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David L. Peterson
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Climate Change and United States Forests

 Springer

Climate Change and United States Forests

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Climate Change and United States Forests

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The remainder of the twenty-first century will pose significant challenges for natural resource managers as they respond to rapid and unexpected changes. We have spent most of our careers studying how forest ecosystems work and how to keep them working so they can continue to provide a myriad of benefits to society. We hope that our efforts in producing this book will help ensure the sustainability of forests in the face of climate change for future generations. We dedicate this book to Gordon Weynand for his unwavering support and to the next generation, future stewards of the global environment: Aadya, Aaron, Christian, Christina, Nate, and Zak.

Foreword

Managing forest ecosystems has always been about dealing with change and providing for the future. *Climate Change and United States Forests* shows how changes in the climate are causing pervasive and far-reaching changes in forest ecosystems. The book helps us, the benefactors of services provided by forest ecosystems, connect the scientific dots and better understand the big patterns. Hopefully, these insights will drive our thinking and actions as we confront recent and future changes in our forests.

The authors have methodically surveyed the scientific literature for a wide range of climatic effects, organizing them into regional projections for the future and calling for flexibility and nuance in management and policy action. Their exploration of a large and growing body of science gives us a clear, intricate, and balanced picture of both challenges and opportunities, unencumbered by ideological advocacy and policy prescriptions. What follows is not a doomsday prophecy supported by selections from the literature, but a clear-eyed synthesis of observations and insights from climate and forest science. It offers both alarm and hope, challenging us to address the overarching asynchrony of a climate changing faster than some forest systems and species can adapt. Whether, when, and how to intervene with proactive adaptation are ultimately society's decisions, but the assessment that follows can help assure that these choices are well-informed.

The picture here is not of a new scientific terrace where we can stop and catch our breath, but of systems in motion, where we must use scientific inquiry and management experience to provide signals of pattern shifts, new configurations, and emerging issues. This is the science of the unsettled, where decision makers and citizens must learn to refuel in flight.

This is a summary for those who take and learn from actions. It raises hope and provides examples of taking action to deal with the changing climate. It encourages us to move forward with actions that help us understand and deal more effectively with the complexities of different climatic effects in different systems. While the myriad uncertainties about climate change are obsessively debated and amplified by theorists, policy scholars, wonks, ideologues, and advocates, it is refreshing that science can be interpreted from the perspective of proactive adaptation and

learning. We have the tools—silviculture, genetics, fire and fuels management, engineering, hydrology, forest products, forest economics—that can be modified or used in different combinations to help steer adaptive processes. We may need to deploy these tools not just to manipulate systems but also for learning, because as the book fully discloses, there is a lot we do not yet know. It is heartening to know that resource managers and institutions are already taking action, establishing new partnerships, and innovating strategies and techniques that will allow us to adapt to a cadence of change that will accelerate.

The authors emphasize that actions must be based on new realities. Most obvious but perhaps underappreciated is the fact that the climate is indeed changing. These changes, which have become increasingly supported by observation by scientists, managers, and citizens, have profound effects on forest resources and our abilities to use, appreciate, and manage them. And they call on us to reexamine and challenge assumptions about stationarity and heretofore predictable and recurring cycles that may underlie some of our forest management practices. These changes must be put in temporal and spatial perspective and understood in the context of what we already know about how forests grow and change. We know a lot about how forests vary geographically, how they respond to multiple stresses, and the roles they play in various biogeochemical cycles. The book challenges us to integrate these new findings into the design of actions and measures of success as the forest around us moves and changes.

We are now encouraged to build “climate smartness” into how we undertake forest management and how we assess issues of policy and social expectations. The changing climate should not be a stand-alone issue, but rather a property of all resource discussions and decisions. By describing climate change effects in a risk management framework, the authors have provided a structure to guide integration. All decisions involve weighing the tradeoffs among benefits, costs, opportunities, and risks, and it is easier to blend climatic effects on forests into ongoing decision processes when they are expressed in the common language of risk assessment and risk management. Climate change is a component of broader risk-based thinking in which all elements of forest enterprise are integrated—vegetation protection and management, roads and access, harvesting and products.

The book is a vivid reminder that we humans influence forests through (1) the overarching and increasingly evident role of global climate change, and (2) multiple, direct influences of an expanding population on urban development, fire management, commerce, water use, and other resource-dependent activities. Where these two factors collide in systems already attuned to patterns of natural disturbance, we are seeing changes we have not had to deal with before. Deforestation of the last two centuries may have been acute and visible, but the solution was inherently simple yet massive: protect, reforest, manage. Today’s issues created by climate change intersecting with the intricacies of an existing forest are more complex and less amenable to blunt national policy prescriptions.

The overall impact of the book may be to change the way we think and talk about forests. The authors assure us that despite the effects of a changing climate, all is

not chaos. But we do need to “get up and move around a little” to get new blood flowing to our collective brain. As climate changes play out into different regional weather patterns and responses, we cannot assume that forests will stay as they are or where they are today. We need to reexamine what we expect from forests and what ecosystem services they can provide. Forests and their changing provision of services are not limited to the traditionally defined rural sector that produces forest products; forests are also vital elements of infrastructure in urban and agricultural systems. Changes are underway not only for the forest landscape, but also for the forest in the landscape, wherever it may occur.

We can now address multiple, interacting sources of stress and disturbance and the rapid changes they create as they combine, and not limit our thinking to just fire, insects, disease, air pollution, invasive species, and human development as separate influences. Paying more attention to extreme conditions and events will allow us to understand how their patterns differ over time and space and their influence in the life cycles of forest systems. It is critical that we closely follow regenerative pathways after these events, no longer assuming that the system will be “reset” predictably to some familiar forest condition. Rather than looking at effects on one species at a time, we need to monitor and understand changes in entire forest systems, positioned at the intersection of cycles for water, carbon, and other vital ecosystem functions.

An emerging imperative from the book concerns our most basic approaches to creating and using knowledge in a rapidly changing world. The results described here serve as both warning and inspiration to develop better ways to convert existing and emerging knowledge into proactive decisions about tomorrow. We need to become better at interpreting trends, describing alternative futures and designing forest management actions that are robust and flexible to a wider range of future conditions. Research and development are vital for finding our way forward through a changing climate. Without the integration of advancing forest and climate science, a broad picture of our nation’s changing forests is not possible. Syntheses such as this help us identify gaps, reset our focus, and remind us that resource management is itself a learning device.

But this book also shows that the best science for adaptation will be conceived in strong adaptive research-management partnerships. We must find new ways for scientists, managers, and citizens to work together to pool their observational powers and intelligence to continually reexamine the realities of forest systems. With so many changes underway and more to come, we cannot afford to follow the linear, sequential model of science-based management in which actions are contingent on research providing the absolute certainty that never quite arrives. New relationships between science and management, as demonstrated in examples here, will streamline our learning and integrate emerging lessons from experimental science, experiential learning, and traditional forms of knowledge.

Ultimately, adaptation is not an action or a set of actions. It is a way of gaining and using knowledge, of creating and preserving options, and of cultivating new institutions that are agile, open, and flexible enough to provide enduring values

in dynamic forest ecosystems. *Climate Change and United States Forests* can be viewed as a call for new strategies and institutional arrangements to address adaptation in this larger sense, as we venture from forests as they are today to forests of the future, shaped by the interacting forces of climatic, demographic, and economic change.

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Preface

Climate Change and United States Forests assesses the current condition and likely future condition of forest resources in the United States relative to climatic variability and change. Derived from a report that provides technical input to the 2014 U.S. Global Change Research Program National Climate Assessment, it serves as a framework for managing forest resources in the United States in the context of climate change. A complete synthesis of all of the effects of climatic variability and change on forest resources in the United States would require a multi-volume effort, especially given the enormous scientific literature on climate change over the past 20 years. Therefore, we focus on topics that have the greatest potential to alter the structure and function of forest ecosystems, and therefore ecosystem services, by the end of the twenty-first century.

Part I provides an environmental context for assessing the effects of climate change on forest resources. First, recent changes in environmental stressors, including climatic (e.g., temperature, droughts) and other biophysical phenomena (e.g., wildfire, insects), are summarized in Chap. 1. Then, state-of-science projections for future climate are presented for parameters relevant to forest ecosystems (Chap. 2).

Part II provides a wide-ranging assessment of vulnerability of forest ecosystems and ecosystem services to climate change. Biogeochemical cycling (including carbon), hydrology, and forest dynamics, which are strongly affected by climate and are expected to change significantly in some regions of the United States, are the focus of Chap. 3. We anticipate that altered disturbance regimes and stressors will have the biggest effects on forest ecosystems, causing long-term and in some cases permanent changes in forest conditions. Chap. 4 documents the effects of ecological disturbance and examines projected future disturbance regimes. Forest values and the socioeconomic context for human-forest interactions in the United States, ranging from rural to urban environments, are discussed in Chap. 5. Chapters 3, 4 and 5 cannot capture the enormous variability in biogeographic phenomena across U.S. forests; therefore, Part II concludes with a series of short summaries of climate change effects, issues, and adaptation for eight regions of the United States (Chap. 6).

Part III describes social and management responses to climate change in U.S. forests. Current status and trends in forest carbon, effects of carbon management, and carbon mitigation strategies are summarized in Chap. 7. Current and projected greenhouse gas emissions make climate change inevitable, so it is imperative that we prepare forest ecosystems and land management organizations for a permanently warmer climate. We are fortunate that principles of climate change adaptation are well established and that tools and resources to facilitate this management transition are available (Chap. 8). Risk assessment is regarded as a foundation for the 2013 National Climate Assessment and the Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) (expected in 2014). Part III concludes with a framework for risk assessment, including case studies, to provide a structured approach for projecting future changes in resource conditions and ecosystem services (Chap. 9).

Finally, Part IV describes how sustainable forest management, the paradigm that guides activities on most public and private lands in the United States, can provide an overarching structure for mitigation of and adaptation to climate change (Chap. 10).

Because of the complexity of forest ecosystems, it is often difficult to conclude whether recently observed trends or changes in ecological phenomena are the direct result of human-caused climate change, climatic variability, or other factors. Regardless of the cause, forest ecosystems in the United States at the end of the twenty-first century will differ from those of today as a result of changing climate. Surprises are likely—some forests may change faster than we expect, some forests may be more tolerant of a warmer climate than we expect, or a new non-native insect may be a “game changer” by quickly killing large areas of native forest species. Because the current trajectory of greenhouse gas emissions implies at least one to three centuries of higher temperatures, preparing for future changes in forest ecosystems is imperative.

Climate change science must quickly move from the academic realm to the applied world of resource management. Land managers in the United States are faced with a landscape that has been greatly altered, with some 90 % of the nation’s forest having been harvested in the nineteenth and twentieth centuries. Urban areas are encroaching on wildlands. Private forest land is becoming increasingly fragmented and is expected to decrease in the future. Non-native flora often comprises more than 10 % of the vegetation in a given location. Although production forestry is still important in some regions, especially the southeastern United States, restoration is dominant in other regions. Because restoration must now occur in a warmer climate, we can no longer use static images of the past (e.g., historic range of variability) as targets for future conditions. We must provide land managers with the expertise, scientific principles, and techniques for transitioning forest ecosystems into a warmer, more variable climate.

Because our charge was to provide input to the U.S. National Climate Assessment, we have a provincial focus on United States forests and have not considered the broader geographic realm of North America and other continents. However, we anticipate that this book will contribute to ongoing efforts to synthesize information

at continental and global scales (e.g., the Fifth IPCC Assessment). In terms of on-the-ground management of forest resources, vulnerability assessments and adaptation strategies are most useful at the regional to sub-regional scales, and we hope that recent collaborative efforts described in this book will propagate across all landscapes in the United States.

We are optimistic about the future of forest resources in the United States, assuming that a strong commitment to monitor and respond to climate change is institutionalized within land management agencies and other organizations. Failure to do so may preclude future options for ensuring the long-term productivity and functionality of forest ecosystems. How will future generations judge the resource stewardship of our generation?

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