

# Grand Challenges for Resilience-Based Management of Rangelands

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## Abstract

The social and ecological contexts for rangeland management are changing rapidly, prompting a reevaluation of science, management, and their relationship. We argue that progression from steady-state management to ecosystem management has served the rangeland profession well, but that further development toward resilience-based management is required to ensure that ecosystem services are sustained in an era of rapid change. Resilience-based management embraces the inevitability of change and emphasizes that management should seek to guide change to benefit society. The objectives of this forum are to: 1) justify the need for adopting resilience-based management, 2) identify the challenges that will be encountered in its development and implementation, and 3) highlight approaches to overcoming these challenges. Five grand challenges confronting the adoption of resilience-based management, based upon the insights of 56 rangeland researchers who have contributed to this special issue, were identified as: 1) development of knowledge systems to support resilience-based management, 2) improvement of ecological models supporting science and management, 3) protocols to assess and manage tradeoffs among ecosystem services, 4) use of social-ecological system models to integrate diverse knowledge sources, and 5) reorganization of institutions to support resilience-based management. Resolving the challenges presented here will require the creation of stronger partnerships between ecosystem managers, science organizations, management agencies, and policymakers at local, regional, and national scales. A realistic near-term goal for achieving such partnerships is to initiate and support collaborative landscape projects. The creation of multiscaled social learning institutions linked to evolving knowledge systems may be the best approach to guide adaptation and transformation in rangelands in the coming century.

## Resumen

Los contextos ecológicos y sociales para el manejo de pastizales están cambiando rápidamente, provocando una reevaluación de la ciencia, y los vínculos entre ellos. Aquí proponemos que el reciente cambio de enfoque de un estado constante a un modelo de manejo de ecosistema ha servido bien a la profesión de manejo de pastizales, pero es necesario un cambio adicional al manejo basado en resiliencia que garantice que los servicios de los pastizales continúen beneficiando a la sociedad en una era de cambios rápidos. El manejo basado en la resiliencia enfatiza el manejo colaborativo y el aprendizaje social para guiar la adopción y transformación en sistemas ecológico-sociales. Los objetivos de este foro son 1) justificar la necesidad para adoptar manejo basado en la resiliencia, 2) identificar los desafíos que se interpondrán en el camino para su desarrollo e implementación y 3) destacar los enfoques para superar estos desafíos. Se identificaron cinco categorías de desafíos de un manejo basado en resiliencia, usando las ideas de 55 científicos especializados en el manejo de pastizales que han contribuido especialmente a este tema: a) desarrollo de sistemas de conocimiento para soportar los sistemas de manejo basado en resiliencia, b) mejoramiento de modelos ecológicos apoyados por la ciencia y manejo, c) protocolos para evaluar y manejar el intercambio entre los servicios del ecosistema, d) uso de sistemas de perspectivas socio ecológicas para lograr una mayor participación de los interesados, y e) reorganización de las instituciones para apoyar el manejo basado en resiliencia. Se ha hecho evidente que un mayor conocimiento científico por sí mismo es insuficiente para promover los modelos de manejo basado en resiliencia en los pastizales. Las soluciones de los retos que se presentan aquí requerirán de la creación de asociaciones más fuertes entre manejadores de ecosistemas, organizaciones científicas, agencias de manejo y los creadores de políticas a nivel local, regional y nacional. La creación de instituciones sociales de aprendizaje vinculadas a la evolución de los sistemas de conocimiento es nuestra esperanza para guiar la adaptación y transformación en pastizales en el presente siglo.

**Key Words:** Adaptive management, ecosystem services, knowledge systems, postmodern science, social-ecological systems, transformation

## INTRODUCTION

We cannot solve the problems we have created with the same thinking that created them. —Ludwig (2001)

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The alternate editor-in-chief, M. K. Owens, was responsible for peer review and acceptance of this article.

Manuscript received 6 June 2012; manuscript accepted 4 September 2012.

Rangeland management was introduced at the turn of the 20th century to halt degradation and restore severely overgrazed ecosystems. Beginning about midcentury, it emphasized maximum sustainable production of specific commodities, primarily livestock products. In the 1990s, the emergence of ecosystem management employed a broader systems approach to address the complexity of natural resource problems (Koontz and Bodine 2008), and it continues to be an important management model. It is becoming clear, however, that rangeland management and the science supporting it must progress further to accommodate

**Table 1.** Glossary of terms and concepts presented in this synthesis (adapted from Cash et al. 2003, Chapin et al. 2010, and Reed et al. 2010).

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<i>Adaptation</i>	—social, economic, or cultural adjustment to a change in the physical or social environment.
<i>Ecological model</i>	—simplified construct based on scientific theory and/or personal experiences to identify notions and assumptions of how systems change.
<i>Ecosystem services</i>	—benefits that humans receive from ecosystems.
<i>Knowledge system</i>	—technologies and institutions that bring together and mobilize diverse sources of information to support decision-making.
<i>Resilience</i>	—the capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks.
<i>Resilience-based management</i>	—management strategies that support human well-being via adaptation and transformation of social-ecological systems to sustain the supply of ecosystem services in changing environments.
<i>Social-ecological system</i>	—system with interacting and interdependent physical, biological, and social components.
<i>Social learning</i>	—a change in understanding that extends beyond the individual to become part of broader social units or communities of practice.
<i>Transformation</i>	—fundamental change in social-ecological systems that results in the formation of novel state variables and feedbacks, ecosystem services, and livelihoods.

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an increasing demand for ecosystem services in changing environments (Ludwig 2001; Havstad et al. 2007; Briske and Thurow 2011). Many rangelands have been altered by persistent vegetation change, soil degradation, invasive species, and changing climate; such state changes are expected to accelerate (Nandintsetseg et al. 2007; Stafford Smith et al. 2007; Williams and Jackson 2007; Dai 2011). Social change has also occurred, including stakeholders, markets, and policies influencing ecosystem management (Holmes 2002; Fernandez-Gimenez and Batbuyan 2004; Sheridan 2007). As a consequence, rangelands are increasingly being managed for diverse uses, including wildlife conservation, cropland, mine sites, and urban or renewable energy developments (Grau et al. 2008; Buenemann and Wright 2010; Belnap et al. 2012 [this issue]; Herrick et al. 2012 [this issue]), in addition to traditional services.

The accelerating rate of ecological and social change has led ecologists, ecosystem managers, and some policy makers to embrace resilience as a framework for management (Walker and Salt 2006; Chapin et al. 2009; Benson and Garmestani 2011). Resilience has been defined as “the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks” (Walker et al. 2004). In practice, resilience refers to the maintenance or creation of desirable ecological states and avoiding the thresholds that lead to less desirable ones (Elmqvist et al. 2003). The maintenance of states that provide a desired combination of ecosystem services can be achieved by designing management actions to support the continually evolving characteristics of social-ecological systems (systems comprising humans and their environment; Table 1; Walker et al. 2004).

In parallel with increasing enthusiasm for resilience as a management framework, there is mounting concern that conventional approaches to scientific research will not adequately support it (Boyd and Svejcar 2009; Smith et al. 2009; Butler and Goldstein 2010). Traditional “normal” science emphasizes the use of

experiments, often at small scales, to develop generalizations concerning specific elements of ecosystem behavior (Sayre et al. 2012 [this issue]). The information produced is seldom directly relevant to management because there are few incentives within the scientific community to apply this knowledge to specific cases faced by managers (Ludwig et al. 1993, 2001). The minimal predictive capacity of individual theories, narrow spatial and temporal scales examined, and infrequent consideration of societal and administrative complexities experienced by managers and policymakers further limit the use of science as a guide for management (Ludwig et al. 1993; Briske 2012; Driscoll and Lindenmayer 2012). More often, anecdotal evidence and past experiences are used as guides instead (Pullen et al. 2004; Lawton 2007).

The “post-normal” (Funtowicz and Ravetz 1993) or “post-modern” (Allen et al. 2001) approach to science could more effectively promote resilience by virtue of its emphasis on biophysical and social contexts rather than broadly applicable generalities. Its aim is to use the tools of science to address the complexities of specific localities, and it acknowledges that the problems structuring scientific inquiry emerge from human perspectives (Sayre et al. 2012 [this issue]). This approach to science underpins what has become known as “resilience-based” management or “ecosystem stewardship” (Chapin et al. 2009, 2010). In contrast to steady-state or ecosystem management approaches, resilience-based management embraces the inevitability of social and environmental change, and management seeks to guide change to benefit society (Table 2). This concept is broader than the antecedent ecological resilience concept (Holling 1973) because it emphasizes the properties of entire social-ecological systems, rather than the persistence of particular ecological states linked to historical conditions. The term “resilience” in resilience-based management pertains to societal well-being and not necessarily to particular ecological or social structures; indeed, change in these structures is often necessary to sustain well-being (Walker et al. 2004). While resilience-based management offers clear advantages in ecosystems experiencing rapid social-ecological change, methods to implement it are only now emerging.

We outline five grand challenges associated with the development of resilience-based management for rangeland systems. We garnered ideas from papers within this special issue, collectively representing the insights of 56 rangeland researchers reflecting on the successes and failures of the rangeland profession over the past century. We also consulted synthetic works in topic areas addressed by these and other authors to review each challenge. Rather than listing a large number of specific concerns (e.g., Sutherland et al. 2009; Fleishman et al. 2011), we identified a small number of broad (i.e., grand) challenges that are of particular importance to rangeland management as well as specific issues embedded in those challenges (e.g., Morton et al. 2009). Our hope is that the insights and recommendations in this special issue may catalyze a reevaluation of educational programs, research agendas, and policies.

## CHANGING CONTEXT FOR RANGELAND SCIENCE AND MANAGEMENT

The Earth’s social-ecological systems have entered an era of unprecedented change (Rockstrom et al. 2009; Chapin et al.

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