

HIGHLIGHTS

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Big Questions Emerging from a Century of Rangeland Science and Management

Brandon T. Bestelmeyer, Rick E. Estell, and Kris M. Havstad

The Jornada Experimental Range, alongside the rangeland discipline, is about a century old: What have we learned to help guide rangeland management for the next century? Fourteen articles in a special feature commemorating the Jornada centennial address several big questions about the future of rangelands, including how livestock production can be sustained with reduced grass cover, responses to invasive species, and how to manage for diverse ecosystem services. In this introduction, we briefly review the content of those articles. Our hope is that the special feature catalyzes a renewed consideration of rangeland policies, research agendas, and educational programs.

“The Range Problem” After a Century of Rangeland Science: New Research Themes for Altered Landscapes

Nathan F. Sayre, William deBuys, Brandon T. Bestelmeyer, and Kris M. Havstad

After a century of rangeland science, we see a need to redefine the dominant themes of research and to develop approaches different from those used in the past. Science must be conducted at larger spatial and longer temporal scales, embrace the heterogeneity of range landscapes, including their inhabitants, and focus on how people interact with specific landscapes. This “postnormal” science must also serve a broader public and engage local knowledge and actual management “experiments”—past and present, successful and unsuccessful—to test the effects of management in the light of new models, hypotheses, technologies, and problems.

Increasing Shrub Use by Livestock in a World with Less Grass

R. E. Estell, K. M. Havstad, A. F. Cibils, E. L. Fredrickson, D. M. Anderson, T. S. Schrader, and D. K. James

Grasslands are in decline globally, in part because of shrub encroachment and competing land uses. However, global demand for red meat is expected to rise substantially during the next 30 years. To accommodate these demands, methods to increase livestock production on shrub-dominated rangelands are needed. Although some techniques are currently available to enhance the dietary use of woody plants (e.g., choosing appropriate breeds and species and using supplements and additives, behavior modification, and genetic selection), new technologies are needed to use shrub-dominated rangelands optimally.

Is Proactive Adaptation to Climate Change Necessary in Grazed Rangelands?

Andrew Ash, Philip Thornton, Chris Stokes, and Chuluun Togtohyn

Climate variability shapes ecosystem functioning and management of rangelands, but does that mean rangeland managers are prepared to cope with climate change? We find existing strategies and incremental adaptation will be sufficient to deal with most of the challenges provided by the gradual expression of climate change in the next two decades. However, projections of greater climate change in the future means that the responses required are beyond existing adaptation strategies, and transformational change will be required. A diversity of technological, management, and policy adaptation options that are proactively planned will be required to manage the impacts of climate change.

Introduced and Invasive Species in Novel Rangeland Ecosystems: Friends or Foes?

Jayne Belnap, John A. Ludwig, Bradford P. Wilcox, Julio L. Betancourt, W. Richard J. Dean, Benjamin D. Hoffmann, and Sue J. Milton

We propose a simple decision framework to support management of exotic species invasions and to evaluate trade-offs associated with their management. Our framework balances the value of novel ecosystems created by the invasive species vs. the cost of restoring systems to their preinvasion state. We suggest that when restoration costs and ecosystem value of the invaded system are both low, restoration should be attempted. When the cost and value are high, the system should likely be retained. Under the two remaining circumstances, however, social discourse will be needed to establish desired management actions.

Conservation of Pattern and Process: Developing an Alternative Paradigm of Rangeland Management

Samuel D. Fuhlendorf, David M. Engle, R. Dwayne Elmore, Ryan F. Limb, and Terrence G. Bidwell

Rangeland management is built from a utilitarian perspective that focuses on sustaining livestock production by protecting dominant forage species and soils. Although this perspective has contributed to conservation in some ways, it is incapable of conserving rangeland landscapes for the full suite of ecosystem services. We develop and present an alternative paradigm, "Conservation of Pattern and Process," focused on understanding and restoring broadscale patterns of fire and grazing to promote a shifting mosaic that is required for multiple uses and conservation. We propose six basic principles for conservation of pattern and process on rangeland ecosystems.

Revolutionary Land Use Change in the 21st Century: Is (Rangeland) Science Relevant?

J. E. Herrick, J. R. Brown, B. T. Bestelmeyer, S. S. Andrews, G. Baldi, J. Davies, M. Duniway, K. M. Havstad, J. W. Karl, D. L. Karlen, D. P. C. Peters, J. N. Quinton, C. Riginos, P. L. Shaver, D. Steinaker, and S. Twomlow

Rapidly increasing demand for food, fiber, and fuel, together with new technologies and the mobility of global capital, are driving revolutionary changes in land use. Millions of hectares of rangelands are being converted to crop production. We propose four strategies to increase the relevance of rangeland science to these challenges, including development and adoption of a dynamic and flexible, resilience-based land-classification system and data-supported models that represent 1) all lands, irrespective of use; and 2) the consequences

of land conversion to various uses, instead of changes in that state or condition that are focused on a single land use.

Identifying Rangeland Restoration Targets: An Appraisal of Challenges and Opportunities

Thomas A. Monaco, Thomas A. Jones, and Thomas L. Thurow

Restoration targets for a given ecosystem can range from a historical benchmark to novel systems. This article outlines how the use of rangeland health assessment and state-and-transition models can identify potential restoration targets for degraded rangelands. However, because restoration cannot be accomplished through a single intervention, intervention activities essentially serve as mechanistic trials, generating site-specific information to adaptively refine ongoing management and to calibrate expectations of associated costs and benefits. This adaptive management approach not only reduces the uncertainty involved in restoration but also enhances the discussion between stakeholders and policy makers regarding trade-offs among management options.

Rangeland Degradation, Poverty, and Conflict: How Can Rangeland Scientists Contribute to Effective Responses and Solutions?

Donald J. Bedunah and Jay P. Angerer

We review the causes and impacts of rangeland degradation in the developing world and the challenges of applying rangeland science to improve conditions. Range scientists can provide direction and guidance in methods and opportunities for improvement of degraded rangelands. Conflict and poverty can create situations where sustainable rangeland use is overwhelmed by short-term needs of safety and food security; however, providing science and training on sustainable management can help promote societal stability and make a difference where conflicts are not too severe. Sustainable projects will require accountability and will enhance self-reliance, allowing community empowerment and adaptability to changes.

How Can Science Be General, Yet Specific? The Conundrum of Rangeland Science in the 21st Century

Debra P. C. Peters, Jayne Belnap, John A. Ludwig, Scott L. Collins, José Paruelo, M. Timm Hoffman, and Kris M. Havstad

The disciplines of range science, basic ecology, and global ecology use different approaches to extrapolate information from well-studied locations to other land units. In this article, we 1) describe the limitations of these current approaches, 2) describe an integrated approach that takes advantage of the strengths and minimizes the weaknesses

of individual approaches, and 3) discuss the implications of this integrated approach to the future of range science when climate and human drivers are nonstationary. This integration will be critical for applying range science to specific land units and to addressing problems facing society at regional to global scales.

Opportunities for Increasing Utility of Models for Rangeland Management

Justin D. Derner, David J. Augustine,
James C. Ascough II, and Lajpat R. Ahuja

Increasing the utility of models for rangeland management remains a key frontier to assist land managers with decision making. Opportunities exist, through 1) better matching of model complexity and outputs with enterprise-level goals, 2) increasing user friendliness and Web portal accessibility, and 3) forecasting effects of a changing and variable climate, including directionality, magnitude, and uncertainty. A fundamental understanding of the ecological drivers and spatio-temporal variation in their effects on ecosystem functions are needed to facilitate 1) landscape-level decision making for multiple ecosystem goods and services, and 2) determinations of spatially explicit locations for application of conservation practices to optimize desired outcomes.

The Elusive Promise of Social-Ecological Approaches to Rangeland Management

Mark W. Brunson

Natural resource scientists increasingly argue that management strategies should account for linkages between the human and ecological elements of nature to enhance ecosystem resilience. For range managers to embrace this approach, we need better tools and concepts to understand how social and ecological systems are interconnected. This article describes arguments in favor of a social-ecological approach as well as why some scientists question its usefulness. It then proposes a conceptual model that describes social-ecological linkages and their consequences, focusing on how human and biophysical processes operate at both large and local scales to influence management choices.

A Strategy for Rangeland Management Based on Best Available Knowledge and Information

Jason W. Karl, Jeffrey E. Herrick, and
Dawn M. Browning

Current tools for knowledge discovery and application in rangeland management are limited because they cannot ad-

equately judge the ecological relevance of knowledge to specific situations. We propose the development of integrated knowledge systems that would collect knowledge and information from different domains and define the relevance by location and ecological attributes (e.g., soils, climate, vegetation). This would create a flexible mechanism for organizing, finding, and applying knowledge to rangeland management. The proposed knowledge-systems concept and recommendations are an opportunity to take advantage of emerging technologies and the collective knowledge of rangelands to address changing ecosystems and evolving threats.

Range Education in the 21st Century: Striking the Balance to Maintain a Relevant Profession

Laurie B. Abbott, Karen L. Launchbaugh, and
Susan Edinger-Marshall

Today's range education programs face numerous challenges as we strive to meet the changing needs of our profession and society. We propose a multifaceted approach to address modern needs, including 1) conducting needs assessments to ensure programmatic relevance into the future, 2) developing innovative teaching approaches to ensure mastery of fundamentals and contemporary skills, 3) creating opportunities for multiinstitutional collaboration and sharing of educational resources, 4) defining learning outcomes and core competencies to ultimately align professional qualifications, educational standards, and curriculum, and 5) increasing public awareness of the rangeland profession as a disciplinary pillar of natural resource science and management.

Grand Challenges for Resilience-Based Management of Rangelands

Brandon T. Bestelmeyer and David D. Briske

The inevitability of change in rangeland systems requires that the profession consider a dynamic science and management philosophy known as "resilience-based management." We assembled concepts from the special-feature articles and associated literature to identify five grand challenges to the implementation of resilience-based management in rangelands. The five challenges are 1) development of knowledge systems, 2) improvement of ecological models, 3) assessment and management of trade-offs among ecosystem services, 4) use of social-ecological system models, and 5) reorganization of social institutions to support resilience-based management. Resolution of these challenges is a long-term goal that can begin at the local level through collaborative landscape-management projects.