Conservation Sciences	$500,000
	Adaptation in USGS budget	USGS	$9 million
	Federal Highways	DOT	$0

Research and Monitoring	Proposals for work on climate change studies on adaptation	USGS	$2.5 million
	USFWS research on climate change	USFWS	$250,000 to $500,000
	Population assessment and management for Spruce Grouse In Lowland Boreal Habitat of NY State	New York Department of Environmental Conservation	$120,000
	Monitoring of Bicknell's thrush for 2 years to provide baseline information needed to conserve Bicknell's thrush and other mountain birds.	New York Department of Environmental Conservation	$35,000
	Non-game fish and game priority research collaboration	California Department of Fish and Game	$987,000
	Assessment of Boreal Forest Bird Habitats in the Adirondack Park	New York Department of Environmental Conservation	$100,000
	Sea level rise study	SLAMM model	$50,000
Restoration	Annual restoration activities in Olympic National Forest	USFS	$5 million
	Restoration of 8 acres of marsh in Blackwater NWR	USFWS	$333,000
	Restoration and management on 10,000 acres of BLM land	BLM	Over $1 million

Appendices

APPENDIX A

Survey Participant List

Sector	Contact Name	Institution, agency or organization
Academic	Robert R. Twilley	Louisiana State University
Academic	Reed Noss	University of Florida
Academic	David Inouye	University of Maryland
Academic	Josh Lawler	University of Washington
Academic	Donald F. Boesch	University of Maryland
Academic	Erica Fleishman	Stanford University
Academic	Mac Hunter	University of Maine
Federal	Angela Zahniser	Bureau of Land Management
Federal	Dwight Fielder	Bureau of Land Management
Federal	Karla Bird	Bureau of Land Management
Federal	Amanda Babson	Environmental Protection Agency
Federal	Bill Jenkins	Environmental Protection Agency
Federal	Jeremy Martinich	Environmental Protection Agency
Federal	Jordan West	Environmental Protection Agency
Federal	Kevin Moody	Federal Highways Administration, Department of Transportation
Federal	Steve Earsom	Federal Highways Administration, Department of Transportation
Federal	Mark Eakin	National Oceanic and Atmospheric Agency
Federal	Leigh Welling	National Park Service
Federal	Brian Czech	U.S. Fish and Wildlife Service
Federal	Daniel M. Ashe	U.S. Fish and Wildlife Service
Federal	John Morton	U.S. Fish and Wildlife Service
Federal	Michael Bryant	U.S. Fish and Wildlife Service
Federal	Pete Jerome	U.S. Fish and Wildlife Service
Federal	Robert Adamcik	U.S. Fish and Wildlife Service
Federal	Joe Burns	U.S. Forest Service
Federal	Kathy Halleran	U.S. Forest Service
Federal	J.Michael Scott	U.S. Geological Survey
Federal	Jill Baron	U.S. Geological Survey
Federal	Sue Haseltine	U.S. Geological Survey
NGO	Gary Tabor	Center for Large Landscape Conservation
NGO	Nate Svoboda	Society for Conservation Biology
NGO	Lara Hansen	EcoAdapt
NGO	David Wolfe	Environmental Defense Fund
NGO	Stacy Small	Environmental Defense Fund
NGO	Gary Lovett	Institute for Ecosystem Studies
NGO	Hector Galbraith	Manomet Center for Conservation Sciences
NGO	Marni Koopman	National Center for Conservation Science and Policy
NGO	Jack Williams	Trout Unlimited
NGO	Molly Cross	Wildlife Conservation Society

NGO	Michale Glennon	Wildlife Conservation Society
NGO	Lesley Karasin	Wildlife Conservation Society
NGO	Steve Zack	Wildlife Conservation Society
NGO	Anne Schrag	World Wildlife Fund
State	Rocky Beach	Washington Division of Fish and Wildlife
State	Richard Leopold	Iowa Department of Natural Resources
State	Aaron Bruce	Iowa Department of Natural Resources
State	Tim Churchill	Tennessee Wildlife Resources Agency
State	Dennis Figg	Missouri Department of Conservation
State	Mike Harris	Georgia Department of Natural Resources
State	John O'Leary	Massachusetts Division of Fisheries and Wildlife
State	Amber Paris	California Department of Fish and Game
State	Dave Schad	Minnesota Fish and Wildlife Service
State	Tim Breault	Florida Fish and Wildlife Conservation Commission
State	Dave Whitehurst	Virginia Department of Game and Inland Fisheries
State	Doug Parsons	Florida Fish and Wildlife Conservation Commission
State	Laura Richards	Nevada Department of Wildlife
State	Jeff Vonk	South Dakota Game, Fish and Parks
State	Steve Ferrell	Wyoming Game and Fish
State	Mike Stone	Wyoming Game and Fish
State	Bruce Thompson	New Mexico Department of Game and Fish
State	Jim Tolan	Texas Parks and Wildlife Department
State	Doug Vincent-Lang	Alaska Department of Fish and Game
State	Patricia Riexinger	New York Department of Environmental Conservation
State	Tracey Tomajer	New York Department of Environmental Conservation
Other	Charles Kruger	Great Lakes Fishery Commission
Other	Wendy Watson-Wright	Department of Fisheries and Oceans, Canada

APPENDIX B

Adaptation Survey Methodology

This study presents results of a survey of natural resource professionals regarding natural resource and wildlife adaptation to climate change. This effort was conducted jointly by the Association of Fish and Wildlife Agencies (AFWA), Defenders of Wildlife (DOW), The Nature Conservancy (TNC) and the National Wildlife Federation (NWF), and was funded through a grant from the Doris Duke Charitable Foundation. The objectives of the survey were: 1.) To define natural resource adaptation to climate change; 2.) To compile a catalogue of adaptation techniques and strategies agencies and organizations are using to manage land under climate change; and 3.) To compile examples of ongoing adaptation projects across the country.

We identified potential survey participants with expertise in the field of conservation planning, resource management, climate change, and wildlife biology through our own staff and contacts. We targeted state fish and wildlife agency directors and managers, United States federal resource managers and policy-makers, academic scientists, and nongovernmental organization conservationists to gather information about their individual and/or agency involvement in managing natural resource adaptation to climate change. We selected participants to include a diversity of disciplines, job responsibilities, ecosystem/habitat expertise, and geographic distribution. We divided survey participants into three groups for the purpose of administering the survey: Group one included academics; Group two included state fish and wildlife agency directors and managers, an international fishery commission science director and a Canadian federal natural resource agency science director; and Group three included US federal natural resource agency managers and nongovernmental organization conservationists.

We conducted interviews with survey participants over the phone using a standard survey instrument (Appendix B) that was provided to them prior to their interview. Three interviewers, one for each participant group, conducted all the interviews. The three interviewers tested the survey instrument with a small subset of survey participants and discussed those results to assess the utility of the survey instrument and to assure a consistent interview approach with the remainder of the survey participants. No substantive changes were made to the survey instrument as a result of the initial test. Each interviewer recorded survey results either electronically or manually on a copy of the standard survey instrument. In addition to the questions on the standard survey instrument, each interviewer asked follow-up questions to elicit additional information appropriate to participants' discipline, expertise and job responsibility and used outside sources when suggested to further develop information provided through the surveys.

It is important to note that the responses captured are a survey, not a census, conducted over the telephone. Participants were not required to exhaustively discuss all agency- or organization-wide adaptation efforts, but rather to capture the work they know of or are involved with. Therefore omissions may have occurred and interviewee error could similarly have resulted in missing examples. The results of the survey should be read as representative examples, not an exhaustive and comprehensive catalogue.

APPENDIX C

Climate Change Adaptation Survey Guide

Interviewee: Interviewer:
Date:

Background Information

1. **What is your area of expertise**
   - Fisheries
   - Wildlife
   - Forestry
   - Ecology/Ecosystems
   - Other

2. **What role do you fill in your agency?**
   - Field practioner
   - Staff scientist/specialist
   - Manager
   - Executive
   - Other

3. **What ecosystems are you most familiar with?**
   - Coastal/Oceans
   - Freshwater
   - Forests
   - Grasslands/Shrubland
   - Other

4. Do you work with a particular species?

5. How long have you been working in this field?

Adaptation Questions

Definition

1. In two or three sentences, how do you define climate change adaptation for natural systems?

Best Practices

2. What changes have you made to your program's management planning process to account for CC impacts
3. Can you give me examples of practices or techniques you know of that you are employing on the ground to help your ecosystem/project area adapt to predicted changes in climate?

Metrics

4. How do you measure success when implementing an adaptation plan?

Challenges

5. What is your greatest unmet need in planning for or implementing adaptation practices?

Cost

6. In the past year how much have you budgeted for climate adaptation within your program

7. Do you have examples of specific projects or techniques with costs associated with them?

Partnering

8. Have you created partnerships or worked with others on adaptation projects?

9. How do you share information about your efforts or learn about new techniques from others?

APPENDIX D

FEDERAL AGENCY SURVEY

I. BACKGROUND & SURVEY SAMPLE

We contacted over 50 federal agency staff and 23 of those staff were able to participate in our study. Those interviewed represented the U.S. Fish and Wildlife Service (6 participants), the Environmental Protection Agency (4), the Bureau of Land Management (3), the U.S. Forest Service (3), the United State Geological Survey (3), the Federal Highways Administration (2), the National Oceanic and Atmospheric Administration (1), and the National Park Service (1). Collectively this group covered a vast geographic span, from Alaska to North Carolina, from agency headquarters in Washington D.C. to the wilderness of the Olympic National Forest. Eleven of the federal experts interviewed have expertise in ecology and ecosystem science; eight in wildlife biology; six in management and restoration ecology; four in the policy sphere; two each in fisheries, forestry, climate change, planning, and oceanography and one in coral reef ecology. Twelve of the participants serve as staff scientists within their agencies, while eight are in a management role (of their program, division, or management unit). Another four participants serve in an executive role.

Almost half (11) of the participants described their work as addressing multiple ecosystems and 14 said they do not work on one particular species. Eight participants work or have past experience working in coastal and oceanic systems; five in forest ecosystems; five in grassland and shrubland ecosystems; four in freshwater ecosystems; and two in deserts. Experience with particular species included work on the prairie grouse, desert tortoise, spotted owl, sage grouse, red wolf, piping plover, brown bear, martin, and many others. The majority of participants (16) have over 20 years of experience in their field.

II. DEFINING ADAPTATION

Federal experts put forward a variety of definitions of adaptation. While responses differed, there were some commonalities within the group. Twenty-one out of 23 participants said that adaptation involved taking new actions, making decisions, and planning for or managing natural systems. Seven participants specified that enhancing resiliency was a critical component of adaptation. Six participants use the IPCC definition of adaptation, "adjustment in natural or human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities." Some of the more specific actions participants considered to be adaptation included adjusting management practices and objectives to account for climate change and changing conditions (4); maintaining and minimizing disruptions to ecological flows and processes (3); reducing non-climate threats (3); using strategic habitat conservation or planning (2); increasing connectivity (2); identifying resources or processes at risk; maintaining representation; maintaining redundancy, resilience, and connectivity; helping species adapt to change; facilitating species movement; changing organizational missions; and working to understand how habitats are moving. Other terms mentioned included proactive, strategic, and comprehensive change.

Several participants outlined a process-based definition to describe adaptation. One participant directed me to a recent publication that described the process: "Successful adaptation of natural resources to climate change begins by identifying resources and processes at risk from climate change, defining thresholds and reference conditions, establishing monitoring and assessment programs, and engaging in management actions that increase the adaptive capacity and ecological resilience of these resources**."**[8] Another said that adaptation was a process of working to reduce risks and improve resiliency by proactively identifying areas that are particularly vulnerable, monitoring for changes, and developing or implementing adaptation plans.

Other participants expressed caution or outright dislike of the term adaptation used beyond its original biological meaning. These respondents pointed out that the biological definition of adaptation is "Any change in the structure or functioning of an organism that makes it better suited to its environment."[9] This process occurs at an evolutionary time-scale, rather than at the time scales of rapid human responses to manage change and help systems adapt. Participants noted that the confusion between the terms is potentially detrimental and needs to be avoided at all costs. One participant strongly disliked the use of the term and preferred the term "accommodation" to describe the concept, and that managers should be working towards helping natural systems accommodate change.

III. BEST PRACTICES

Programmatic Changes

Federal participants indicated that the first step in addressing adaptation to climate change within federal agencies is making climate change a part of program priorities, securing increased funding to reflect that new focus, changing program planning and increasing capacity to address adaptation. Under this lens, participants identified a number of internal agency changes that have been made in an effort to address climate change. The DOT, USGS, USFS, EPA, NOAA, NPS and USFWS now have information about climate change on their websites and some have recently released climate change planning tools available online (more below). Participants from four out of eight agencies said that their agencies have made addressing climate change a part of their overall agency strategies or program areas, while two agencies reported that there has been no official change to their programs. Two participants are from programs within their agency that were created solely for the purpose of dealing with climate change, such as the Climate Ready Estuaries Program of the Environmental Protection Agency. Many other participants noted that they are now evaluating existing programs to determine how to address climate change or refocus their efforts in light of climate change.

One participant from the U.S.Fish and Wildlife Service noted that at this point changes in management or planning are mainly reactive to deal with current impacts of climate change, but in the future they expect this to change. USFWS is currently completing a strategic plan

[8] Baron, J.S., L. Gunderson, C.D. Allen, E. Fleishman, D.H. McKenzie, L.A. Meyerson, J. Oropeza, and N. Stephenson. In review. Options for National Parks and Reserves for Adapting to Climate Change.
[9] Oxford English Dictionary (www.oed.com)

for climate change, as well as a climate change action plan for National Wildlife Refuges. USFWS has also formed an intra-agency body to address climate change.

One participant noted that climate change has increased the horizontal flow of ideas within the agency and has led to more collaboration and increased interagency work. For example, National Park Service is now offering more informal and educational opportunities to engage the public on climate change and has been working with the EPA for some time to make NPS "climate friendly," in terms of emissions reductions. The program provides national parks with management tools and resources to address climate change through emissions reductions both within park boundaries and the surrounding community.

Planning

All federal agency staff interviewed are thinking about climate change and planning for adaptation. The development of adaptation strategies and tools was a major component of their ongoing work. Currently, participants from five out of eight agencies reported that in some cases they are incorporating climate change information (including impacts and management strategies to deal with climate change) into revisions of existing management plans. For example, general management plans for several national parks now include limited information on climate change. These parks include Golden Gate National Park, Everglades National Park, Channel Islands National Park, Gateway National Park and Apostle Island National Park. In the future more NPS management plans will include climate change and scenario based planning. Similarly, participants from the U.S. Fish and Wildlife Service report that climate change is slowly being incorporated into Comprehensive Conservation Plans for National Wildlife Refuges.

At least five of the federal agencies interviewed have staff involved in partnerships, collaborative workshops or focus groups working on climate change adaptation. One such partnership has evolved on the Albemarle Peninsula in North Carolina. The Alligator River National Wildlife Refuge Complex on the Albemarle Peninsula is involved in coalition with groups including The Nature Conservancy, Duke University, and the Department of Defense, and is developing an adaptation plan to prepare for the local impacts of sea level rise on the Peninsula. The group is developing a hydrologic model for the Alligator River to guide restoration of the altered landscape with water control structures. The partners are also considering the use of salt tolerant native species to aid restoration efforts and the installation of oyster reefs close to and paralleling refuge shorelines. These oyster reefs will dampen wave action thus reducing shoreline erosion, simultaneously improving water quality and benefiting the shellfish industry. These reefs would reduce wave energy, and erosion, and could contribute to shoreline enhancement. The oyster reefs create new shallow-water habitats, and semi-sheltered shores. Finally, the partners are working to develop monitoring protocols to track project results, developing linked species-habitat models to use as decision support tools, and developing methods to monitor carbon sequestration derived from restoration practices on the refuge.

Many of the participants interviewed noted that they are involved in projects to develop adaptation strategies, tools to refine conservation plans, or models to help understand impending changes. Tools are aimed at assessing impacts and vulnerabilities to climate change, using scenario-based planning to revise existing management plans, creating new

tools for prioritizing land for conservation efforts, identifying climate refugia and planning for landscape connectivity.

Tools have also been developed to predict and alert managers to present and future climate-related stress. NOAA's Coral Reef Watch program has developed several tools that utilize remote sensing and in-situ observations for near real-time and long term monitoring, modeling and reporting. The tools are designed to help manage and monitor the risks to coral reefs from bleaching events associated with high temperatures. The tools alert managers to the possibility of thermal stress, which allows managers to better respond and monitor during these events. The tools also provide seasonal forecasts that allow managers to track when reefs may be likely to experience thermal stress. Managers can monitor for change based on those predictions. Unfortunately, there is currently little that can be done to stop a bleaching event, but NOAA is also working to develop strategies to prevent or reduce bleaching. NOAA also has similar tools for ocean acidification and has produced publications on managing for coral bleaching with management strategies for reefs during bleaching events, information about maintaining system resilience, identifying more resilient reef areas, restoring reefs, understanding the factors that lead to bleaching events, monitoring bleaching events, and communicating with the public about the damages to the reef system.

Modeling is a critical component of planning for adaptation to a changing climate. Models are being developed within federal agencies to assess vulnerability to sea level rise, to identify climate refugia, to examine species-vegetation shifts, and to plan for connectivity and linked landscapes. In Alaska, the U.S. Fish and Wildlife Service is working in partnership with a dozen state, federal and NGO partners to examine the cumulative impacts of natural processes and disturbances, including climate change on the Kenai Peninsula. This model will allow the partners to understand the relative impacts of climate change in relation to other landscape changes. The Fish and Wildlife Service is also involved in an effort facilitated by the Scenarios Network for Alaska Planning (SNAP) to sustain landscape levels of biodiversity by creating a connected landscape. This effort is using scenario-based planning to complete a state-wide strategic habitat conservation assessment with the goals of (1) Identifying lands and waters in Alaska that likely serve as landscape-level migration corridors currently and in the future given climate change; and (2) Identifying conservation strategies with partners that would help maintain landscape-level connectivity by focusing conservation efforts, minimizing redundant research and monitoring efforts, and by sharing data and information for these areas.[10]

The National Park Service is developing scenario-planning to guide future revisions of their general management plans. The scenario planning as a framework allows managers to implement "bet-hedging options," to plan management options for a suite of future scenarios. This type of planning will allow managers to deal with the uncertainty associated with climate change predictions and modeling. While managers may not have the information to predict exactly how their system will change, scenario planning will give them a sense of the variation they can expect and allow them to take action in the near term to manage for a range of future conditions. Other agencies, such as USGS, NOAA, and the

[10] www.snap.uaf.edu/news/ongoing-project-landscape-connectivity

EPA are involved in predictive modeling or research to support climate change adaptation and the synthesis of relevant planning and management information for managers.

Several federal agencies provide both internal and external guidance for adaptation planning. For example, the Environmental Protection Agency recently developed the Climate Ready Estuaries Program to help the National Estuary Programs (NEPs) and coastal communities become 'climate ready' by providing tools and assistance to assess climate change vulnerability and to plan for adaptation.[11] The program provides a web-based toolkit (www.epa.gov/cre/toolkit.html) with information, data, planning tools, webinars, workshops, adaptation options and technical assistance for NEPs and coastal managers. The program is also providing targeted assistance to a small group of NEPs to identify climate change vulnerabilities, develop adaptation plans, and begin to implement selected adaptation strategies. The EPA will use these projects to assemble lessons learned and to inform future efforts.

As part of the targeted group, the Partnership for the Delaware Estuary (The Partnership) is working with its collaborators in the watershed to begin evaluating which resources are most at risk and prioritizing what should be done to monitor, protect, or defend the most valuable and vulnerable features. The Partnership's Climate Adaptation Project will focus on assessing vulnerability and adaptation needs for three critical "case study" resources in the Estuary: drinking water, tidal wetlands, and shellfish. The final product will be an adaptation plan that will provide new guidance on monitoring, management actions, and policies that have the greatest benefit for maximizing the "natural capital" of these key life-sustaining features in the Delaware Estuary and its watershed. The project is also examining the cost of sea level rise in terms of lost ecosystem services. Researchers at EPA are exploring how ecosystem services change or are lost as coastal community composition shifts due to sea level rise.

The U.S. Forest Service has also compiled information to guide the planning process. The service recently released the following guidance documents: Climate Change Considerations in Project Level National Environmental Policy Act (NEPA) Analysis, and Climate Change Considerations in Land Management Plan Revisions. These documents are intended to provide the agency with support as they work to incorporate climate change into land management planning and NEPA analysis. The guidance documents address both how management decisions may influence climate change through changes in global pools of greenhouse grasses, and how climate change will affect forest and grassland ecosystems.

While the majority of participants (21 out of 23 or 91 percent) admitted they are in the early stages of adaptation, all survey participants noted that they are at least considering adaptation strategies on their lands, reviewing existing stressors to these systems, or evaluating current management techniques and thinking about how these may need to change with climate change. They stressed the need to work collaboratively when possible, to learn to deal with uncertainty, and to increase public engagement on the issue.

On-the-Ground Strategies

[11] http://www.epa.gov/cre/

While planning efforts are ongoing across the agencies interviewed, there are very few on-going adaptation projects. Participants noted that many of their current management and restoration projects address aspects of climate change adaptation, but were not implemented with adaptation in mind. These include removing invasives, restoring riparian ecosystems, and forest thinning. Many participants also were able to suggest adaptation strategies that they have been thinking of or hearing about. These included hydrologic restoration, riparian and stream restoration, invasive species removal, forest thinning, erosion prevention, removal of barriers to migration, translocation of species, strategic growth of conservation lands, managing sprawl, increasing landscape connectivity, implementing bet-hedging options, using adaptive management approaches, and employing scenario planning. However, very few agencies are implementing these actions specifically to address climate change at this time.

Reduce other elements of global environmental change: Twenty-two participants noted that managing for current stressors, such as habitat fragmentation, sprawl, invasive species, intense fires, and altered hydrologic cycles is an important aspect of adaptation, and something that is already ongoing. One of the participants from the U.S. Fish and Wildlife Service noted that the overall strategy for the National Wildlife Refuge System is to manage these "other" stressors and that their ongoing efforts will help these systems to be more resilient to change in the future. One participant stressed that currently the biggest threat to ecosystem comes from land and water conversion, not from climate change. He said that if we are able to manage this threat adapting to climate change will be easier, but if we don't manage sprawl and habitat destruction now climate change will be unstoppable. At present, there were no examples provided by federal agency of ongoing management strategies that have been revised based on adaptation planning.

Establish habitat buffer zones and wildlife corridors: Improving habitat connectivity and establishing habitat buffers was an adaptation strategy discussed by the majority of survey participants (18). Currently, connectivity planning projects with federal participation (outlined above) are ongoing in Alaska. Other efforts to create networks of connected conservation lands include green infrastructure assessments, a powerful conservation planning tool employed by EPA's Region 3 Environmental Assessment and Innovation Division. Green infrastructure is a concept used to describe strategically planned and managed networks of natural lands, working landscapes and other open spaces that conserve ecosystem functions and provide associated benefits to human populations.[12] Under climate change, the need to conserve connected networks of land with natural resource and wildlife value becomes increasingly important. Connected networks of conservation land will allow species to migrate in response to climate change, to protect ecosystem services, sequester carbon, and maintain ecosystem resilience and natural disturbance cycles. In Region 3, the EPA has partnered with several states including Maryland and Virginia as well as municipalities to complete green infrastructure or natural infrastructure assessments to guide conservation and development in the future. While non-regulatory in nature, these assessments can help communities strategically plan for natural resource goals as well as economic growth and development. Efforts are currently underway in Pennsylvania and West Virginia to complete GI-assessments, and climate change is something that may be considered as part of these plans.

[12] http://www.greeninfrastructure.net/content/definition-green-infrastructure

Implement "proactive" management and restoration strategies**:** Participants noted a variety of strategies that may be used in the future to actively facilitate the ability of species, habitats and ecosystems to accommodate climate change impacts. Potential future strategies suggested by participants included species translocation, planting alternative species that are more resilient to specific impacts of climate change and using dredge materials to enhance marsh accretion rates in areas threatened by sea level rise. One participant noted that the BLM is thinking about planting southern genotypes of plant species further north and higher in elevation as part of future restoration efforts. Another commented that BLM has already been using a different species mix for reseeding after fire events because of dryer than usual conditions in the West. A national wildlife refuge manager noted that more salt tolerant species may be used in future marsh restoration efforts to account for rising sea level.

An ongoing example of proactive management and restoration comes from Blackwater National Wildlife Refuge (NWR) on the coast of Maryland. The refuge has been losing ground since the 1930's at a rate of 150-400 acres a year due to sea level rise, coastal subsidence, erosion, saltwater intrusion and invasive species. The Blackwater National Wildlife Refuge's Comprehensive Conservation Plan calls for the refuge to restore the wetlands to 1933 conditions, a challenge in light of the rapidly rising tide and loss of 8,000 acres of land. Already, there have been a number of restoration efforts at Blackwater. In the early 1980's approximately 12 acres of marsh were restored, while a project in 2003 restored a total of eight acres. The 2003 project cost approximately $333,000 to implement, and has been carefully monitored since that time.

Other strategies to reduce coastal loss at Blackwater NWR include the installation of a weir on a canal to reduce salt water intrusion; a highly successful extirpation of over 9,000 invasive nutria; controlling populations of resident Canada geese to protect sensitive vegetation; and installing straw bale wave breaks. More recently, the U.S. Fish and Wildlife Service, the U.S. Army Corp of Engineers, the Maryland Port Administration, and the University of Maryland have partnered to form the Maryland Mid-Chesapeake Bay Restoration Project. The project seeks to restore recently inundated wetland in Dorchester County and the refuge. Future restoration efforts may utilize dredged material taken from the approach channels to the Baltimore Harbor in the Chesapeake Bay. The Maryland Port Administration must remove 3.5 - 4 million cubic yards of dredged material each year, and the dredge could potentially be used to expand Poplar Island, conduct large island restoration in the mid-Chesapeake Bay, or complete wetland restoration in Dorchester County and Blackwater Refuge. The feasibility, practicality, cost, and benefits of the restoration efforts still need to be assessed and the cost is expected to quite high.

Increase monitoring and adaptive management practices**:** Federal agency survey participants recognized the need for monitoring and adaptive management to understand the impacts of climate change on natural systems. Six participants noted that adaptive management was an important tool for managing ecosystems and species with climate change.

Existing species and ecosystem data may help managers to plan for and track changes that are happening in response to climate change. One participant noted that existing data has generally not been examined through the lens of climate change and there may be opportunities to use this data in new ways. Monitoring efforts focused on climate change

are currently ongoing in Alaska. Unlike many of the refuges in the lower 48 states, Kenai National Wildlife Refuge is actively monitoring variables in the context of climate change, including glacial recession, methane outputs from marshes, and fires. NOAA's Coral Reef Watch Program is also actively engaged in monitoring and assessing the status of coral bleaching events around the world and helping managers to monitor bleaching events as they happen to aid future management efforts.

Participants also cited efforts to develop monitoring techniques. For example, the U.S. Fish and Wildlife Service staff at the Alligator River National Wildlife Refuge Complex is working with other partners to develop outcome-based monitoring and assumption-driven applied research to monitor on-the-ground strategies for dealing with sea level rise. The Climate Ready Estuaries program at EPA is also working to help the National Estuaries Program and other coastal areas plan for monitoring the effects of sea level rise in the future. Others noted that monitoring will be a critical component of adaptive management in the future.

Metrics

This question was difficult for many survey participants due to the lack of ongoing adaptation projects and because as many noted, defining or modifying goals and targets for management under climate change is a complicated topic. Only several participants are currently using metrics to monitor ongoing adaptation work, but many are planning for and thinking about metrics.

Eight participants noted that in order to establish metrics for measuring success, land managers need to define or modify goals and targets at the onset of adaptation planning and apply ongoing management throughout the project to track progress towards these goals. Hand in hand with establishing goals and targets is establishing a baseline, and as one participant noted, baselines have been contentious in the past and in a climate change world have the potential to become more so as baselines become "moving targets." Participants noted that management goals may vary dramatically and will be site and context specific and that the processes that are most important to protect need to be identified. One participant suggested that scenario planning is an integral tool to employ when setting goals and making decisions. Scenario planning allows the users to work with multiple plausible scenarios to make management and planning decisions based on a range of possible futures.

Six participants noted that adaptive management was a key component of adaptation planning and monitoring and that the adaptation process should include ongoing monitoring and refinement. While participants were hesitant to discuss specific metrics that could be used to monitor the effect of different adaptation strategies, 11 suggested general species or ecosystem related metrics, such as ecological integrity indicators, assessing degrees of ecological connectivity, species population metrics, species occurrences and viability metrics, and measures of ecological complexity. Two participants mentioned that measuring acres of conserved land is a simple but important metric to measure our progress towards maintaining open and un-fragmented habitat to provide the opportunity for species and ecosystems to adapt. Examining the strategic location of these lands on the landscape may also be an important component of this measurement. Several participants noted that the actual monitoring process and even some of the metrics are not likely to change, but the variables of interest and the management goals may shift.

Finally, several participants are engaged primarily in facilitating the adaptation process, rather than managing land or species on the ground. They defined and measured success somewhat differently and in some cases had a more clear idea of how they would monitor success. For example, the number of people using a tool developed to predict the impact from climate change stressors, or the number of state wildlife action plans incorporating staff-developed climate adaptation information could be a measure of success for these types of efforts.

IV. CHALLENGES

The most frequently cited challenge among federal agency employees was the need for place-based techniques and strategies for adaptation and readily available examples of techniques that are currently in use. Participants noted that while significant general guidance exists for managing lands in a climate change world, there is little information available listing specific techniques that can be used to manage ecosystems and species under climate change and even fewer examples showcasing adaptation strategies in specific locations. The lack of sufficient models and other tools was cited by 5 federal agency employees. Participants listed tools such as downscaled climate models for their region, linked ecological and climate forecasting models, and tools to value and measure ecosystem services as an imperative component of planning and managing under climate change.

A lack of institutional capacity and resources to work on climate change was a challenge noted by 6 survey participants. One respondent noted that staffing up on climate change was the number one challenge to the agency. Others noted that increased training opportunities, outreach and education, and staff training on climate change and adaptation were urgently needed. Other challenges identified included a significant lack of funding; the scale and scope of climate change; failure to address the root causes of climate change and biodiversity loss; lack of internal commitment to work on climate change; a lack of data on the efficacy of different strategies for adaptation; difficulties around planning under uncertainty; a lack of detailed information about certain impacts of climate change (e.g. restoration after fire); lack of critical resources, such as a centralized data repository for climate change impact studies; existing framework of laws, regulations, and policies that are too rigid to deal with climate change; fear of litigation if the wrong decision is made; the need for institutional flexibility to manage adaptively and learn from mistakes; monitoring needs; limited opportunities for collaboration; the convergence of multiple stressors; lack of comprehensive risk assessments; barriers to species migration; and finally, defining goals and targets and determining what endpoint you are managing towards.

Though not cited specifically as a challenge by many of the participants, setting goals and targets for management areas in the future was a concern that surfaced in a number of surveys. One participant said that you cannot implement management strategies, monitor these strategies, and learn from your work in an adaptive management framework unless you have defined the targets you are managing towards. Traditionally, federal management targets have been based on historical conditions, with an acceptable range of variations around these "static" conditions. A number of participants noted that managing under climate change will require a vastly different approach because of the dynamic nature of ecosystems that are responding to change as rapid and broad in scope as climate change.

V. EXPENDITURES

Costs for ongoing adaptation strategies were not available from most federal participants because few adaptation projects are underway. We did manage to capture some of the costs involved in planning, program budgets, research and tool development and restoration (both proactive restoration and restoration to reduce existing stressors). Planning costs included development of a scenario planning prototype at the National Parks Service, and the development of 6 adaptation plans through the EPA's Climate Ready Estuaries Program. Several participants offered estimates of their overall agency or program budget for climate change work. The National Park Service, National Wildlife Refuge System, and the Federal Highways Program currently have no funding specifically designated for climate change adaptation. Other agencies, such as the USGS, have a huge budget of around $35 million for climate change work and an estimated program budget of $9 million specifically for adaptation. Agency participants also gave examples of specific research items, and restoration activities (Table 2).

One National Wildlife Refuge Manager noted that while the current budget for climate adaptation is at zero dollars, he is developing a project proposal with partners asking for $3 million in funding to implement a number of different adaptation strategies including developing a hydrologic model to guide restoration efforts, planting of appropriate native plant species, installation of oyster reefs, developing outcome-based monitoring and assumption driven applied research to monitor on-the-ground project results, developing species-habitat models, and measuring carbon sequestration derived from the restoration practices.

Many participants noted that the scale and scope of the adaptation strategy will determine future costs and that while there is little being spent currently within their agencies, they expect this to change with the change of administration in January 2009.

VI. PARTNERING, COMMUNICATION & OUTREACH

Partnering

Creating partnerships and working collaboratively was overwhelmingly identified as a key component in federal climate change adaptation efforts. Of 24 participants, 20 said they are involved in creating new partnerships to work on adaptation. One example of this is the partnership effort developing on the Albemarle Peninsula where a number of groups including the USFWS, the Department of Defense, the EPA, the Nature Conservancy and others are working on a plan to help multi-jurisdictional coastal lands adapt to sea level rise. Participants noted that climate change adaptation was far too broad a challenge to address in isolation, and that the scale and scope of climate change would require coordinated efforts across all agencies and non-governmental organizations. The agencies also talked about the importance of the science agencies working with the land management agencies to develop strong adaptation plans, establish sound scientific monitoring regimes, and deal with uncertainty.

In addition to new partnerships, seven participants said they are involved in existing climate change adaptation research partnerships and 9 participants said existing partnerships they are involved with are considering climate change as they move forward.

Communication and outreach

Participants were also asked to share how they communicate about climate change adaptation, conduct outreach and learn about new adaptation strategies and techniques. The answers included many standard methods of communication, such as email and phone calls with personal contacts, as well as more centralized approaches, such as developing climate change resource centers to facilitate communication, outreach and knowledge transmission. The most frequently cited way to communicate and learn new strategies was through attending conferences, summits, and focus groups (13 participants). Ten participants noted that interviews, informal conversations and email was part of their communication efforts, while another ten said they give presentations, facilitate panel discussions, or lead webinars. Nine participants actively produce peer-reviewed scientific literature to communicate their research and 7 produce and read newsletters, fact-sheets or other in-house publications.

All agencies interviewed had some amount of climate change information available on their website (difficult to find on BLM and FWS website). Several agencies, including the EPA, NOAA, USFS, USGS and DOT now have detailed climate change information and tools available for planning, and developing adaptation strategies for climate change. The recently launched web-based clearing house of information on transportation and climate change from the DOT provides an introduction to climate change as it relates to transportation, lists impacts and adaptation options, mitigation strategies, links to federal, state and local action plans and policies, and other resources. The US Forest Service devotes an entire section of their website to climate change with many useful links and internal publications. They have also developed an online climate change resource center.

Other communication, outreach, and learning strategies included informal internal groups, federal interagency working groups, staff training and capacity development, agency intranet use, webinars, outreach publications, developing training and awareness tools, and informal and formal educational products. Many staff interviewed noted the importance of communication and called for a centralized source for climate change information, specific to adaptation and natural resource management. One participant noted that sharing information and learning about new research or management efforts can be a big challenge because there is not one area of central clearing house that he knows of for this type of information. Because of this lack there may be duplicative efforts. He suggests the formation of a Climate Change Adaptation Community of Practice that would involve federal and state agencies, NGOs and other stakeholders.

APPENDIX E

STATE AGENCY INTERVIEWS

I. BACKGROUND AND SURVEY SAMPLE

We surveyed 23 individuals including 21 state fish and wildlife agency members, the science director of the Great Lakes Fishery Commission and the Assistant Deputy Minister, Science for the Canadian Department of Fisheries and Oceans. State fish and wildlife agency members interviewed included Alaska, California, Florida (2), Georgia, Iowa (2*), Massachusetts, Missouri, Minnesota*, Nevada, New Mexico*, New York (2*), South Dakota*, Tennessee, Texas, Virginia, Washington, and Wyoming (2*) (*Denotes agency Director was interviewed).

The 23 individuals interviewed were asked a series of questions to describe their area(s) of expertise; the role they fulfilled in their agency, the type and location of ecosystems they were most familiar with, species they focused on, and how long they had worked in the field. Respondents could select more than one area of expertise and type of ecosystem they were familiar with.

Twelve individuals indicated they possessed wildlife expertise, 11 had expertise in ecology and ecosystems, nine in fisheries and two in forestry. Twelve respondents indicated the performed and executive role in their agency, five functioned as a staff scientist/specialist, four were managers and two described themselves as policy analysts. Twelve individuals were familiar with freshwater ecosystems, seven with grassland/shrubland ecosystems, six with forest ecosystems, five with coastal/ocean ecosystems, three described themselves as having broad-based ecosystem knowledge and one was familiar with desert ecosystems. The respondents all described themselves as working with a broad range of species and habitats. The interviewees were a highly experienced group of professionals. Sixteen individuals had worked in their field for more than 20 years, five had 10 to twenty years of experience and two had five to ten years of experience.

II. DEFINING ADAPTATION

Asking 23 highly trained, competent, experienced natural resource professionals to define climate change adaptation for natural systems is akin to asking 23 devoted wine lovers to describe a wine they all just shared. No two perceive it the same. That being said, some common elements did emerge from the 23 vintage definitions of climate change adaptation the survey respondents offered. The most frequently mentioned (16 of 23 responses) was that climate change adaptation includes people taking action, making decisions or managing. That was followed closely (15 of 23) by the concept that action will take place in an environment of changing or dynamic climate (one also noted, importantly, the uncertainty of the change), in contrast to traditional natural resource management approaches where climate wasn't considered a variable. Conserving species, habitats or biodiversity was cited as an element of adaptation by 14 of 23 respondents. Six respondents discussed the concept of resiliency, while five spoke of sustaining or increasing uses and benefits. Two

respondents drew a distinction between climate change adaptation and climate change mitigation by defining mitigation as effort to limit the climate change.

III. BEST PRACTICES

Planning

The survey responses indicated fish and wildlife agencies have taken a variety of actions to help them plan for climate change adaptation. The actions including creating internal planning bodies; using the agency Wildlife Action Plan as the vehicle to plan for climate change adaptation; adding or re-tasking staff other than their wildlife diversity program manager to coordinate adaptation planning; assigning their wildlife diversity program manager to coordinate adaptation planning; modifying agency plans (e.g. land acquisition, species restoration) other than the WAP to include climate change adaptation; participating in inter-agency climate change bodies; conducting, or planning to conduct research and/or modeling on climate change impacts; conducting, or planning to conduct vulnerability assessments for species or habitats; training and coaching staff to increase technical or cultural capacity with the agency; and altering regulatory or development project review processes to accommodate climate change consideration.

A majority of the respondents, representing 12 of 21 agencies, indicated their agency has created an intra-agency body to address climate change impacts on fish and wildlife resources and to plan for climate change adaptation. Variously titled as committees, think tanks, or working groups, these bodies usually included high level managers or agency executives and were assisted by supporting staff. For example, Florida has a four-person internal team to stimulate internal capacity development and integrate strategic planning within all agency Divisions. This team is staffed by a policy analyst and infrastructure under this team includes a Communication and Outreach Team and a Research and Monitoring Team. The Team will redefine conservation objectives and examine key questions regarding "exotic" species and threatened and endangered species issues – today's exotic may become tomorrow's native – also looking at how definitions of endemic, threatened etc are being changed, challenged by climate change. In turn, each program division within the agency has its own internal team to focus on climate change adaptation within each division. California has an internal Climate Change Task Force that includes policy level people and is tasked with identifying and picking the issues the agency needs to address to deal with climate change as well as a Climate Change Advisor who reports to the agency Director.

In addition to internal working groups, seven state agencies (AK, CA, IA, NM, NY, VA, WA) are members of inter-agency bodies tasked with dealing with climate change. These inter-agency groups are mostly at the state Governors' cabinet or sub-cabinet level and are charged with addressing the full range of climate change impacts. The state fish and wildlife agency role is to ensure that natural resource issues are included in the process.

Most of the state fish and wildlife agencies (10 of 17) have elected to us their Wildlife Action Plan (WAP) as a vehicle to accommodate planning for climate change adaptation. This approach allows agencies to take advantage of the work that has already gone into conservation planning for so-called species of greatest conservation need – the species that may be most at risk of climate change impact. It also allows agencies to utilize existing

internal and external networks that were created to develop the WAP. For example, California considers the WAP to be a critical vehicle for outreach and communication and for developing research needs and priority actions for each bioregion within the state. Nevada has begun a year and a half process to develop an adaptation strategy to incorporate in their WAP using $400,000 in state bond fund monies. This strategy will cut across all agency divisions. They have engaged partners who helped develop their original WAP to assist with this effort and have contracted with the University of Nevada – Reno to write a white paper about climate change impacts on fish and wildlife to serve as guidance document for the WAP revision process.

Nine state agencies have added staff or reassigned an existing staff member, other than the wildlife diversity program manager to improve capacity to deal with climate change and planning climate change adaptation. Some states (AK, CA, TN) have assigned a special assistant or advisor to work directly with the agency Director; others (FL, IA, NM, NY, SD) have added capacity at the staff specialist level; and some have tasked an existing program division chief to focus on climate change(FL, WY). Five state agencies (GA, MA, MO, NV, WA) have assigned the lead to the person who manages the wildlife diversity program or is the WAP coordinator.

Eight state agencies (CA, MA, MN, NY, TN, TX, WA, WY) have changed planning processes in addition to the WAP to include consideration of climate change adaptation. Most of the coastal state agencies interviewed (CA, NY, TX, WA) have some planning process underway to deal with sea level rise and/or freshwater inflow changes and have incorporated fish and wildlife issues in this process. Massachusetts is incorporating climate change adaptation considerations in habitat acquisition planning, landowner incentive program (LIP) planning and habitat management planning for state owned/managed lands. Washington is adapting all major plans for climate change strategies, for example the. Salmon and Steelhead in the 21st Century Plan includes consideration of climate change impacts. In addition, Washington has employed a so-called "Stronghold" approach in its planning processes. This approach focuses attention on those areas that are most pristine and least affected and therefore are thought to be best able to withstand/adapt to climate change impacts. The Department of Fisheries and Oceans Canada has formed a Science Management Board chaired by the Deputy Minister and including sector directors. This board is working to integrate climate change as an issue within the Department's ecosystem-based management framework.

Seven of the state agencies interviewed and the Canadian Department of Fisheries and Oceans (CA, FL, MA, MN, NV, TN, WA, DFO) are conducting or plan to conduct significant research or modeling projects or programs to gain information to help the deal with climate change adaptation. California and Florida are both assessing forested lands and potential for restoring/managing forest lands to enhance carbon sequestration. Massachusetts and Washington are both engaged with partners to develop finer scale models to predict climate change impacts at local and regional levels. Massachusetts is working with TNC and Manomet Center for Conservation Sciences to apply a TNC-developed tool called Climate Wizard to do a comprehensive analysis of climate change impacts at fine scales. This effort will attempt to focus climate models down to 8 km^2 and will be used to detect rates of change in habitat at that scale. They are validating this approach by using Wizard to "backcast" using historic data at 4 km^2 detail. This approach is being shared at a regional

scale with other New England states using shared habitat classifications. Washington has proposed doing a scientifically-based, vulnerability assessment in partnership with the University of Washington. This modeling approach is based on probabilities and will be used to predict vegetation changes and consequent changes in species associations. The model includes species level assessment of climate change vulnerability and vulnerability assessments for major habitats down to $1km^2$ scale. Similar to the New England states, Oregon and Idaho are joining Washington in this effort.

Minnesota has committed funding and is implementing two long term fisheries monitoring programs: one is focused on ciscoes and other coldwater species while the second is a whole lake monitoring project which includes key lakes in various geographic areas. This second effort is looking at fish and other populations, water quality, temperature and other variables. Nevada has tasked its Diversity Division biologists with proposing climate change research projects for the next two-yr budget cycle. Tennessee is sponsoring research on which geographic areas will be most affected by climate change and is proposing a modeling effort with USGS that will look at climate change impacts on a 100-yr time scale. In Canada, DFO has started a Climate Change Science Initiative charged with improving predictions of impacts and looking at climate variability, emerging issues and socio-economic impacts. This includes a five-yr research plan to look at: 1. fish population impacts; 2. habitat impacts and interactions with fish populations; 3. Climate change variability; and 4. Ecosystem assessment and management strategies developed via modeling.

Five state agencies (MA, MN, NY, WA, WY) are doing or planning to do species and/or habitat vulnerability assessments. These efforts in Massachusetts and Washington are linked to the modeling effort described earlier. Minnesota has initiated assessments of wildlife habitats and populations and how they will be affected by climate change. These assessments will form the basis for recommendations on how the agency must change wildlife management programs to respond to climate change. New York has begun to train staff to do habitat and species vulnerability assessments, while Wyoming is also starting vulnerability assessments commencing with a research proposal to look at vulnerability of Colorado River cutthroat trout range-wide.

Four state agencies (FL, NM, NY, WY) are engaged in training and/or coaching programs to help them deal with climate change adaptation. These range from technical training for vulnerability assessments to actions to increase internal recognition of climate change as an issue, to gain comfort with dealing with climate as a dynamic rather than a static issue and foster common understanding of climate change among field staff and agency managers.

California has modified its state environmental review law known as the California Environmental Quality Act to incorporate climate change implications in its regulatory review process. Georgia has modified the criteria it uses to review proposed coastal development projects and how they may impact sea turtle nesting habitat. These criteria factor in sea level rise and incorporate those impacts in setback requirements.

On-the-Ground Strategies

Most of the fish and wildlife agencies surveyed have not yet deployed specific management projects focused on climate change adaptation. Most agencies are still in the planning phase of climate change adaptation and are not yet ready to develop specific adaptation strategies,

techniques or projects. Many states cited the lack of fine scale predictive models for local or regional climate change impacts as an impediment to developing and implementing specific adaptation strategies and techniques. This emphasizes the importance of efforts such as those being undertaken by Massachusetts, in partnership with TNC; and Washington, in partnership with the University of Washington, Oregon and Idaho, to develop predictive models of climate change impacts at a local and regional scale.

While the survey didn't yield an abundance of specific adaptation projects, some state fish and wildlife agencies cited projects that are part of their Wildlife Action Plans and that are directly relevant to climate change adaptation. For example, California's efforts to develop conservation strategies for sensitive bat species and western pond turtle recognize that adaptation to climate change is a significant issue that must be addressed in the strategies. Similarly, New York is assessing population changes in spruce grouse and other boreal bird communities that exist in habitat that may be significantly altered by climate change. Also, as indicated in the previous section, many state agencies are engaged in revising existing management plans or writing new ones to include climate change adaptation considerations.

Many survey respondents cited the importance of existing programs to fostering climate change adaptation. Habitat restoration/management and land acquisition, including the acquisition of water rights were the most frequently cited strategies. Several states indicated they were re-examining their land acquisition priorities in light of predicted climate change impacts. These efforts also await better fine scale models of those impacts before they can be brought to fruition. Several states cited work on maintaining or creating habitat connectivity and wildlife migratory corridors. Management of riparian corridors and buffer zones was also frequently cited. Survey respondents that mentioned riparian zone management emphasized the importance of that strategy given the climate change model predictions for more frequent extreme run-off events and subsequent ecological and socio-economic impacts.

Some species management decisions are being strongly influenced by climate change impacts. Minnesota is altering its white-tailed deer harvest strategies in response to milder winters and reduced winterkill. Texas and Department of Fisheries and Oceans Canada are using long term monitoring data sets to detect changes in estuarine and coastal fish population abundance and distribution likely caused by changes in temperature regimes or freshwater inflows. These data are driving harvest management and policy decision-making.

Metrics

The survey revealed very few examples of metrics that were specifically designed to measure the success of climate change adaptation practices or projects. This is not surprising given the paucity of specific climate change adaptation practices or projects that agencies have implemented to date. No agency reported they had utilized metric measurements to refine an on-going climate change adaptation effort. Conversely, most agencies reported they are using or will use existing long-term data series to detect impacts of climate change and, eventually, measure success of climate change adaptation efforts.

Texas is using its 30-yr bay and estuary monitoring program to develop stock assessments for individual species and is specifically looking for climate change impacts. For example, recent analyses have documented a significant reduction in southern flounder recruitment in

warmer winters. Massachusetts is "mining" old data series to look for climate change impacts.

Development of metrics was specifically mentioned as a part of the climate change planning processes in most agencies (FL, CA, IA, MA, MN, MO, NV, NY, TN, WA, DFO). California is currently grappling with developing metrics and some measures of success for biodiversity conservation are included in the California Resources Agency overarching state climate change strategy. Nevada is working to establish performance measures for each of its major ecosystems in the next six to eight months using a workshop/working group process. These performance measures will be incorporated in Nevada's WAP.

More generally, several agencies (FL, MO, MA, MN, NY, SD, TN, WA) are now, or plan to, monitor habitat quality and distribution, and several (MN, NY, TN, TX, WA, DFO MN, NY, TN, TX, WA, DFO) are looking at species population abundance and distribution. Respondents from both Missouri and Tennessee encouraged placing a priority on developing broader system or biodiversity metrics and secondarily on species population parameters. Three agencies (MN, MO, DFO) mentioned tracking water quantity and quality. Both New York and Department of Fisheries and Oceans Canada are monitoring invasive species parameters including species numbers, abundance and distribution.

IV. CHALLENGES

The most frequently cited issue confronting agencies (12 of 21 agencies) was lack of fiscal and human resources to address climate change adaptation. Fish and wildlife management agencies have long been stressed to the breaking point and the recent economic downturn and consequent impacts on agency budgets has just exacerbated this limitation. These agencies indicated they did not currently have adequate resources to deploy robust climate change initiatives while continuing to deliver or being forced to cut back existing core programs. Several state agencies noted that providing additional federal dollars to tackle this issue would also likely require developing additional sources of matching funds and any efforts to increase federal funding should be undertaken with recognition of that need as well. On human resources, one agency identified loss of institutional memory and capacity with the increased rate of retirement of experienced staff and expressed concern that it cannot be replaced quickly by just adding new funding.

Uncertainty surrounding exactly what climate changes will be at the local and regional scale was the next most often cited concern. Eleven agencies (GA, IA, MA, MN, NY, SD, TN, WA, WY, GLFC) indicated they need models that predict climate change impacts at finer geographic scales than the models that are currently available. This information is critical to agency efforts understand climate change impacts to habitats and species; to conduct vulnerability assessments; and to develop and implement adaptation plans. As noted earlier in this report, Massachusetts and Washington, in collaboration with partners, are developing methods to develop fine scale models. The Nature Conservancy's work to develop a tool known as Climate Wizard also addresses this need. On a related topic, eight agencies (FL, GA, IA, MA, NY, SD, VA, WY) indicated they needed to do vulnerability assessments before they could develop specific adaptation strategies, practices and projects.

Several agencies noted that they faced internal cultural challenges that they were working to address in order to improve their capacity to address climate change adaptation. These included making a shift from thinking of climate as static to dynamic; gaining full staff awareness that climate change is real and that significant impacts on fish and wildlife are imminent; and overcoming institutional inertia to change. Five agencies specifically mentioned a need for technical training. Similarly, external socio-political challenges, including lack of public awareness; lack of acceptance that some fish and wildlife "traditions" will be impacted by climate change; political opposition to public discourse about climate change; and lack of political will to address an issue that extends over many election cycles were described by some agencies. One respondent noted that the conservation community needs to nurture continuing open discussion about climate change and be sensitive to the danger of group think.

A need for better information management systems was expressed by four state agencies (FL, MA, MO, VA). Expanded or improved habitat and population monitoring was cited by four agencies (FL, GA, MA, NY) as was research into understanding impacts of climate change or developing new tools to respond to climate change (FL, MA, VA, WY). Three of five state agency Directors interviewed expressed a need for a checklist of things to do now to address climate change adaptation. The need to re-think some accepted definitions (e.g. "endangered species," and "invasive species") in light of climate change impacts was expressed by three respondents. Two respondents counseled that a species management approach was inadequate to deal with climate change and encouraged adopting an ecosystem-based management (EBM) approach. Lastly, two respondents cited a need for new or additional jurisdictional authority with one specifically focusing on the need for fish and wildlife agencies to have increased authority for water management.

V. EXPENDITURES

No agency interviewed had a separate line in their budget to specifically account for climate change adaptation and respondents varied widely in what types of spending they included in their estimates of climate change adaptation expenditures. For that reason, the information summarized below is incomplete and should be interpreted with great caution.

Four agencies declined to provide an expenditure estimate because they didn't budget separately for climate change adaptation and lacked a basis for providing an estimate. Two agencies indicated their expenditures were in the range of $25-50,000; one estimated $50-100,000; six estimated $100-250,000; two estimated $250-500,000; two estimated $500,000-1,000,000; one estimated $2,500,000-5,000,000 including the annual cost of a long-term monitoring program; and one responded more than $5 million including the cost of land acquisition. Clearly, a more detailed survey than this one would be required to produce reliable and comparable expenditure data.

VI. PARTNERING, COMMUNICATION & OUTREACH

A majority of state fish and wildlife agencies (FL, CA, IA, MA, MN, MO, NV, NY, TX, VA) described using, or planning to use, some sort of, conference, summit, symposium, or workshop as an important part of their communication and outreach efforts. Florida's three-day climate change summit in October, 2008 included presentations by internationally

recognized climate change science and policy experts followed by breakout workshops for a diverse group of agency employees and stakeholders. The breakout groups produced recommendations for Florida to consider in their developing Climate Change Strategic Plan. Iowa hosted a November, 2008 symposium of natural resource agency leaders from across the country to discuss dealing with the full range of climate change impacts, including wildlife conservation. Missouri will focus its February, 2009 annual natural resource conference on climate change. More than 1,000 natural resource professionals and agency stakeholders are expected to attend. Other agencies reported holding workshops with stakeholders specifically for the purpose of integrating climate change adaptation in their WAPs. Many of these focused workshops were supported by NWF.

Five state agencies (CA, IA, MA, NY, WA) have, or are planning a dedicated climate change section on their website. A quick site search of all surveyed agencies revealed that, with one exception, all have at least some information about climate change on their site.

Three agencies (AK, FL, IA) are in the process of developing a climate change communication and outreach strategy or plan. Alaska is developing strategies for both the Governor's sub-Cabinet and the Department of Fish and Game. The Florida climate change strategic planning process includes the work of a Communications and Outreach Team. Iowa DNR has recently hired a public relations specialist and will dedicate a portion of that staffer's time to climate change communication efforts.

Some agencies are looking at developing publications that focus on climate change. Notable among these is California's contemplated series on climate change "poster species" in which the economic and social aspects of climate change impacts on species would be detailed. The objective of the series is to inform stakeholders how climate change impacts on fish and wildlife will affect them and to build support for climate change adaptation before the public gets focused on other climate change impacts. The Department of Fisheries and Oceans (DFO) Canada is developing a series of two-page science "stories" about climate change to disseminate via the DFO website.

Virginia has utilized the results of 2008 public survey of Virginians' attitudes regarding climate change conducted by the Miller Center of Public Affairs at the University of Virginia to stimulate internal and external discussion of climate change impacts of fish and to motivate support for climate change adaptation.

CONCLUSIONS

The results of this survey clearly show that the overwhelming majority of fish and wildlife management agencies interviewed are actively engaged on the topic of climate change adaptation. Several agencies, including California, Florida, Massachusetts, and Washington, have made significant strides in organizing and planning to manage climate change adaptation and have begun or are on the verge of implementing active management efforts in this arena. Most other agencies are rapidly catching up. All agencies reported obstacles to dealing with climate change that ranged from inadequate fiscal and personnel resources, to lack of fine scale climate change predictive models, to political will to recognize and address climate change impacts on fish and wildlife resources. These obstacles are real,

but none are insurmountable so long as the greater fish and wildlife conservation community pulls together and focuses talent, energy and resources on this issue. Significant progress has already been made in this regard. There is clear cause for optimism that the conservation community will affirmatively and effectively address climate change impacts on fish and wildlife.

Many survey respondents indicated that a checklist of "things to do now" would be of great help in their efforts to address climate change adaptation. With a tip of the hat to David Letterman, we offer the following ten recommendations in response to that need and with full recognition that it is an imperfect and incomplete list.

APPENDIX F

NGO SURVEY SUMMARY

I. BACKGROUND AND SURVEY SAMPLE

The 15 individuals interviewed were among 30 contacted, chosen from non-governmental organizations outside our own. They were asked a series of questions to describe their area(s) of expertise; the role they fulfilled in their agency, the type and location of ecosystems they were most familiar with, the species they focused on, and how long they had worked in the field. Respondents could select more than one area of expertise and ecosystem they were familiar with.

The participants represented 9 conservation organizations: the World Wildlife Fund, the Conservation Biology Institute, Trout Unlimited, the Wildlife Conservation Society, the Center for Large Landscape Conservation, the National Center for Conservation Science and Policy, EcoAdapt, and Manomet Conservation Science Center and the Institute for Ecosystem Studies. Most individuals interviewed serve as staff scientists in their organizations. Two individuals were directors of their departments, and one respondent serves as the executive director, staff scientist, and founder of her organization. Expertise was split between wildlife and climate change science, though most had expertise in both fields. Two respondents have expertise specifically in climate change adaptation and one participant has expertise in restoration ecology.

Most NGO staff interviewed had experience working in specific ecosystems, but their current work spans multiple ecosystems. Experience in specific ecosystems or regions of the country included the ecosystems of the greater Yellowstone area; the Albertine Rift Valley of Africa, Northern Australia; western ecosystems; sub-alpine forest; Pacific Northwest Forests; old growth forests; high plains; Rocky Mountains; Adirondacks boreal; Arctic Alaska and Canada; boreal forests; intermountain west; treeline ecotones; sagebrush steppe; tallgrass/mixed grass prairie; marine; coastal freshwater systems; freshwater aquatic ecosystems; agricultural systems; forest land; chaparral; and coastal salt water systems. Experience working with different species ranged from birds to amphibians, with most participants currently focusing on many species in a given system or at a project site. The individuals interviewed had significant experience in the field of conservation: 4 participants have been working in the field for over 20 years, 5 for over 10 years, and 3 for less than ten years.

II. DEFINING ADAPTATION

In general the NGO respondents accepted the term "adaptation" to describe management actions undertaken to help ecosystems and species survive climate change. Participants tended to employ their own definition for adaptation, rather than referring to an already established definition from the literature. Their definitions emphasized a range of responses and activities taken to build resilience in natural systems and to minimize the effects of climate change on natural resources. Several NGO participants included the element of managing for change in their definition, which fit into the general definition of responses

taken to allow natural systems and/or wildlife to change but maintain essential functions, resiliency, and integrity in response to an altered climate.

Out of 15 participants, six specifically used the phrase "build resilience," while most others used terms such as "responses to ameliorate or lessen the impacts from climate change." Some commented that climate change adaptation will require new ideas or "search images" for what an ecosystem or habitat will look like in the future. Other terms to describe adaptation included "modification of natural systems to accommodate climate change," "proactive management," "allowing for continuation of function," and "responses to the climate change effects that are inevitably going to happen even if we eliminated all green house gas production tomorrow."

Respondents also eluded to the broad nature of adaptation: they included things like planning, policy responses, ecosystem management, aiding species migration, and other actions geared towards anticipating, preparing for, adjusting and responding to the impacts of climate change on natural systems. One participant commented on the elusive nature of the term, "It's something you know when you see it, but it's hard to define," while another remarked that the term has not been sufficiently defined or widely accepted.

Alternative terms: Four survey participants do not use the term adaptation to discuss management activities geared towards building resilience or minimizing the impact of climate change. Several participants expressed concern that the term adaptation is readily confused with the scientific use of the term. The Oxford Dictionary of Science defines adaptation as "Any change in the structure or functioning of an organism that makes it better suited to its environment." This process occurs at an evolutionary time-scale, in direct contrast with rapid human responses to help manage change. Participants noted that the confusion between the terms is dangerous, particularly among the media who may conflate the two meanings. Evolutionary adaptation occurs over much longer time scales than planned management actions to help ecosystems "adapt" to climate change. Experts are concerned that many species will not be able to adapt evolutionarily to climate change given the accelerated pace of change and the reduced evolutionary capacity in today's fragmented ecosystems.

Alternative terms used to describe adaptation included the term preparation, which is the preferred term at the National Center for Conservation Science and Policy. The definition given for preparation was similar, "Climate change preparation for natural systems is action taken to manage ecological systems for long-term persistence under climate change. This includes the development of management strategies based on climate change projections and knowledge of the system, the implementation of management actions that increase resilience and resistance of natural systems to climate change, and managed change, when resistance is no longer an option."

III. BEST PRACTICES

While the NGO participants generally are not land managers, their programs often support the work of land managers or conservationists working on the ground. The survey captured some specific examples and many general responses and guidance related to planning and on-the-ground adaptation strategies. Additional information from organization websites or

organizational publications was used in some cases to supplement survey responses when participants made specific reference to these information sources. It is important to note that the examples captured here do not reflect all efforts underway at each of the organizations we interviewed, but rather a small sampling that was referenced by the staff person contacted. More information about ongoing adaptation work at each organization can be found on their respective websites.

Programmatic changes

Conservation NGOs have made internal changes to programs in the last several years, developed new programs to deal with climate change, and engaged in helping management agencies and other organizations plan for climate change. Almost all conservation NGO staff interviewed said that their organizations had recently evaluated how their programs operate, restructured or re-allocated funds to address the impacts of climate change, applied for grant funds to address climate change, or created new programs to deal with climate change adaptation work. Some organizations did not have programs dealing with climate change until as recently as the last 1-2 years.

At the far end of this spectrum is the creation of entirely new organizations to address climate change adaptation. One participant is the senior scientist and executive director of the recently launched organization created specifically to address climate change adaptation. The goal of this organization is to help create the field of adaptation, to build capacity by training people to do the work of adaptation, and to design and implement collaborative adaptation projects. Already staff is working with agencies and organizations to help redefine their management and planning strategies to incorporate climate change adaptation.

Planning

Conservation NGOs often serve in an organizing role, bringing together different sectors and partners to work on regional or local adaptation planning activities. Partners may include natural resource managers, research scientists, urban and suburban planners, state and local governments, agency staff, tribal leaders, recreation specialists, industry leaders, the energy sector and others. Eleven out of the 15 participants interviewed noted that they were convening working groups or focus groups around climate change adaptation, and nine out of 12 participants said they have been actively engaged in workshops, conferences, and working groups on the topic.

One participant from the Wildlife Conservation Society is working to bridge the divide between science and conservation by leading a collaborative Climate Change and Conservation Working group at the National Center for Ecological Analysis and Synthesis (NCEAS). This group is bringing scientists and conservation planners together to develop a framework for using site-based adaptation strategies in conservation planning. The Nature Conservancy, Conservation International and The World Wildlife Fund as well as several universities and government researchers are involved in this effort. The working group is charged with: 1) Developing a strategy for how to approach conservation planning under future climate conditions; and 2) Applying that strategy to several regional case studies of wildlife habitat protection in the Intermountain West of North America. This broader NCEAS working group effort will be complemented by regional roundtable discussions such

as the May 2007 workshop WCS convened on how climate change may impact conservation priorities in the Greater Yellowstone Ecosystem.[13] This working group will guide the development of place-based strategies in different systems. The process begins with a vulnerability assessment to determine which lands are most sensitive to the impacts of climate change and a more detailed assessment to look at the species and habitat specific impacts of change. Following the vulnerability assessment the group works with managers to determine what to do about projected impacts. For example, WCS lead a workshop with Montana State Fish and Game department using a scenario-based approach to look at the impacts of climate change on natural systems in Montana and to begin to plan to address these impacts. This approach allows examination of a spectrum of different management response strategies based on the range of scenarios.

The National Center for Conservation Science and Policy is leading an initiative called the Climate Futures Forum. In conjunction with the Climate Leadership Initiative at the University of Oregon, NCCSP is working in the Rogue, Umatilla, Klamath, and Upper Willamette River basins to implement four basin-scale climate change preparation (adaptation) planning pilot projects to predict the range of adverse impacts of climate change to natural ecosystems and focal species and human systems; identify strategies and policies for increasing ecological and community resilience; make specific recommendations to guide communities in making necessary lifestyle changes; and identifying data gaps, research needs and monitoring progress. The goal is to develop specific recommendations for natural ecosystems, human infrastructure, human systems, and economic systems. [14]

The Environmental Defense Fund (EDF) is also working on collaborative efforts with partnerships and alliances of landowners in locations across the country. EDF is moving from working on projects with single landowners to working on projects with landowner associations and building partnerships that address conservation issues strategically at a larger scale. One particular project is taking place in the Edwards Plateau region of central Texas. Here, EDF facilitated the creation of the Bandera Canyonlands Alliance (BCA), a new landowner association representing approximately 8,000 acres of unique species and habitats. The goal of the BCA is to work collaboratively to conserve and manage natural resources in the Bandera Canyonlands region. The project developed because landowners, with help from EDF, realized that they would be much better positioned to address threats to landscape integrity, including climate change, by working collaboratively. Several participants noted that the scale and scope of climate change will demand this type of landscape scale approach to conservation and resilience-building actions.

Several of the organization participants interviewed said that they are working in partnership with state agencies to help plan for adaptation. For example, the Manomet Center for Conservation Science was recently awarded a Wildlife Action Opportunities Fund grant through the Doris Duke Charitable Foundation to work with state wildlife agencies to ensure that the State's investments in wildlife management and conservation, as outlined in the 2005 State Wildlife Action Plan (SWAP) addresses projected impacts of climate change. Manomet will also help to facilitate the adoption of climate strategies by the state agency's SWAP implementation partners. The goal of the project is to help state conservation

[13] http://www.wcs.org/globalconservation/northamerica
[14] http://www.nccsp.org/climate-change/preparing-local-communities-and-ecosystems-for-climate-change

agencies identify some of the most important wildlife resources in the state, assess their vulnerabilities to climate change, evaluate and improve climate adaptation strategies, and ensure these strategies are implemented.[15] Outcomes of this project in Massachusetts will include: 1.) A companion publication to the SWAP that updates SWAP conservation strategies to address climate change; 2.) scientific reports on the vulnerabilities of Massachusetts wildlife and wildlife habitat to climate change; 3.) widely applicable methodology for rapid assessment of climate change vulnerabilities of wildlife and wildlife habitat; and 4.) a process that can be used more widely to identify and evaluate adaptive climate change conservation strategies. The project involves a number of partners including the Massachusetts Department of Fish and Wildlife, the Nature Conservancy, and key land trusts in the state.

The Center for Large Landscape Conservation is working in partnership on the Crucial Areas and Connectivity Assessment project lead by the Montana Fish, Wildlife and Parks Department. The Assessment effort brings together scientists and resource specialists, representatives from industry, academics, federal, state and local agencies, NGOs and the general public to product a set of tools for adaptation planning. Tools coming out of the Assessment will include (1) digital GIS maps identifying important species and habitat information; (2) an assessment of risks to fish, wildlife, and their habitats; (3) recommendations for best planning, development and management practices in or near crucial areas; and (4) policy recommendations for effective use of these tools. The Assessment will be incorporated into revisions of the Montana SWAP to help the state prepare for climate change adaptation.

Other NGO participants are developing tools and strategies for climate change adaptation, participating in research and model development or implementation, and using these tools to create conservation plans for the future. The World Wildlife Fund is involved in over 20 projects world-wide, combining research and monitoring with development of appropriate adaptation tools for both natural and human systems. In the Southeastern U.S., where longer drought periods, agriculture changes, and coastal deterioration due to sea-level rise and storms threaten natural resources, WWF is currently conducting a vulnerability analysis for the region and increasing awareness about the impacts of climate change by recruiting high school students in the development of the vulnerability assessment. WWF will use the data gathered from this study to develop and implement adaptation strategies in the region and work with local stakeholders.[16] In the Northern Great Plains WWF is also using modeling techniques to predict shifts in the location of sagebrush habitat with climate change. WWF is combining this information with data on how climate change may affect West Nile virus and where oil, gas and wind power development occur, to develop a regional-scale view of the best places for sage grouse thrive in the future. Ultimately, this information will be used to conserve the most viable sage grouse populations in the Northern Great Plains.

Climate change adaptation is also being added to existing conservation tools or tools that are still in the development stages. The Conservation Biology Institute recently released Data Basin, a web tool that helps users connect to conservation data, information, and expertise.

[15] http://www.manomet.org/projects1.html
[16] http://www.worldwildlife.org/climate/adaptationprograms.html

Individuals and organizations can explore existing datasets, upload or download datasets, produce and share customized maps, and connect with experts if they want more information about a particular topic.[17] CBI now has plans and funding to dedicate a portion of this site to climate change adaptation. The site will facilitate information and data-sharing and provide contacts for experts working on climate change adaptation.

On-the- Ground Strategies

The NGO participants currently are focused on planning and policy development for adaptation and provided few examples of ongoing climate adaptation efforts. A number of respondents included examples such as convening working groups, working on vulnerability assessments in order to prioritize critical lands and resources, and developing tools to work on the adaptation challenge as discussed above.

Reducing other elements of global environmental change

While climate change is perhaps the greatest impending conservation challenge, the combined effects of climate change and other stressors such as invasive species and habitat degradation will have disastrous consequences for natural systems. Participants noted that working to remove existing stressors on natural systems is something that can be done immediately to build system resilience to climate change. Participants cited invasive species removal, reducing habitat fragmentation, working to decrease pollution into waterways, closing down sensitive coral reef areas to recreation and other human activities during times of stress, and working to retain high population levels as potential strategies. Participants noted that most of the work their organizations have been involved with over the past decades has aimed at reducing stressors in natural systems such as those mentioned above. One participant noted that while all efforts to reduce stressors are important, strategic re-prioritization of existing stressors will be a necessary component of managing under climate change.

Managing for ecologic function and protection of biodiversity

Maintaining ecologic function and promoting biodiversity is tied to increased ecosystem resilience. A number of restoration strategies aimed at repairing or maintaining ecologic function are ongoing across the country. Participants listed projects including riparian restoration, restoring hydrologic systems, restoring natural fire cycles and maintaining forests to decrease opportunities for catastrophic fires, and restoring grassland ecosystems. For example, the Wildlife Conservation Society is working with the USDA Forest Service and others to promote the benefits of forest thinning and prescribed burning to reduce fire risk and enhance wildlife populations in areas of the west prone to catastrophic fires due to increasing temperatures and drought conditions.[18] Trout Unlimited uses a protect-reconnect-restore formula to help increase resistance and resilience to climate change. They work to protect and expand existing population strongholds and reconnect hydrologic systems and populations through projects such as removing in-stream barriers, and restoring hydrologic flows. They also work to increase ecological complexity by restoring deeper pools and side channels in streams to provide cool water refuges for climate sensitive species.

[17] http://databasin.org/cbi/info/aboutPage
[18] http://www.wcs.org/globalconservation/northamerica

Several participants noted that it is imperative to manage in a more holistic manner to address ecologic function and biodiversity, as well as to capture all scales of heterogeneity present in the ecosystem. Capturing heterogeneity is a form of bet-hedging that will allow us to preserve all components of an ecosystem and allow it to best respond to change.

Establishing habitat buffer zones and wildlife corridors

Reconnecting landscapes to facilitate species migration in response to climate change was also considered an important strategy by NGO participants. Three participants are engaged in restoring hydrologic connectivity through actions such as removing dams and other stream impediments to increase connectivity. Other groups are involved in helping to create conservation plans and policies that result in the creation of connected networks of protected areas that will enable species to move across the landscape in response to climate change. WCS Canada and the Adirondack Program are engaged in planning for the northern Appalachian region through the Two Countries One Forest Project. This project identifies critical at-risk landscape linkages under greatest threat from climate change and other pressures. In Montana, the Center for Large Landscape Conservation is actively involved in the Crucial Areas and Connectivity Assessment lead by the Montana Fish, Wildlife and Parks (discussed above). The assessment, launched in November 2008, will produce a set of conservation planning and information tools to assist local, regional, and statewide decision-makers, developers and agency staff to conserve wildlife corridors and crucial habitat throughout Montana. All information will be incorporated in the Montana SWAP and will employ significant stakeholder input to develop recommendations and guidelines to help federal, state, county and private sector decision makers better understand how their decisions may impact crucial areas.

Implement "proactive" management and restoration strategies

Strategies in this category include all *active* facilitation of species, habitats and ecosystems to accommodate climate change impacts. Examples include translocating species to new locations, beach re-nourishment, barrier island expansion, marsh creation, and planting climate-resistant species. At this time, none of the participants referenced specific strategies that fell under this category, but did note that proactive management, such as species translocation and the use of dredged material for barrier island expansion were often controversial issues and usually expensive to implement.

Increase monitoring and adaptive management practices

Many of the participants are actively engaged in monitoring to better understand the impacts of climate change on specific ecosystems and species. For example, WWF is involved in an effort in Montana to identify sensitive locations on the landscape for monitoring for the presence of thresholds that would alert managers that climate change was impacting an ecosystem. Other organizations, such as WCS are employing baseline information to understand the potential impacts of climate change on species populations. In the Adirondacks, WCS has been monitoring the status and distribution of boreal birds. Because climate change is the primary threat to this habitat type, data on the distribution, abundance and population trends of the species are being collected to help work to save the species. The Center for Large Landscape Conservation is developing frameworks for monitoring actions that can be built upon as resources and information become more available. Most participants noted that using an adaptive management framework was an important aspect

of implementing adaptation strategies and that sound strategies should incorporate control sites into management design.

A note on mitigation

Several participants noted that while adaptation is critical because of inevitable climate change, the conservation community cannot lose focus on mitigation. Participants stressed that reducing green house gas pollution is the only long term fix for climate change and the only permanent solution that will ensure the future of wildlife and natural resources. Two participants noted that some ecosystems, such as arctic Alaska and high alpine systems there may not be any viable adaptation options. This may be the case in more ecosystems in the future if action is not taken now to reduce emissions and curtail future warming and climate change.

Metrics

Adaptation work is clearly in the early phases of development, and this made the question of metrics used to measure the success of an adaptation plan difficult for many respondents. While some respondents noted that they do not have a clear sense of what metrics can be used because they've not seen adaptation on the ground yet, others suggested general indicators for the conservation community and management agencies to monitor human progress towards working on the adaptation challenge. For example, one respondent noted that a measure of success would be when all states begin incorporating climate change and adaptation into their conservation plans and when climate change really permeates every plan and action to manage and conserve land.

Conservation groups who design tools or databases cited different types of metrics than a land manager might use. For example, one participant who is involved in creating a database for climate change adaptation research and data said that metrics of success for her work measure user numbers and participation, as well as the ability of the site to attract funders and partners.

Finally, one participant noted that while you can't measure adaptation success in most systems for quite some time, there are ways of making the process iterative so you can measure small gains, rather than outright success at different intervals. For example, she noted that a manager might chose to measure the number of coral bleaching events over a given period of time to determine if their work is increasing or decreasing the systems resiliency to bleaching. All respondents noted that good sound science and monitoring will be an important component of successful adaptation work.

IV. CHALLENGES

The unmet needs for planning or implementing adaptation practices fell out in 2 major categories: the lack of resources and funding for adaptation work, and the lack of knowledge about adaptation or institutional capacity to move forward. One respondent noted that adaptation started to become an acceptable topic to discuss right around the time that our nation hit a major economic crisis. Climate adaptation work will cost money and times are currently tight, especially for many agencies.

Beyond a lack of resources, the lack of knowledge, agreement, examples of adaptation practices and adaptation training for conservation and land managers is also lacking. Respondents noted that while people are hungry for solutions there is no real consensus on a definition of adaptation. Adaptation may mean one thing to one person and an entirely different thing to another. Further, adaptation work has not gone much further than the talking and planning stage, so there are few examples of adaptation work on the ground that can provide examples to others. Land managers and agency staff are hungry for case studies and examples of practices currently in use so that they feel more secure going into planning for adaptation. One participant said that there has been a lack of desire to work on adaptation from managers who are already doing their best to deal with immediate issues like wildlife and flooding and who may not think climate change adaptation is as pressing as other current issues. The inherent uncertainty associated with climate change projections also makes adaptation an unpalatable challenge for many land managers.

Data-sharing and collaboration were also cited as activities that need to happen more both within the NGO community and with academic institutions and state and federal agencies. Several participants noted that there are problems with data-hoarding, where scientists or institutions don't want to share data, or researchers may simply not know about online outlets for their data. Participants noted that the competitive environment created by grant applications and limited conservation funding can also sometimes prevent the development of beneficial partnerships.

Finally, participants called for an entirely new conservation paradigm to permeate through the conservation and land management community. One participant said that scientists coming out of school should be trained in adaptation, current practitioners need to be more climate aware and all conservation and management activities should be framed in light of climate change.

V. EXPENDITURES

Survey respondents did not have cost figures for specific adaptation practices, but were able to provide some figures from their programs that address climate change adaptation or other aspects of their climate change work, such as model development (Table 2). Others responded that the need for funding for adaptation is urgent and that any money we are spending on conservation without considering adaptation is money not well spent. A number of organizations were able to provide information on the cost of their climate change program work. Estimates ranged from $200,000/year to $4 million per year. In one case, the entire organizational budget was devoted to adaptation work, though specific funding levels were not provided.

VI. PARTNERING, COMMUNICATION & OUTREACH

Partnering

All participants in the survey are actively engaged in a wide variety of partnerships and often build partnership groups. Participants were actively involved in forming working groups, organizing conferences, leading lecture series, engaging in training opportunities, and serving on advisory panels (see above). Most NGO participants said that the work of climate change is too big for any one group to take on individually, and report that partnerships are

highly profitable for all involved. One participant suggested that we need an adaptation RGGI (Regional Greenhouse Gas Initiatives), or multi-state collaborative efforts working on adaptation. He and many other participants stressed the need for the development of an information network that we can all use to communicate, create partnerships, and share knowledge.

Communication and outreach

In addition to creating and participating in partnerships, NGO participants are actively engaged in communication and outreach around climate adaptation. The majority (14) of participants work for organizations that include information about climate change and adaptation (sometimes called other names such as preparation) on their website. Ten participants noted that they regularly attend conferences, summits, and symposium on climate change, and seven said that they participate in working groups on some aspect of climate adaptation. Another seven participants said giving presentations, participating in panel discussions, and chatting informally or through interviews was an important part of their communication strategy. Peer reviewed papers, sponsoring or organizing conferences and summits, newsletters and in-house publications, and shared research projects were all mentioned as popular communication and outreach tools.

APPENDIX G

ACADEMIC SURVEY FINDINGS

The primary emphasis of this survey project, and hence the focus of the survey questions, was targeted to resource management professionals. However, given the significant attention that adaptation to climate change has received in the scientific literature as well as the importance of primary scientific research to inform management decisions, we felt that it would be useful to glean perspectives of some of the prominent academic professionals who have been working on the issue.

I. SURVEY SAMPLE & RESPONDENT BACKGROUND

We surveyed seven researchers (primarily fish/wildlife biologists and ecologists) representing diverse regions [LA, ME, CA, MD(2), WA(2)] and fields of interest. Geographical regions of research focus were varied, including: Coastal Louisiana, South Florida, Latin America, Pacific Islands, Chesapeake Bay and watershed, Mississippi Delta, Florida Everglades, Baltic Sea, Colorado Rocky Mountains, North America, Intermountain West, and Great Basin. Five of the scientists were most familiar with forests and/or grassland and shrubland habitats, two with freshwater, coastal, and marine systems. Three of the seven respondents have focused their work on specific species (one on wildflowers, bumble bees, hummingbirds, other pollinators, and hibernating small mammals; one on birds and butterflies, and one on vertebrates, especially birds), while the others have worked on a broad range of species. Five of the seven have been working in their field for more than twenty years.

II. DEFINING ADAPTATION

Perhaps not surprisingly, five of the seven academics defined adaptation in the more "traditional" sense, referring either to the natural ability of a particular species to adjust its behavior, range, physiology, or other characteristics over time to enable it to survive in a new environment, or to how much an ecosystem might change (e.g., changes in location, structure, or processes) due to "boundary conditions." One of those five respondents referred to "adaptation" as an unfortunate term given this more traditional definition and suggested that "adjustment" would be a better term in reference to management and policy actions on the part of humans, while another acknowledged the likely need for "active intervention" to maintain ecological processes and facilitate movement of organisms. The remaining two respondents defined adaptation as managing natural systems to conserve their integrity, functions, and services in the face of climate change.

III. BEST PRACTICES

Planning

Responses to the question of best practices for natural resource management planning were somewhat limited given the academic rather than management focus of the participants. Four of the scientists acknowledged the importance of vulnerability assessments, particularly in terms of identifying potential ecosystem responses as well as the interplay between climate and non-climate stressors. Several people identified the need for a broader spatial and temporal context for planning as well as greater emphasis on adaptive management, with one

adding that more fundamental changes are needed to improve the probability that management will achieve its objectives, including significant improvements in communication among researchers and managers. One respondent suggested that there should be increased attention to connectivity, efforts to address existing stressors that are likely to be exacerbated by climate change, and attention to species that will not be able to adapt without direct intervention such as assisted colonization or ex situ conservation.

On-the-Ground Strategies

Four of the seven survey participants identified specific examples of on-the-ground adaptation strategies within their areas of focus:

- A World Bank project to reconnect the Magdelena River to Lagoon in the Caribbean coast of Colombia. The project was considered to be very effective until the canals filled in and money was unavailable for canal maintenance. This project focused on fixing "boundary conditions" of sites that have been altered from land-use change, including river management decisions.
- The recent purchase of conservation lands in the upper part of the watershed as part of the Everglades restoration effort. This was cited as another example of changing land use and boundary conditions so systems can adapt to climate change.
- Strategies to change nutrient inputs from point and non-point sources in an effort to reduce hypoxia in the Chesapeake Bay. In this case, the system response has not been as predicted, so project managers are revising their strategy (in this case, they have to calibrate the system level responses to the degree of change in land use management). Essentially, they are taking an adaptive management approach.
- Phase 1 of the State of Maryland's Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change focuses on sea-level rise and coastal storms.
- At the Rocky Mountain Biological Laboratory, there are several studies going on that are monitoring changes in altitudinal distribution (wildflowers and bumble bees), changes in phenology (e.g., migration, hibernation), and some studies at the genetic level. This work is aimed at documenting natural adaptation rather than facilitating adaptation.
- In the Scientific Forest Management Area of Baxter State Park (ME), an effort is underway to plant red oak (*Quercus rubra*, a species near the southern edge of its range) on sites that would not likely support red oak regeneration under climate conditions of the recent past. The oaks are obtained from nearby sites that are relatively warm and dry, so this is an example of very small scale assisted colonization within the geographic range of the red oak.

Metrics

Metrics to determine the success of adaptation strategies were fairly general. One respondent emphasized the importance of identifying clear, measurable targets at the onset of adaptation planning, with ongoing monitoring throughout the project to assess whether targets have been met. It was also suggested that thresholds (such as range of values) should be identified that will trigger changes in management, with sufficient resources to sustain implementation over time. In addition, several specific metrics were identified by three of the scientists. One mentioned the fact that specific metrics will necessarily vary given the particular conservation goal, but in general they could including maintaining viable populations,

maintaining ecosystem functions, and restoring natural disturbance regimes. It was also suggested that the ultimate measure of success is the long-term persistence of a species, community, or ecosystem, and the variety of interactions in which they are involved.

IV. CHALLENGES

The primary unmet needs that were identified by the academic group included the need for more reliable downscaled climate models, the need for better collaboration among researchers and resource managers, greater support for long-term scientific assessments necessary to understand complex problems, and the need to acknowledge and incorporate the inherent uncertainty of climate change into management plans. Several participants underscored the importance of directing their research efforts to inform management decisions, although one suggested that a major challenge is increasing the willingness to incorporate climate change into management planning when (a) contemporary management challenges are difficult enough and (b) the consequences of climate change are hypothetical, uncertain, and mainly lie well beyond planning horizons.

V. EXPENDITURES

In terms of expenditures, the primary responses specified budgets for relevant research activities, although several participants are also involved in project management. Amounts ranged from $0 (either the question was identified as not applicable or the respondent did not have specific budget authority) to up to $2,500,000 (more multi-year projects). In-between, one researcher has a budget of $1,000,000 to assist with planning restoration projects and evaluating project impacts on environmental benefits. One identified budgets for relevant research projects ranging from $5,000 to $800,000. One highlighted a budget within the $500,000 to $1,000,000 range offered in the survey question for activities related to research and communication.

One notable response was the suggestion that we build thinking about adaptation into our 'infrastructure policy' of public works, including a recommendation that all public work projects should have a 1-3% investment in R&D on system adaptation (so, a $50 million public work project would have a budget of $1.5 million).