Chapter 6
Future Assessment Activities

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Introduction

Climate change science has progressed significantly since the first National Climate Assessment (NCA) was produced (National Assessment Synthesis Team 2001). The ability to project climatic regimes and effects on forest ecosystems has increased through improved models and scaling techniques, as well as a combination of experimental studies and field observations that have either validated expected responses or challenged conventional thinking. However, as noted in previous chapters, critical information gaps exist in our ability to project how forest ecosystems will respond to the direct and indirect effects of climate change. Ongoing research is addressing many of these knowledge gaps, although the complexity of some scientific issues makes it clear that management and policy decisions over the next several years will continue to be made based on imperfect information.

By as early as the mid-21st century, a warmer and more variable climate, along with interacting stressors, will challenge the ability of public and private land managers to manage forest resources. In response, large-scale adaptation and mitigation strategies and tactics will need to be developed and applied across the United States to ensure the sustainability of ecosystem services in a changing climate. Engagement will be required in both biophysical and socioeconomic research to make viable options available to manage re-sources that are being affected by climatic variability and change at various spatial and temporal scales.

The 2013 NCA and the technical products that federal agencies and others are providing to the NCA are taking the first steps to help improve nationwide climate assessment capabilities in an integrated fashion. In the forest sector, a number of issues have emerged that need attention from national stakeholders and federal and state agencies, as well as from a resource management perspective. The current NCA approach is more focused than past climate assessments in supporting the Nation's activities in adaptation and mitigation, and in evaluating the current state of scientific knowledge relative to climatic effects and trends. It advocates a long-term, consistent process for evaluating climatic risks and opportunities and for providing information to support decisionmaking processes. The U.S. Global Change Research Program and NCA are working toward establishing a permanent assessment capacity both inside and outside of the federal government.

The NCA plans to have assessment activities draw upon the work of stakeholders and scientists across the country as an ongoing and continuous process. Assessment activities will support the capacity to conduct ongoing evaluations of vulnerability to climate stressors, observe and project effects of climate change within regions and sectors, allow for the production of a set of reports and Web-based products that are relevant for decisionmaking at multiple levels, and develop consistent indicators of progress in adaptation and

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mitigation. The NCA is working to make products of this process useful within management and policy contexts. It is expected that an ongoing NCA process will be established and sustained through a cooperative community-wide effort that incorporates federal, state, and local governmental agencies, nongovernmental organizations, academia, and tribal and private interests. The long-term objective of the process is to enhance coordination of climate assessment efforts and facilitate communication between stakeholders and data providers.

Regional Issues

Several large-scale emerging issues identified by the forest sector will need attention beyond the 2013 NCA effort. Ecological disturbance, invasive species, urban forests, forest conversion to other uses, and fragmentation will need ongoing research and monitoring so adaptation options can be developed and evaluated. Additional effort is also needed to better understand how climate change will affect ecosystem services, human health, water and watersheds, energy and bioenergy, carbon (C) sequestration, and forest industry viability. Many organizations are working to identify potential vulnerabilities and effects, along with adaptation options to address them, but few analyses and interventions are set within a risk-based framework. Developing a risk-based framework to assess climate-related changes is therefore a critical need for the future.

Developing a Risk-Based Framework

The NCA provided a simple set of guidelines on how to use a risk-based framework for technical input products for the 2013 report (Yohe and Leichenko 2009). The guidelines are based on the risk and uncertainty framework developed by the Intergovernmental Panel on Climate Change (Moss and Schneider 2000). Risk assessment is also being incorporated in other national and state climate change management efforts. For example, all four National Research Council panel reports of "America's Climate Choices" incorporate this framework, as does the draft Adaptation Plan for the United States. Although incorporating risk throughout a technical input product is challenging, the NCA recommends that this framework be incorporated at least for key vulnerabilities. Key vulnerabilities are those with a large magnitude, early timing, high persistence and irreversibility, wide distributional aspects, high likelihood, and high importance (based on human perceptions) (Schneider et al. 2007). All characteristics do not necessarily apply to a key vulnerability, and findings that may have a low likelihood but high consequence are still of interest to the NCA audience because of their high risk.

A risk management framework for natural resources identifies risks and quantifies the magnitude and likelihood of environmental and other effects to the extent possible. Although risk management frameworks have been used (often informally) in natural resource management for many years, it is a new approach for projecting climate-change effects, and some time may be needed for both scientists and resource managers to feel comfortable with this approach. Risk assessment for climate change should be specific to a particular region and time period, and needs to be modified by an estimate of the confidence in the projections being made. Further work is needed to refine and expand existing risk management frameworks to better address climate change vulnerabilities and potential effects.

Social Issues

The complexities of human behavior and social vulnerability, value and significance of forests, and their joint sensitivity to climate change argue for social science research and community involvement when planning for, managing, and communicating about climate change in the forest sector. Research indicates that place matters, the planning or decisionmaking process matters, and original, specific, and local solutions may be best. However, a consistent and logical framework is needed to quantify ecosystem services across different forested landscapes, communities, and management institutions and to incorporate a wide range of biophysical and social values.

Management Options

The scientific literature is growing, and on-the-ground activities are underway, but no standard evaluation framework exists to aid decisions about effective management approaches—encompassing both biophysical and social processes—for adapting to or mitigating climate change. A framework is needed that will incorporate elements such as local forest productivity, management objectives, and socioeconomic conditions.

Identifying areas where forests are most vulnerable to change (i.e., have low resistance and resilience) and where the effects of change on ecosystem services will be greatest is a significant challenge for resource managers. One would expect forest ecosystems and species near the limits of their biophysical requirements to be vulnerable, but the complexities of fragmented landscapes and multiple stressors are likely to change response thresholds in many forest ecosystems. Under these conditions, traditional approaches to forest management are likely to fail. Management approaches that anticipate and respond to change by guiding development and adaptation of forest ecosystem structure and function will be needed to sustain desired ecosystem services and values across large landscapes and multiple decades. Land managers who are currently managing forest ecosystems in a sustainable manner are probably already using “climate smart” practices, and implementation of climate smart management at all spatial scales and by a variety of organizations (federal agencies, private land owners, conservation groups) can affect long-term resilience and sustainability. However, a systematic effort to communicate and implement these experiences more extensively is needed.

Ecological Disturbances and Extreme Events

Climatic variability is a driver of regionally episodic fires and endemic insect outbreaks; therefore, “new” science on climate and ecological disturbances is principally concerned with quantifying the mechanisms and variability in relationships between climate and ecological disturbance. Relationships between pathogens and climate change are not as well understood, but it is plausible that higher stress in tree species will reduce forest vigor and increase mortality. From an ecosystem perspective, thresholds can be reached either through cumulative effects of individual disturbances over time or one large event, and can lead to new forest composition, land cover, and landscape patterns. However, more information is needed on the interaction of ecological disturbances and other environmental stressors, especially for large spatial and temporal scales.

Climate affects forests through extreme events (e.g., hurricanes, wildfire, etc.) and through enabling conditions (e.g., long warm or cool periods, and long wet or dry periods). These events or enabling conditions can have short-term effects on forests, after which there is a transition or recovery, followed by long-term outcomes. Management can primarily respond to the enabling conditions by building resilience, as well as facilitating the transition or recovery. Are we prepared to confront and respond to climate-related forest changes within the context of forest management? The answer lies in our ability to recognize potential loss, quantify risk, examine options, identify tradeoffs, anticipate rare but high-consequence events, and invest commensurate with risk. The challenge before us will require new tools, information, and technology, as well as the experience of resource managers.

Coordination With Other Assessment Activities

Evaluating the future of forests requires understanding of human behavior in the context of a changing climate. Recently, the U.S. Forest Service conducted an assessment of current and future forests and rangelands, as required by the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, which mandates that current conditions, trends, and forecasts for the next 50 years be assessed. Recent changes to the assessment mandated by the RPA include (1) presenting conditions, trends, and forecasts in a global context, (2) utilizing global climate models (three were used) and emission scenarios (e.g., A1B, A2, and B2), and (3) integrating the analysis with socioeconomic factors (e.g., wood product markets and the price of timber, and agricultural markets and the future of crop prices). The RPA assessment indicates that forest area in the United States peaked in 2010 at 253 million ha and will likely decline through 2060 to between 243 and 247 million ha. Product markets, population, income, and climate all interact to determine future forest area, biomass, and forest C. Climate will influence the outcomes, and although significant variation exists across potential climate futures, it is still small relative to human factors in the short run.

Effects on Tribal Lands

American Indian and Alaska Native tribes face disproportionate risks from climate change. Tribes have unique rights, cultures, economies, and vulnerabilities to climate change effects. For indigenous peoples, the effects of climate change and the proposed solutions may affect tribal subsistence, land rights, cultural survivability, and financial resources. Tribes recognized a critical need for coordination among public agencies and organizations in accessing climate change resources and information, and in 2009, the Tribal Climate Change Project (University of Oregon 2012) was established to determine the needs, lessons learned, and opportunities American Indian tribes have in planning for the effects of climate change. Key research areas for the project are (1) increased understanding of tribal adaptation and mitigation planning for the physical effects of climate change, (2) increased understanding of management of off-reservation resources, and (3) government-to-government relationships in addressing climate change through consultation, cross-landscape assessments, and tribal involvement in federal and state climate change plans. These types of research efforts will continue to be important for filling critical knowledge gaps.

Carbon Estimation

Through the U.S. Forest Service Forest Inventory and Analysis (FIA) program, C accounting is accomplished by first estimating land use and then estimating forest biomass. Forest C flux is approximated as a change in forest stocks over time. The FIA is primarily a large-scale inventory, and climate change would need to have a significant effect on net forest growth for FIA data to detect it. Accounting for C and managing ecosystems raises significant questions because of the uncertainty in how C pools will change with climate. Thus, management will require an integrated approach to mitigation and adaptation at large spatial scales. Avoiding deforestation and increasing afforestation can be recommended in the near term, whereas application of improved forest management across various regions may cause C losses in some locations and gains in others. Applying climate smart management at the stand scale is important but will be more effective in a broad landscape context.

Carbon mitigation can also be assessed through life cycle analysis**.** A recent synthesis of findings about the mitigation effectiveness of alternate forest management and wood use options concluded: “In the long term, sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual yield of timber, fiber, or energy from the forest, will generate the largest sustained mitigation benefit” (Metz et al. 2007). This raises the questions: “Which forest management and wood use strategies yield the greatest offset, in the near term and long term?” and “How confident are we in gains from those actions?” Afforestation and avoided deforestation are approaches with the highest confidence (lowest uncertainty) for providing C mitigation. Other approaches for which moderate uncertainty exists about effective mitigation include decreasing harvest, increasing forest growth, reducing hazardous fuels, using wood for energy, and substituting wood for nonwood products. Additional investigation is needed for all these topics. Life cycle evaluations of management and wood use options suggest more intensive approaches to wood production, harvest, and use to maximize C mitigation. The nature of future C markets, especially a regulated C market versus a voluntary market, will affect participation and influence wood product markets. Participation by private land owners may depend on management objectives and type of ownership (e.g., small vs. large properties). The motivation of private corporate entities relative to wood and C management, if surveyed accurately, will also provide important insights.

Conclusions

Abundant data exist on the climatic, physical, ecological, and social aspects of how forests and forestry may respond to climate change, but the synthesis and integration of these for identifying adaptation options and making decisions are limited by (1) an inability to respond rapidly to new information such as projections of future climate; (2) social, political, and economic forces that affect the structure and function of forest ecosystems and their management; and (3) inadequate resources for synthesis and integration, particularly for adaptation and mitigation options and consequences. Stakeholders provided diverse recommendations for preparation of the forest sector technical report for the NCA, and most stakeholders emphasized that connections among various biophysical and social factors are not well understood or easily modeled. For example, the effects of climate change on wildfire can be partially mediated by fuels management, which in turn has a set of cascading effects on other forest processes and values, depending on the efficacy and intensity of management.

A number of periodic assessments by the Forest Sector are relevant to the NCA request for delivery of interim products between the 2013 and the 2017 NCA reports. For example, required sustained efforts such as the RPA assessment and periodic efforts such as the National Sustainability Report (USDA FS 2011) can provide integrated national-scale information pertinent to the issues discussed here. However, a concerted effort will be necessary to identify these products and make them available to resource managers and decisionmakers.

Literature Cited

Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA); 16 U.S.C. 1601 (note).

Metz, B.; Davidson, O.R.; Bosch, P.R., eds. 2007. Mitigation of climate change. Contribution of Working Group III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press. 752 p.

Moss, R.H.; Schneider, S.H. 2000. Uncertainties in the IPCC TAR: recommendations to lead authors for more consistent assessment and reporting. In: Pachauri, R.; Taniguchi, T.; Tanaka, K., eds. Guidance papers on the cross cutting issues of the Third Assessment Report of the IPCC. Geneva, Switzerland: World Meteorological Organization: 31–51.

National Assessment Synthesis Team. 2001. Climate change impacts on the United States: the potential consequences of climate variability and change: foundation report. Report for the U.S. Global Change Research Program. 2nd ed. Cambridge, United Kingdom; New York: Cambridge University Press. 618 p.

Schneider, S.H.; Semenov, S.; Patwardhan, A. 2007. Assessing key vulnerabilities and the risk from climate change. In: Parry, M.L.; Canziani, J.P.; Palutikof, P.J. [et al.], eds. Impacts, adaptation and vulnerability. Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press: 779–810.

University of Oregon. 2012. Tribal climate change project. http://tribalclimate.uoregon.edu. (23 July 2012).

U.S. Department of Agriculture, Forest Service [USDA FS]. 2011. National report on sustainable forests—2010. FS-979. Washington, DC.

Yohe, G.; Leichenko, R. 2009. Adopting a risk-based approach. In: Climate change adaptation in New York City: building a risk management response. New York: New York City Climate Change Adaptation Task Force, Annals of the New York Academy of Sciences: 29–40.