

Grasslands in the Borderlands

Understanding Coupled Natural-Human Systems and
Transboundary Conservation

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In a Nutshell

- Grasslands in the transboundary Chihuahuan Desert provide ecosystem services that promote human well-being.
- Overgrazing, water withdrawal, drought, and prairie dog removal threaten the integrity of this important ecosystem.
- The prairie dog, a keystone species, forestalls the invasion of woody species and helps prevent desertification. However, prairie dogs are threatened, having declined by more than 95 percent throughout their historic range.
- Grassland restoration, control of shrubland expansion, and prairie dog protection are needed to maintain ecosystem services of the transboundary Chihuahuan Desert.
- Research and experience from the Janos research site in the Mexican state of Chihuahua has important implications for arid and semiarid grasslands in both the United States and Mexico.
- A new paradigm is needed to better connect agricultural production and water availability with the long-term conservation of grassland ecosystems that support these services.

Introduction

Grasslands are one of the shared ecosystems that dominate the heart of the North American continent. The Chihuahuan Desert grasslands that straddle the border between Chihuahua in Mexico and New Mexico, Arizona, and Texas in the United States are undergoing rapid transition to

desertified shrubland conditions. Policy-driven land-use changes are reducing grassland capacity to maintain biodiversity and ecosystem services that support human well-being, including ranching, hydrological systems, and the prevention of desertification. Grassland degradation began first in the United States and then spread into Mexico, becoming more pronounced in parts of Mexico during the past two decades. Degradation patterns in the United States can inform Mexican conservation efforts, and relatively intact Mexican ecosystems can provide valuable insights into functional grassland systems. Research and experience from the Janos research site in the state of Chihuahua thus has important implications for arid and semiarid grassland systems that extend throughout both the United States and Mexico.

As this chapter discusses, black-tailed prairie dogs (*Cynomys ludovicianus*) in this region are a keystone species and an important ecosystem engineer critical for maintaining biodiversity and grassland ecosystem function and in turn for supporting ecosystem services to humans. This process is disrupted by poor land management (i.e., cattle overgrazing), resulting in environmental degradation that is evident in a loss of biodiversity and alteration of ecosystem function. In this chapter, we argue that conservation of grassland–prairie dog systems must be coupled with an understanding of ecosystem services and human needs. We suggest ways of overcoming the negative cycle of overgrazing and discuss how this approach can be implemented binationally.

Background

Mexico, the United States, and Canada share a continent governed by myriad linked ecological processes that reach across political boundaries. Political decisions within each country may impact ecological processes from local to global scales and transcend political boundaries, affecting a vast array of known and yet unknown ecological services. Grasslands are an important example of these linkages; they maintain a large and diverse set of living organisms and ecological processes whose persistence depends on the presence of large tracts of native grasslands that may span multiple jurisdictions. However, large-scale land-use changes caused by industrial agriculture, urbanization, infrastructure development, and desertification are reducing North American grassland systems' capacity to maintain biodiversity and ecosystem services.¹ Next, we discuss components of ecosystem change affecting the grasslands of the transboundary Chihuahuan Desert and one of its keystone species, the prairie dog.

Grassland Connectivity

The central grasslands of North America are characterized by a mosaic of grassland patches colonized and uncolonized by prairie dogs. This heterogeneous landscape supports high levels of interdependent biodiversity, often with strong associations with prairie dogs. Prairie dogs create ecological niches necessary for the persistence of many continental migratory species such as the Ferruginous Hawk (*Buteo regalis*) and the Mountain Plover (*Charadrius montanus*). The Chihuahuan grasslands, maintained by black-tailed prairie dogs (fig. 12.1), provide critical habitat for migrating birds such as Golden Eagles (*Aquila chrysaetos*) and Burrowing Owls (*Athene cunicularia*). These migratory species link this region ecologically to the northern Great Plains of the United States and Canada. More locally, populations of pronghorn antelope (*Antilocapra americana*), bison (*Bison bison*) (fig. 12.2), and other endangered species require a continuous flux of individuals between the United States and Mexico to maintain viable populations that guarantee their long-term survival. Such movement is also required as species adapt to highly variable environments typical of arid- and semiarid regions.²

The connectivity of these dynamic ecosystems is challenged by a political boundary representing widely divergent land policies and large-scale human threats, such as global warming. Maintaining connectivity across the Mexico–U.S. border requires coordinated conservation efforts and ecologically sound management practices in both countries. The need for collaborative management is greatly increased by the wall that is being built to restrict the flow of undocumented workers across the border. For example, the border wall north of Janos, Chihuahua, is too wide and tall for large mammals, but not for people, to cross. However, because the wall is a deterrent, it funnels people to the more remote areas heavily used by wildlife. If solid walls, like those in parts of Arizona, are built in more remote areas of the Chihuahuan Desert, where currently only barbed-wire fence marks the international line, the movement of nonflying animals may cease altogether (see also chapter 6 in this volume).

Cattle Ranching

For nearly two centuries, the main economic activity in northern Mexico and the southwestern United States has been cattle ranching. During this period, poor livestock management, removal of keystone species, and suppression or lack of fire have contributed to significant landscape changes in the region.³



Figure 12.1. Black-tailed prairie dog. The black-tailed prairie dogs from the Janos grasslands of Chihuahua are essential for the conservation of the biodiversity of the Great Plains region of North America. Photograph by Gerardo Ceballos.



Figure 12.2. Janos bison. The Janos-Hidalgo bison of Chihuahua and New Mexico are the only free-ranging bison in Mexico and the southwestern United States. In order to persist, they need an open landscape across the international boundary. Photograph by Rurik List.

Overgrazing was widespread in the United States in the late nineteenth and early twentieth centuries;⁴ however, by 1955, the situation had reversed.⁵ Grazing in the United States was then being better managed, but overgrazing in Mexico was becoming more prevalent in response to federal agrarian policies that established communally managed lands called *ejidos*.

Ejido land units may be too small for effective livestock production in landscapes that are reliant on integrated ecological processes at much larger scales. For instance, in many ejidos it is often very difficult to adjust cattle numbers in response to environmental conditions; thus, the land's carrying capacity is exceeded. The increasing availability of supplemental feeds allow *ejidatarios* to maintain large numbers of cattle during drought years, and high cattle densities prevent reestablishment of palatable herbaceous species during postdrought periods. As a result, less-palatable species, most notably shrubs, have begun to replace grasslands.

In conjunction with such ranching practices, the establishment of shrub-dominated areas, the aridity of the system, and the prevalence of bare ground have caused soil erosion and degradation. The combination has had several results: loss of productive herbaceous species required for pastoralist cultures; loss of key grassland species; and changes in ecological processes, such as fire, that are necessary for maintaining the structure and function of the grassland ecosystem. Many people, especially young people, have left the region's ejidos for the United States because the now degraded landscapes no longer support the ejidatarios' agricultural livelihoods.

The Janos region of northern Mexico, at the northwestern corner of the state of Chihuahua, is a top priority for biodiversity conservation in North America. However, pressures from agricultural development as well as inadequate management practices and planning seriously threaten the region's biodiversity. Conservation efforts have often failed by neglecting to incorporate people as part of the ecological system. The success of conservation programs and economic development will be limited if efforts are focused on restricting natural-resource use rather than on improving current management practices. Economic activities such as agriculture and grazing can benefit from greater understanding of the region's ecological setting, while becoming compatible with conservation.

The Grassland–Prairie Dog Ecosystem

The conflict between the conservation of grassland ecosystems that support prairie dogs and economic activities in the southwestern United States and northern Mexico is a case study in the problems mentioned in the previous

section. It is clear from our research in the Janos region that declines in prairie dog populations have their own long-term, large-scale, negative effects on biodiversity, ecosystem services, economic activities, and human well-being. Coupling the conservation of prairie dogs with economic activities is perhaps the only way to maintain the livelihood of local people and regional economies and at the same time to preserve the ecological characteristics that made these activities possible. In the following paragraphs, we describe in detail the complex ecological setting and its direct relationships with human well-being. This new way of looking at these relationships makes economic development, conservation, and human well-being compatible.

Prairie dogs are keystone species and ecosystem engineers of the Chihuahuan Desert grasslands.⁶ They transform grassland landscapes by grazing and constructing extensive burrow systems. Their mounds and large colonies create a mosaic of islandlike habitat patches that differ in biotic composition and ecosystem properties from surrounding grassland areas, increasing biodiversity across the greater grassland landscape.⁷ Many other grassland species utilize their burrows and colonies as key habitat and depend on prairie dogs as prey.⁸ Prairie dogs play an important role in cycling nutrients and preventing shrub encroachment.⁹ Such ecosystem services are especially valuable in the Chihuahuan Desert grasslands, where shrub encroachment and desertification are major issues.¹⁰

Despite their ecological importance, prairie dog populations are declining throughout their range;¹¹ all five species (Gunnison *Cynomys gunnisoni*, white-tailed *C. leucurus*, black-tailed *C. ludovicianus*, Mexican *C. mexicanus*, and Utah *C. parvidens*) are listed or are the subject of petitions for listing as threatened or endangered in either the United States or Mexico. Threats to prairie dogs in the United States include sylvatic plague, urban development, agriculture, poisoning, and shooting. The prevailing threats in Mexico are desertification, agriculture, and, possibly, climate change (predicted to cause an increased frequency and severity of drought in the Chihuahuan Desert region).¹² Prairie dog declines in the United States have caused declines in associated species, including the black-footed ferret (*Mustela nigripes*), Burrowing Owl, Ferruginous Hawk, Mountain Plover, and swift fox (*Vulpes velox*).¹³ Over a thirteen-year period, our research in the Janos region has demonstrated drastic reductions in biodiversity along with declining prairie dog populations (fig. 12.3). These losses can be attributed to extreme land degradation due to overgrazing and conversion of native grassland to cropland, combined with natural drought cycles. The threefold decline in prairie dog densities and the approximately 70 percent reduction

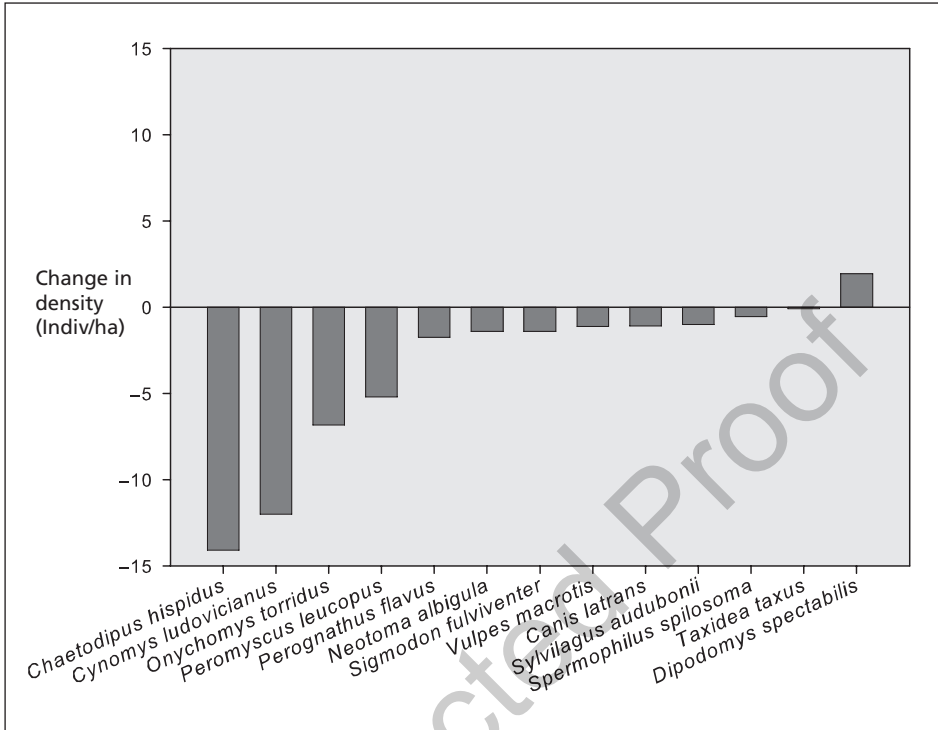


Figure 12.3. Change in abundance over the period from 1992–1994 to 2000–2001 of mammal species known to be associated with prairie dogs and their colonies in the Janos region of Chihuahua.

in prairie dog colony size¹⁴ have undoubtedly contributed to the decline of many species known to utilize prairie dogs as prey or their colonies for habitat, such as the coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), and other small mammals, and are further jeopardizing the viability of the black-footed ferret population in the region.

Today, the most significant threat to the persistence of prairie dogs in Mexico (including the Mexican prairie dog, *Cynomys mexicanus*, in the eastern Chihuahuan Desert) is the expansion of irrigated agriculture for cotton, potato, and corn production. Despite a ban on developing new groundwater wells in Janos and the requirement for environmental impact assessments to convert native vegetation to agriculture, some farmers illegally drill wells and plow over grasslands and prairie dog towns. Because of corruption of officials and the inefficient enforcement of environmental

laws, regulatory mechanisms have proved insufficient to stop illegal well drilling and land conversion.

Cattle and Prairie Dogs

Prairie dogs have been exterminated throughout an extensive portion of their historic range under the assumption that they compete with cattle for forage. Depending on management and environmental conditions, the interaction between cattle and prairie dogs can be either synergistic or competitive. Synergistic interactions between ungulates (a category including cattle) and prairie dogs occur in areas of the mixed grass prairie of North America. It has been documented that large ungulates, such as bison and elk, form "grazing associations" with prairie dogs. Both native and domestic ungulates are often attracted to prairie dog colonies because the forage there is more nutritious. In turn, prairie dogs benefit when livestock help to maintain lower-stature vegetation that allows greater visibility of and vigilance against predators.¹⁵

Without the presence of prairie dogs, cattle can cause grasslands to be transformed into shrublands. Ungulates eat the seed pods of the mesquite, a shrub that is replacing grasslands. They then deposit the seeds on the soil, often far from the parent plant. If the seeds germinate, and the seedlings survive and mature, they produce more seed. Plant by plant, mesquite eventually replaces grasses and the amount of forage for ungulates steadily declines, the structure of the vegetation is altered, and the whole system drifts to desertification. However, if prairie dogs are present, they limit the establishment of woody vegetation and maintain grassland systems by removing pods, eating mesquite seedlings and saplings, and clipping shrubs.¹⁶ Prairie dogs, therefore, control mesquite expansion and preserve the grasses for both prairie dogs and ungulates to eat.

The presence or absence of large prairie dog colonies in northern Mexico is also related to desertification processes as well as to the ranching practices and grassland transformation discussed here. With the ejido system and the 1970s agrarian movement in Mexico, overgrazing by cattle led to competition between prairie dogs and cattle for the same grass; this competition worsened with drought in the 1990s and early 2000s. In the 1980s, owners of private land began poisoning prairie dogs, allowing mesquite shrubs to gain dominance. In communal lands, the poisoning was less intensive. Instead of the grassland's being transformed to shrubland in the absence of prairie dogs, the area was transformed from a perennial grassland to an annual grassland and bare ground.

Recent studies in Chihuahua demonstrate that the persistence of prairie dogs has been a key element in maintaining grasslands even under severe overgrazing and drought. In areas where prairie dogs have disappeared, mesquite has rapidly invaded. When prairie dog colonies have been restored, they exterminate mesquite.

In the southwestern United States, as in Mexico, desertification of grasslands is in part related to prairie dog disappearance.¹⁷ The cattle boom of the 1880s and the U.S. government-funded poisoning campaigns eradicated all but a few U.S. prairie dog colonies. Mesquite expanded in areas once dominated by prairie dogs, and grasslands began to disappear, leading to desertification, such as that observed at the La Jornada Experimental Range in southern New Mexico.

Ecosystem Services and Change

Grassland loss and conservation have significant implications for many ecosystem services. During the past 150 years, tree and shrub-dominated plant communities have replaced grasslands throughout much of the Mexico-U.S. borderlands region.¹⁸ Patterns and rates of shrub invasion vary with soil, topography, climate, weather, and disturbance history, in addition to changes in the populations and population dynamics of native animals. Although the relative importance of these factors is unknown, several general trends and patterns are widely recognized throughout the region. Creosote bush (*Larrea tridentata*), tarbush (*Flourensia cernua*), and mesquite (*Prosopis* spp.) have expanded into grasslands at lower elevations in the Chihuahuan Desert.¹⁹ Mesquite dominates most former black grama grasslands (*Bouteloua eriopoda*) on sandy soils, but is also increasingly found on finer-textured soils. Similar transitions have occurred in the Sonoran Desert with a different mix of species and a greater dominance by succulent species. As demonstrated earlier, the transformations are accelerated by and may be initiated by overgrazing and drought,²⁰ although climate change, changes in human use, and the eradication of keystone species such as prairie dogs also play a role.²¹

The shift from grasslands to mesquite-dominated shrublands has dramatic effects on ecosystem services. This transformation of grassland to shrubland changes ecosystem processes and the capacity to support ecosystem services. Although the specific nature of the changes varies with plant community, soils, and landscape position, the general relationships are similar throughout the region. Grassland processes in arid and semiarid

lands are related to four types of ecosystem services identified by the Millennium Ecosystem Assessment: water quality, air quality, food and fiber, and biodiversity.²² In particular, with the shift from grasslands to mesquite-dominated shrublands,

1. *Water quality* is enhanced in seasonal streams because there is less erosion from shrublands.²³ This process can also increase long-term water quantity available for human use because reservoir siltation is slowed. *Water availability* for humans and wildlife is modified because grasslands increase infiltration and reduce runoff relative to shrublands. This process can increase the duration of perennial stream flow and spring production, although a recent review indicates that these benefits are more likely to occur in relatively higher-precipitation zones.²⁴

2. *Air quality* is maintained because grasslands have smaller plant interspaces, which limit wind erosion. This erosion is due primarily to the change in spatial distribution, with larger plant patches and interspaces. In addition to its effects on human health, erosion can reduce the aesthetic value of many landscapes.

3. The potential production of *food and fiber* is generally greater in grasslands through both domesticated livestock and wildlife. Long-term data from the Jornada Experimental Range in New Mexico indicate that grasslands at least have the potential to support greater rates of net primary production than shrublands²⁵ and that herbaceous forage production is uniformly higher in grasslands.

4. *Biodiversity* is generally thought to be better supported by grasslands, in part because plant diversity is often greater²⁶ and because prairie dog towns maintain more species, including species at risk, than unoccupied grasslands, and many of those species are not found in shrublands. As a consequence, grassland loss is increasingly associated with regional declines in biodiversity.

Although most ecosystem services currently valued by people in the border region are more effectively supplied by grasslands, mesquite-dominated communities do provide some critical services. Bird diversity is similar or even higher in shrub-dominated systems due to greater habitat structure.²⁷ Honey from mesquite shrubs located in areas with shallow water tables is valued for its unique flavor and often sells at a premium of 50 percent or more higher than honey derived from other sources. Mesquite beans also have value for both humans and wildlife.²⁸

Nonetheless, mesquite dominance reduces future management options and therefore the ability of managers—including ranchers, governments, and

conservation organizations—to manage for different ecosystem services. It is relatively easy to replace grasses with shrubs, but it is difficult to establish or reestablish perennial grasses once a grassland has been transformed into a shrubland. For example, maximizing forage-production services for livestock in shrublands cannot be accomplished without significant external inputs.²⁹ These “thresholds” beyond which it is difficult to return a system to its original state are typical of arid and semiarid ecosystems and are associated with the fundamental changes in the soil-plant-animal relationships and feedbacks discussed in this chapter.³⁰ To predict and prevent such thresholds, both conservation biologists and land managers should use models and decision-making tools that integrate ecosystem processes, such as soils, with wildlife feedbacks.³¹ These models can be used to communicate current knowledge about grass–shrub transitions and identify knowledge gaps to improve land management.

Approach to Grasslands Management

Over the past twenty years, the Janos region has become a premier laboratory for understanding the importance of coupled human-ecological systems in achieving grassland-conservation goals. Our research in this region in northwestern Chihuahua, along with related work by the Malpai Borderlands Group in southern New Mexico and Arizona, strongly demonstrates the need to understand and maintain a complete suite of ecosystem processes in order to maintain viable human populations, functional ecological systems, and ecosystem services.

The Mexican government is in the process of designating the Janos region for protection as a half-million-hectare Biosphere Reserve; this pending designation provides the foundation for conservation of the region’s rich biodiversity. However, to be effective, conservation requires proper management of rural economic activities such as grazing, hunting, and agriculture. Adequate management requires techniques for productive activities that take into account the region’s ecology and sound ecological zoning. Several key management issues are involved in coupling economic and human development with conservation of biodiversity.

Grassland Restoration

Restoring perennial grasslands is critical for the conservation of Chihuahuan Desert ecosystems. Grassland restoration in the southwestern United States and northern Mexico can benefit from the establishment of large prairie dog

colonies and better management of cattle grazing, along with a consideration of the effects of climate change. The prairie dog poisoning promoted by the U.S. government needs to end, and the funds used for it should be reallocated to subsidize ranchers willing to have prairie dogs on their lands. Lessons learned by the Malpai Borderlands Group in southern New Mexico and Arizona and from our work in the Janos site should be applied to other regions to start a large-scale restoration of grassland ecosystems.

For example, fire and prairie dogs play important roles in eliminating seedlings of desert shrubs such as mesquite; both large grazers and fire promote the expansion of prairie dog populations by reducing vegetation height. The elimination of natural fires, extermination of prairie dogs, and overgrazing have promoted the expanse of mesquite shrublands. The semiarid grasslands of North America evolved with large herbivores such as bison; in the latter's absence, well-managed grazing by cattle may in fact have a positive influence on grasslands while also promoting control of mesquite and contributing to local economies, but only if prairie dogs are included in the mix.

Outreach

Strong efforts should be made to conduct outreach both locally and regionally. In both Mexico and the United States, it will be critical to educate landowners and authorities about the role of prairie dogs in maintaining the grasslands, the compatibility of prairie dog and cattle grazing, and the effects of drought and overgrazing in promoting desertification. These issues are most likely the most critical for the persistence of large tracts of perennial grasslands in the Chihuahuan Desert. Such outreach efforts, however, should be conducted differently in the two countries. In the United States, outreach has to be concentrated on both the government and private landowners. In Mexico, it has to address both caretakers of communal lands and private landowners. In both countries, it has to emphasize the benefits of maintaining prairie dogs for the grasslands and the compatibility of conservation and human activities.

Conclusions

Prairie dogs are essential to maintaining grassland ecosystems, ecosystem services, and human well-being. First, the conservation status of borderland grassland–prairie dog systems has important transboundary implications for biodiversity. Prairie dogs support local, regional, and continental biodiversity by maintaining open grasslands and providing habitat for many species.

For instance, the status of migratory bird and raptor breeding populations 1,000 kilometers (620 miles) north of the Mexico–U.S. border can be linked to the health of grasslands in the narrow borderland region. For species such as bison and pronghorn, the influence is more local, and the need of open grasslands to maintain viable populations reaches only a few tens of kilometers north and south of the international boundary. In addition, by maintaining open grasslands, prairie dogs support a more productive ecosystem for cattle, help to increase the amount of water percolating to the water table, and suppress woody plants, thereby curbing desertification and helping to maintain soil stability.

Our results from Janos show that cattle ranching and conservation of prairie dogs are compatible. The lessons learned in the grasslands of the borderlands region of Mexico can be applied to many of the nearly 20 million hectares (50 million acres) that prairie dogs formerly occupied in North America, where cattle ranching is today the main economic activity.

The trilateral (United States, Mexico, Canada) Commission for Environmental Cooperation has published the Black-Tailed Prairie Dog Conservation Action Plan. For the plan to have an impact, the commission will need to coordinate the work of different actors involved in prairie dog conservation across their distribution range in North America. Funding will be needed to combat eradication programs, increase research, and develop improved land-management techniques in priority conservation areas.

Grasslands have played a major role in human history, from the origin of agriculture and the establishment of important past and present cultures to the production of food for a large part of humanity. We have a moral obligation to do whatever is in our power to ensure that the ecological processes that shaped the characteristically rich biodiversity of the grasslands of North America persist long into the future.

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