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

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Abstract

Globally, new combinations of introduced and native plant and animal species have changed rangelands into novel ecosystems. Whereas many rangeland stakeholders (people who use or have an interest in rangelands) view intentional species introductions to improve forage and control erosion as beneficial, others focus on unintended costs, such as increased fire risk, loss of rangeland biodiversity, and threats to conservation efforts, specifically in nature reserves and parks. These conflicting views challenge all rangeland stakeholders, especially those making decisions on how best to manage novel ecosystems. To formulate a conceptual framework for decision making, we examined a wide range of novel ecosystems, created by intentional and unintentional introductions of nonnative species and land-use–facilitated spread of native ones. This framework simply divides decision making into two types: 1) straightforward–certain, and 2) complex–uncertain. We argue that management decisions to retain novel ecosystems are certain when goods and services provided by the system far outweigh the costs of restoration, for example in the case of intensively managed *Cenchrus* pastures. Decisions to return novel ecosystems to natural systems are also certain when the value of the system is low and restoration is easy and inexpensive as in the case of biocontrol of *Opuntia* infestations. In contrast, decisions whether to retain or restore novel ecosystems become complex and uncertain in cases where benefits are low and costs of control are high as, for example, in the case of stopping the expansion of *Prosopis* and *Juniperus* into semiarid rangelands. Decisions to retain or restore novel ecosystems are also complex and uncertain when, for example, nonnative *Eucalyptus* trees expand along natural streams, negatively affecting biodiversity, but also providing timber and honey. When decision making is complex and uncertain, we suggest that rangeland managers utilize cost–benefit analyses and hold stakeholder workshops to resolve conflicts.

Resumen

Mundialmente, nuevas combinaciones de plantas introducidas e inducidas y especies de animales han cambiado los pastizales a nuevos ecosistemas. Mientras que muchos de los interesados en los pastizales (personas que usan o tienen interés en los pastizales) ven un beneficio en la introducción de especies para el mejoramiento de la producción de forraje y control de la erosión, otros se interesan en los costos no planeados tales como el aumento en el riesgo de fuego, pérdida de biodiversidad en los pastizales y amenazas en los esfuerzos de conservación especialmente en reservas naturales y parques. Estos puntos de vista conflictivos son retos para todos los interesados en los pastizales, especialmente para la toma de decisiones en cómo manejar mejor los ecosistemas nuevos. Para formular un modelo conceptual para toma de decisiones, examinamos un amplio rango de ecosistemas nuevos, creados de manera intencional y no intencional de especies no nativas y el uso de tierras que facilitan la expansión de especies nativas. Este modelo simplemente divide la toma de decisiones en dos tipos: 1) francamente–seguro y 2) complejo–no seguro. Discutimos que las decisiones de manejo para mantener ecosistemas nuevos son seguras cuando los bienes y servicios proporcionados por el sistema sobrepasan por mucho el costo de restauración, por ejemplo en el caso de las praderas intensivas de *Cenchrus*. Las decisiones para devolver ecosistemas nuevos a sistemas naturales son también seguras cuando el valor del sistema es bajo y la restauración es fácil y barata como en el caso del control biológico de las infestaciones de *Opuntia*. En contraste, las decisiones ya sea de mantener o recuperar ecosistemas nuevos se complican y son inciertas en casos donde los beneficios son bajos y los costos altos, por ejemplo en el caso de detener la expansión del *Prosopis* y *Juniperus* en los pastizales semiáridos. También las decisiones para mantener o renovar un ecosistema nuevo son difíciles e inciertas cuando por ejemplo, especies no nativas como el Eucalipto se extienden sobre arroyos naturales afectando negativamente la biodiversidad pero también proveyendo madera y miel. Cuando el proceso de toma de decisiones es complejo e incierto sugerimos que los manejadores de pastizales usen el análisis de costo beneficio y talleres entre los interesados para resolver conflictos.

Key Words: *Cenchrus*, decision framework, *Eucalyptus*, *Juniperus*, *Opuntia*, *Prosopis*, rinderpest, West Nile virus

INTRODUCTION

Most rangelands around the world are at least partially dominated by "novel" or "emerging" ecosystems, that is, those containing new combinations of plants and animals arising as a result of direct or indirect human influence (Hobbs et al. 2006; Bridgewater et al. 2011). In rangelands, these novel systems

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generally result from management-induced changes in native plant communities, which create opportunities for invasions or increases in the density (or the range) of alien or native species (Milton et al. 2007). Some of these species can be managed through their removal or containment, whereas other species appear uncontrollable.

Many species have been intentionally introduced to rangelands for purposes beneficial to humans (e.g., erosion control, shade, forage). Purposeful introductions may continue to be of value in some circumstances, whereas in others the introduced species may have produced unintended and detrimental consequences and a case can be made for their removal. The likelihood of novel ecosystems appearing in rangelands will only increase with time because of globalization, climate change (and novel climates), nitrogen deposition, and land-use intensification. The prescriptions for managing these novel ecosystems will be increasingly nuanced, calling for control of some species and not others, and in some places and not others. Who will make these decisions, and on what basis, at what expense, and over what time frame?

Proactive land management is becoming increasingly difficult as past mistakes and current crises consume the time and resources of land managers (Hobbs et al. 2003; Seastedt et al. 2008). Even more difficult is establishing targets for restoration or predicting the future "look" for ecosystems. Past analogs may become increasingly irrelevant because the current range of biotic and abiotic conditions controlling the structure and function of a given ecosystem may be substantially altered, and the influence of these future conditions remains unknown (Fox 2007; Seastedt et al. 2008). In addition, interglacial periods like the Holocene (the last 13,000 yr) characterize only 10 percent of the last million years and are hardly the norm, and in many parts of the world modern biotic communities are only thousands of years old in both composition and distribution (Lyford et al. 2003). The future promises to be even more fleeting as both native and nonnative species, some fast and others slow-moving, shift their distributions across highly human-altered landscapes in response to a continuously and rapidly changing climate.

In many cases, we may no longer be able to constrain many systems within past or even current abiotic or biotic boundaries, but will need instead to learn to accept the new conditions and ecosystems that can exist within these new boundaries (Hobbs et al. 2006). In other cases, current or recently altered ecosystems may be of such high societal value that extraordinary efforts will be made to keep them viable. Facing the challenge of managing novel ecosystems will require transformational, rather than incremental, approaches to land management. These challenges will compel land managers to be even more forward thinking and to adopt new methodologies (Holling 2001).

In this paper, we briefly discuss examples of novel ecosystems created by species that occur on at least two of three continents (Africa, Australia, and North America). These ecosystems were formed by 1) intentionally introducing invasive plants (*Cenchrus* [*Pennisetum*], *Eucalyptus*, *Opuntia*); 2) unintentionally introducing animals (fire ants) and viral diseases (West Nile virus, rinderpest); or 3) unintentionally, through land use, increasing the density of native woody plants (*Juniperus*, *Prosopis*). We discuss how these organisms have altered the communities in which they occur to form novel ecosystems and how managing these systems depend on site-specific goals. We then provide a simple conceptual framework to assist land managers in making decisions about how to respond to novel ecosystems.

CASE STUDIES

Grasses and Succulents

***Cenchrus ciliaris* (L.)**. Native to Africa, the Middle East, across to India, and Indonesia, *Cenchrus ciliaris* (syn. *Pennisetum ciliarum*) (buffel grass) now occurs in many countries around the globe (Marshall et al. 2011). In some rangelands, such as in areas of central and northern Australia, and in northern Mexico and the southwestern United States, *C. ciliaris* can be an aggressive invader and has formed novel ecosystems.

In Australia, *C. ciliaris* was introduced intentionally in the 1870s by Afghan cameleers who discarded *C. ciliaris* when restuffing worn saddle packs and harnesses brought from their homelands (Winkworth 2000). To improve grazing and drought-affected rangelands, *C. ciliaris* was also intentionally introduced to Australia beginning in the late 1950s, and has become a mixed blessing (Friedel et al. 2006). To cattle producers, *C. ciliaris* is very desirable because it establishes highly productive, self-sustaining stands on a wide variety of soil types, especially in tropical and subtropical areas dominated by summer rainfall (Fig. 1). In such environments, *C. ciliaris* can replace native grasses, particularly when landscapes are grazed or disturbed by flooding and fire. Frequent and hot fires can favor *C. ciliaris* (Miller et al. 2010). It is also of value for rehabilitating eroded rangelands and disturbed mine sites, as it provides excellent ground cover.

Whereas these characteristics make *C. ciliaris* a friend to some land managers, its biological and ecological attributes make it a foe to those aiming to conserve natural ecosystems (Friedel et al. 2006). With disturbance, *C. ciliaris* invades natural grasslands and savannas, altering landscape processes

Figure 1. Brahman cattle grazing a *Cenchrus ciliaris* pasture in the Upper Burdekin Catchment, Queensland, Australia, a region with relatively consistent and abundant summer rainfall. (Photo: J. A. Ludwig.)