Book Review

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Peering into the future of wildlands management

Hansen, Andrew J., William B. Monahan, David M. Theobald, and S. Thomas Olliff, editors. 2016. **Climate change in wildlands: pioneering approaches to science and management**. Island Press, Washington, D.C. xiv + 392 p. $70.00 (hardcover), ISBN: 978-1-61091-711-7 (acid-free paper); xiv + 392 p. $35.00 (paper), ISBN: 978-1-61091-712-4 (acid-free paper).

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In recent years there has been a torrent of literature published looking at the effects of climate change on various species and ecosystems. Most of this research hews to fairly traditional contours: how are different climatic variables changing or projected to change; how are these shifts affecting or expected to impact particular species or systems? Far less work looks at what these climatic and ecological changes mean for conservation, and more specifically, how managers should respond and adapt to conditions that are rapidly moving beyond the range of historical variability.

Climate change in wildlands seeks to bridge the gap between the science of climate change and its implications for natural resource management. The volume represents the capstone of a NASA-funded project that challenged researchers to explore the potential for using a variety of sensors, from satellites to in-situ observations, to assess the twin threats of climate and land use changes. The book "tells the story of progress made in climate adaptation" through focusing on federal lands in two regions of the United States—the northern Rocky Mountains and the Appalachians.

Coping with climate impacts is no longer a theoretical concern in these two regions. In summer of 2016, the famed Yellowstone River was closed to fishing for nearly 1 month due to a massive fish kill caused by a parasite, but which was greatly enabled by unusually warm waters. Later that year, an explosive, drought-fueled fire in Great Smoky Mountains National Park devastated the gateway community of Gatlinburg, killing 14 people.

Climate adaptation (not to be confused with adaptation in an evolutionary sense) focuses on reducing climate-related risks and vulnerabilities to natural and human systems, and enhancing their capacity to adjust to and cope with changing conditions. Over the past decade there has been substantial progress in developing the conceptual basis for adaptation, but considerable work is still needed to operationalize these concepts, and to test and refine their application. Indeed, this is the task taken on by the editors and authors of this ambitious volume. To do so, the volume, and underlying project, is structured around a generalized adaptation planning framework, known as the Climate-Smart Conservation cycle, which was developed by an interagency workgroup (Stein et al. 2014). While the climate-smart framework has been applied in a variety of contexts (e.g., climate refugia, Morelli et al. 2016, coral reefs, West et al. 2017), this volume represents one of the fullest efforts to date to explore and test its application.

The 391-page volume is well organized, being divided into four major parts that generally track the flow of the climate adaptation planning process. Part 1 provides an introduction and overview to climate adaptation, and describes the considerable progress made over the past few years in integrating climate science into federal land management efforts. In Part 2, the volume moves to an assessment of past, current, and future climate in the two montane regions. This section includes an innovative landforms-based analysis (Chapter 6) that integrates land use and climatic factors in assessing the vulnerability of geographic areas. Part 3 considers the ecological consequences of current and projected climate change on key resources, primarily through assessing climate-related vulnerabilities for vegetation, tree species, and trout species (native and non-native). The section also includes an exploration of the vulnerability of ecosystem processes, focusing on indicators of water cycling and vegetation productivity. Finally, Part 4 turns to resource management under climate change, summarizing several approaches for identifying possible adaptation options, and offering case studies of climate-informed management at Rocky Mountains National Park and in the Greater Yellowstone Ecosystem.

The editors thoughtfully provide a road map to the volume through a set of introductory chapters, as well as with succinct introductions to each of the book's four parts. These explanatory materials help the reader understand how the various chapters related to one another, and fit into the overall adaptation process. Similarly, each chapter contains a conclusions section that summarizes key points and provides a useful distillation of the sometimes dense and data-rich text. A final chapter (Chapter 17) offers an insightful synthesis elaborating on a number of lessons learned, which stress the importance (among other things) of: science-management

partnerships; the need to focus on management-relevant issues; the value of place-based context; and the imperative for defining and tracking impact.

Despite the book's efforts to connect and apply emerging climate science to management concerns, the majority of the work presented focuses on physical climate signals or impacts and vulnerabilities. This is not surprising given the nature of the underlying NASA-funded Landscape Climate Change Vulnerability Project, but is also a reflection of much of the climate and adaptation science taking place during the project period. In addition, a solid understanding of vulnerability—not just what is vulnerable, but also why it is vulnerable—is key to designing effective adaptation strategies. To their credit, authors of most chapters attempted to decipher the management implications of their results.

One thing that ties together most of the analyses presented in the book is an effort to apply quantitative methods to vulnerability assessments, and to operationalize adaptation concepts that have sometimes been elusive. In particular, several chapters offered quantitative approaches to characterizing *adaptive capacity*, a core but poorly understood component of vulnerability (Beever et al. 2016). Similarly, there are relatively few examples in the literature of assessing the vulnerability of ecosystem processes, as was done in Chapter 7. And building on growing interest in the role of geophysical diversity for conservation and adaptation, Chapter 6 offers an innovative application of climate velocity mapping as a way to better understand the pace and directionality of projected changes in key geographies and habitats.

One minor quibble I have is the notion, offered in a few instances, that climate-smart conservation necessarily focuses on the most vulnerable resources identified through a vulnerability assessment. Rather, depending on one's conservation goals and objectives (which ideally are climate-informed), adaptation actions can focus on the most vulnerable or on the least vulnerable (i.e., most resilient) resources. Adaptation actions can also seek to maintain the persistence of given conditions or to actively manage for changes in future conditions. Vulnerability assessments provide important context to inform management priorities and adaptation strategies, but they do not pre-determine those choices.

By offering a glimpse into the struggles of resource managers to address climate impacts, the book also injects a healthy dose of reality into understanding "science-management partnerships." Yet while the case studies of Rocky Mountains National Park and the Greater Yellowstone Ecosystem provided interesting overviews of some of the ways managers are responding to various drivers of change, much of the work described is more reflective of existing adaptive management rather than the application of adaptation-specific planning frameworks. Indeed, as the editors note, "It is not surprising that progress on the science components of the Climate-Smart Conservation framework has outpaced that of the management components."

Nonetheless, these case studies provide valuable insights for climate scientists as they engage with and attempt to meet the needs of management partners. For instance, the authors of the Rocky Mountains National Park case study (Chapter 14) note that "ologists" often fail to understand that "land management decisions are rarely driven by science; rather human values drive management decisions—always have and always will." That is not to say that climate science (or ecological science more broadly) is irrelevant or unimportant. Indeed, as the impacts of climate change accelerate, we can anticipate that climate and adaptation science will be key to informing the evolution of our societal values—and the conservation goals that reflect those values. Reflecting just such a dynamic, these authors found that in the face of forest-altering disturbances, such as pine beetle outbreaks and fire, one of their biggest challenges was to "educate [Rocky Mountain] park staff and visitors that change is not always equivalent to loss or destruction."

If managing for change is at the heart of climate adaptation, these managers clearly have internalized the concept! By highlighting the emerging science of climate adaptation, *Climate change in wildlands* offers a glimpse into the future of wildlands management, and points the way toward opportunities for meaningfully adapting to rapid and accelerating climate change.

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