Journal of Environmental Management xxx (2016) 1–8

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Research article

Adaptive governance of riverine and wetland ecosystem goods and services

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ARTICLE INFO

Article history:
Received 14 October 2015
Received in revised form
5 May 2016
Accepted 10 May 2016
Available online xxx

Keywords:
Adaptive governance
Resilience
Ecosystem services
Adaptive management

ABSTRACT

Adaptive governance and adaptive management have developed over the past quarter century in response to institutional and organizational failures, and unforeseen changes in natural resource dynamics. Adaptive governance provides a context for managing known and unknown consequences of prior management approaches and for increasing legitimacy in the implementation of flexible and adaptive management. Using examples from iconic water systems in the United States, we explore the proposition that adaptive management and adaptive governance are useful for evaluating the complexities of trade-offs among ecosystem goods and services.

1. Introduction

In the early 21st century, people and societies have developed an unprecedented capacity to manipulate and control ecosystems in order to procure reliable streams of ecosystem goods and services. While humans have altered ecosystems for millennia, it has only been in the past few decades that concepts such as ecosystems goods and services have been proposed as one way to collectively describe the many ways in which humanity and nature benefit from ecosystems (Daily, 1997). A recent global assessment found that many ecosystem services are declining (MEA, 2005).

As our capacity to manipulate the environment has increased, we have also sharpened the focus of how we manipulate the environment to secure ecosystem goods and services. In a gross oversimplification, we seek to control ecosystems by decreasing the natural or inherent variation in ecosystems in order to procure a specified set of ecosystem goods and services. We build dams in river ecosystems in order to control flooding during wet periods and to store water for dry periods. Dams dampen the fluctuations in river flows, by controlling the amount of water released downstream, but also facilitate diversion of water for other types of ecosystem services. In these and many other cases, we stabilize ecological processes in order to achieve economic and social outcomes. In doing so, we optimize for specific goods and services by enhancing efficient production, use and allocation of some at the expense of others. These three objectives; control, stability and efficiency have been achieved in many ecosystems, but not without a cost.

There is a growing body of evidence to indicate that ecosystem management that removes inherent variation, homogenizes spatial patterns and optimizes extraction of a few ecosystem goods increases the vulnerability of these systems to dramatic and unwanted changes (Gunderson and Holling, 2002; Walker et al., 2004; Walker and Salt, 2012). For example, levees, canals and water control structures were put in place to control flooding and to regulate water supply to users in the vast Everglades wetlands of Florida (Light et al., 1995). Development of dams to provide hydropower, irrigation and flood control in the Columbia River basin has evened out flow reducing spring flood and increasing late summer and fall flow (Columbia River Inter-Tribal Fish Commission, 2014; Cosens and Fremier, 2014). Such compartmentalization to control water movement in the mighty rivers of the western U.S. has decreased the variation in flow volumes, slowed the movement of sediments, created new ecosystems, and led to endangerment and extirpation of populations of Pacific salmon as well as non-anadromous species. Similar approaches in fisheries or wildlife

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http://dx.doi.org/10.1016/j.jenvman.2016.05.024
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management also attempt to limit or constrain variability in order to sustain efficient outputs. However, this pattern of ecosystem modification generates an unintended consequence of increased vulnerability (Carpenter et al., 2015), described as the pathology of resource management (Holling and Meffe, 1996). This pathology results from the unexpected response of complex systems to simple management approaches.

While attempts at increasing control over nature have been successful in achieving social and economic objectives, they often have come at the cost of ecological and environmental components. Most regional scale water systems in the U.S. are critical habitat for multiple taxa listed as endangered or threatened. For example, the Everglades system has more than 20 threatened and endangered species (Gunderson and Loftus, 1993). In the Columbia River basin, 8 salmon, 4 steelhead, and 2 resident fish species are listed under the ESA (NOAA, 2012). Other common resource issues that map into ecosystem services include losses in ecosystem functions due to invasive species and water quality degradation (MEA, 2005). In many cases, the changes resulting from intensive management have resulted in new or novel ecosystem configurations (Holling and Meffe, 1996).

The degradation of ecosystem services, such as freshwater provisioning or water quality regulation, or declines in biodiversity can indicate a loss of ecosystem resilience and resulting shift in ecosystem regimes (Folke et al., 2004; Gunderson and Pritchard, 2002). An ecological regime is characterized by a set of structural and functional features, such as shallow, clear water lakes with submerged vegetation (Scheffer et al., 2001), or coral dominated reefs (Hughes, 1994). Regime shifts occur when the dominant structural features of an ecosystem are replaced by alternative ones (Folke et al., 2004). Such regime shifts can be viewed as ecological crises signaling a shift in individual or bundled ecosystem goods and services (Chapin et al., 2009). Ecological crisis may result in unintended and unexpected consequences that substantially alter and reduce services that society has come to rely on. Such crises can reveal failures in policy and management approaches (Gunderson et al., 1995).

By the end of the 20th century in the US, scholars and practitioners were recognizing this loss of resilience and noticing that failures in the top-down governmental approach were leading to new attempts at governance. The NRC (2004) acknowledged the tendency of legislatures to set resource use policy via legislation, and in doing so, decoupled management decisions from local ecosystem dynamics. Such policies led to undesirable outcomes for the ecosystem (collapse of fisheries, crises in forest management) and frustration by stakeholders who depend upon various ecosystem goods and services.

As a result of these crises and failures, new forms of governance emerged;, one of which has been described as adaptive governance (NRC, 2002; Dietz et al., 2003; Bruner et al., 2005; Folke et al., 2005; Gunderson and Light, 2006). Government refers to those arms of the state that make, execute, and amend laws and policies. Governance, on the other hand, includes, but extends beyond the state and state actions to include all persons and groups who try to influence collective action problems (Ostrom, 1990). Governance actors develop and operate by the rules and norms to organize individual and collective actions; these rules and norms include formal laws but also include shared expectations.

Adaptive governance can be contrasted with other forms of governance in key attributes of 1) engaging formal and informal institutions, 2) cross-scale interactions and polycentricity, and 3) focus on knowledge and learning (Chaffin et al., 2014a). Adaptive governance provides space to bring together formal institutions with informal ones to understand, manage and solve complex environmental issues (Schultz et al., 2015). Many formal resource management institutions are geographically defined entities; water management districts in Florida are organized and operate at the scale of a specific watershed, such as the St. Johns River or Suwanee River Water Management District. Spatial boundaries define the power and scope of authority for such agencies and institutions. In addition, many agencies have strictly defined limits on the subject matter they may address. Environmental issues also can involve formal institutions and agents that focus on an idea; such as conservation based NGO's. While this fragmentation in authority and focus may be viewed as inefficient, combined with the capacity to cooperate across boundaries, it sets the stage for polycentricity. Just as many ecological issues cross scales of space and time, adaptive governance is characterized by polycentricity (Dietz et al., 2003). Polycentricity implies that smaller, more local units of governance exist within large, more general ones, and provides institutional diversity and redundancy (Chaffin et al., 2014b). Finally, the third characteristic of adaptive governance is the production and dissemination of new social and ecological knowledge (Pahl-Wostl et al., 2007), thus reconnecting management decisions to ecosystem dynamics. Adaptive governance can provide the co-production and dissemination of knowledge among communities of science, management and resource users (Wyborn, 2015). Such governance engages a broad set of stakeholders and the public.

Gunderson and Light (2006) defined adaptive governance as the set of institutions and framework that facilitates and fosters adaptive management. Adaptive governance compliments adaptive management in that it can address some of the past failures of an adaptive approach that failed to recognize the role of social dimensions of these issues (Lee, 1993; Scholz and Stifte, 2005). Green et al. (2015) suggest adaptive governance as one way of bridging the divide between legal structures that assume away uncertainty and adaptive management that focuses on acknowledging and winnowing uncertainty. Imbedding adaptive management in a process of governance that accounts for the unique needs of a management scheme that continuously evolves provides the means to assure that the legitimacy and cross-sector jurisdiction coordination necessary for acceptance of its implementation by society will be addressed (Cosens, 2010, 2013).

Adaptive management and adaptive governance have been attempted in many large resource systems, such as the Everglades (Gunderson and Light, 2006; LoSchiavo et al., 2013), and Columbia River system (Lee, 1993; Cosens and Williams, 2012). In both of these systems, adaptive management was applied so that managers could address and resolve inherent uncertainty associated with meeting social objectives (Walters, 1986; Chapin et al., 2009). Kai Lee (1993) in writing about experiences with adaptive management in the Columbia River system, was among the first to point out that in such complex systems, managers must confront two different forms of uncertainty. One form of uncertainty involves technical and scientific questions associated with how to resolve resource issues, such as how manipulation of flow regimes influence the recovery of endangered species in the Columbia (Lee, 1993). The second type of uncertainty that Lee (1993) identified lies in the articulation and prioritization of social objectives and goals, an uncertainty he thought was addressed through a deliberative, democratic process. How these different forms of uncertainty are addressed have been critical components to describe the utility and efficacy of adaptive approaches (Gunderson and Light, 2006; Garmestani and Benson, 2013).

As adaptive approaches are being applied to social-ecological systems around the world, there is a shorter history of their application to the framework of ecosystem goods and services (MEA, 2005). The remainder of this article explores linkages among adaptive management, adaptive governance and ecosystem services. We do so by positing that 1) adaptive management can help

Please cite this article in press as: Gunderson, L.H., et al., Adaptive governance of riverine and wetland ecosystem goods and services, Journal of Environmental Management (2016), http://dx.doi.org/10.1016/j.jenvman.2016.05.024