Forest Ecology and Management 360 (2016) 80–96

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Review and synthesis

Achievable future conditions as a framework for guiding forest conservation and management

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ARTICLE INFO

Article history:
Received 22 May 2015
Received in revised form 5 October 2015
Accepted 7 October 2015

Keywords:
Forest management
Conservation
Ecosystem services
Novel ecosystems
Achievable future conditions
Southeastern United States

ABSTRACT

We contend that traditional approaches to forest conservation and management will be inadequate given the predicted scale of social-economic and biophysical changes in the 21st century. New approaches, focused on anticipating and guiding ecological responses to change, are urgently needed to ensure the full value of forest ecosystem services for future generations. These approaches acknowledge that change is inevitable and sometimes irreversible, and that maintenance of ecosystem services depends in part on novel ecosystems, i.e., species combinations with no analog in the past. We propose that ecological responses be evaluated at landscape or regional scales using risk-based approaches to incorporate uncertainty into forest management efforts with subsequent goals for management based on Achievable Future Conditions (AFC). AFCs defined at a landscape or regional scale incorporate advancements in ecosystem management, including adaptive approaches, resilience, and desired future conditions into the context of the Anthropocene. Inherently forward looking, ACFs encompass mitigation and adaptation options to respond to scenarios of projected future biophysical, social-economic, and policy conditions which distribute risk and provide diversity of response to uncertainty. The engagement of science-management-public partnerships is critical to our risk-based approach for defining AFCs. Robust monitoring programs of forest management actions are also crucial to address uncertainty regarding species distributions and ecosystem processes. Development of regional indicators of response will also be essential to evaluate outcomes of management strategies. Our conceptual framework provides a starting point to move toward AFCs for forest management, illustrated with examples from fire and water management in the Southeastern United States. Our model is adaptive, incorporating evaluation and modification as new information becomes available and as social–ecological dynamics change. It expands on established principles of ecosystem management and best management practices (BMPs) and incorporates scenarios of future conditions. It also highlights the potential limits of existing institutional structures for defining AFCs and achieving them. In an uncertain future of rapid change and abrupt, unforeseen transitions, adjustments in management approaches will be necessary and some actions will fail. However, it is increasingly evident that the greatest risk is posed by continuing to implement strategies inconsistent with current understanding of our novel future.

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http://dx.doi.org/10.1016/j.foreco.2015.10.009
0378-1127/

Contents

1. Introduction

The future is increasingly uncertain due to the rapid and compounded environmental, economic, and social changes that characterize the so-called Anthropocene, the geological epoch dominated by human modification of the Earth System (Steffen et al., 2007). High rates of landscape modification and species extinctions are unprecedented, and few, if any, ecosystems remain beyond the influence of human activity (e.g., Likens, 2001; Seastedt et al., 2008; Hobbs et al., 2009). Modern landscapes are social–ecological matrices of patches ranging from "natural/wild" to "intensive commodities-oriented" to "urban" (Hobbs et al., 2014). Novel ecosystems – the product of direct or indirect human activity – are increasingly prevalent and are often characterized by species assemblages and biophysical conditions with no analog in the past (Hobbs et al., 2006). The combined effects of changing climate and land-use, habitat fragmentation, species loss and introductions, and altered nutrient and hydrologic cycles at times exceed the ability of contemporary ecosystems to maintain their structure and function. Such disruptions can result in rapid unanticipated transitions and irreversible thresholds, which have significant social and ecological consequences (see Research Alliance Thresholds Database for examples, http://www.resalliance.org/index.php/thresholds_database). At the same time, there are societal expectations that ecosystems can and will be restored or rehabilitated to functional states, even while climate change, population growth, water diversion, the proliferation of chemicals and numerous other environmental changes impose additional burdens in ways that are not adequately understood (Naiman, 2013). Indeed, a primary goal of ecosystem management is to sustain ecosystem structure and function (Christensen et al., 1996). However, we contend that ongoing changes will in some cases exceed our ability to sustain existing ecosystems, and in such cases, a shift in focus to mitigation and adaptation for ecosystem services will be necessary and therefore produce "novel" ecosystems (e.g., Millar et al., 2007; Hobbs et al., 2014).

The rate and magnitude of environmental and socio-economic change expected over the next several decades will require innovative conservation and management perspectives, as these anthropogenic changes will alter (e.g., increase or decrease) the ability of ecosystems to provide ecosystem services (Hobbs et al., 2014, AIBS, http://actionbioscience.org/environment/esa.html). Ecosystem services are values associated with human well-being and are comprised of needs (i.e., *life sustaining*) and desires (i.e., *quality of life sustaining*), with both tightly tied to ecosystem structure and function. The capacity to maintain or enhance these services is a significant concern, as reductions hold negative and in some cases, potentially dire consequences for human well-being (e.g., www.millenniumassessment.org).

Although many of the concepts presented in this paper can be applied to a wide range of ecosystems, our focus is primarily on forests. Forests are an especially critical component of the modern landscape, providing diverse services such as wood and fiber, climate regulation, carbon storage, biodiversity support, and regulation of water yields and quality (FAO and JRC, 2012; Agrawal et al., 2013; Haddad et al., 2015). Current approaches to forest management in areas dominated by private land ownership are generally fragmented and uncoordinated. While management *goals* may be intended to ensure productivity, environmental quality, and conservation of biodiversity, management *approaches* are often limited in their ability to protect key ecosystem services given the rate and scale of biophysical and social-economic changes. We attribute this deficiency, at least in part, to an outdated view of ecosystems and the Earth System as static or inherently stable rather than dynamic (Pickett et al., 1992; Milly et al., 2008). New approaches focused on anticipating and guiding ecological responses to change are urgently needed to ensure ecosystem services for future generations. This need will likely require challenging some widely accepted principles of forest management and restoration, revising and expanding long-held guidelines and best management practices, and reappraisal of current regulations and laws. For example, focusing conservation efforts on public lands, local preserves, protection of rare species assemblages, and restoration of historic forest ecosystems may prove insufficient. Change is inevitable and might often be irreversible, so the provision of ecosystem services will depend, in part, on the development of novel ecosystems and the emergence of regionally coordinated forest conservation strategies and management