FROM THE FIELD

A Preliminary Analysis of Soil Erosion and Buffelgrass in Sonora, Mexico

Eric P. Perramond
Department of Geography & Environmental Science
Stetson University
Deland, FL 32720-8401

Abstract

An important ecological concern in northern Mexican states is the use and spread of buffelgrass (*Pennisetum ciliare*). Native to Africa and India, it was first imported to the United States as a way to boost the declining productivity of semi-arid rangelands. Its use is controversial for presumed impacts on native ecosystems and its possible role in soil erosion rates in the Sonoran Desert. This paper examines the controversy over buffelgrass in the Mexican state of Sonora. Preliminary results indicate that buffelgrass can be a very effective soil cover, but that soil erosion is high in newly-seeded pastures.

Introduction

Geographers have long given lecture courses on conservation of natural resources and considered the evils of soil erosion. But what have they done as investigators in the field, which may actually lie at the doorsteps of their classrooms?
Carl O. Sauer (1941:19)

Conservation biologists, with little contribution or involvement by geographers, traditionally have addressed the impacts of exotic species on ecosystems (cf. Parsons 1972). The lack of focus by geographers on the subject is understandable, due in no small part to the empirical-analytical challenge that exotics pose in understanding shifting plant and animal dynamics (Noss and Cooperrider 1994). There are exotic specimens, however, that transcend the merely bio-physical aspects. Some exotics are occasionally encouraged to expand, due to government policies or private land-owner decisions. These newly introduced species may pose serious problems for native fauna and flora and, in addition, can negatively affect soil processes. The former has received greater attention from conservation biologists, while the latter has been only partially addressed.

This paper addresses the current dilemma over the introduction, use, and spread of one such exotic, buffelgrass (*Pennisetum ciliare*). This grass was introduced from parts of Kenya and India into the United States during the 1940s and has since gained a foothold in northern Mexico, where it now commonly spreads without human cultivation. The study discusses the impacts of buffelgrass in the state of Sonora, examines the effects of the exotic's spread in the region, and reports preliminary results on soil erosion.
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One of the most pernicious aspects of buffelgrass introduction is the method of planting, wherein native vegetation is bulldozed and the exotic seeded thereafter. Presumably, erosion rates are extremely high with buffel grass introductions because of the method of mechanical plant-cover removal, although no extant data exist. Cattle ranchers have extensively modified rangelands in the state of Sonora, planting buffelgrass in an effort to boost the carrying capacity of semiarid pastures. This study does not question the real possibility that buffelgrass is having a deleterious effect on Sonoran biodiversity, but rather focuses on the issue of soil erosion and the presumed or real effects of buffelgrass plantings.

Study Area

The area under consideration is the middle Río Sonora Valley, in the northern central portion of the state of Sonora in northwestern Mexico (Figure 1). The specific data for this research, however, come from one specific *municipio*:

Baviácora. Akin to their neighbors, Baviacorenses traditionally have been involved in extensive cattle ranching operations since at least the late-17th century. Cattle ranchers, as land managers, transformed and continue to transform the biophysical landscapes of the Río Sonora. These physical landscapes range from the floodplains of the river itself, with its assemblage of cottonwoods and mesquites, to the high altitude oak groves on mountaintops. The Río Sonora's landscapes are filled with cattle, which occupy all types of terrain and vegetation zones. During the 20th century, however, cattle ranchers began to struggle with maintaining production numbers.

Cyclical droughts, the most severe of which occurred in the 1950s, repeatedly struck the rural industry, and the Río Sonora was no exception. As the cattle trade in northern Mexico became closely tied to the United States over the last 50 years, there was a growing interest to "improve" cattle breeds in Sonora, largely by introducing European breeds (Chavez Ortiz 1991). In the Río Sonora, the earliest breeds introduced were Hereford-type cattle that were brought south from Cananea, a mining town just north of the study area. The pace of genetic change in Sonoran livestock has accelerated, as ranchers have added European Charolais and hybrid Brangus breeds. Ranchers have also added more drought-resistant cattle such as Zebu, a breed commonly found in Africa. Parallel to this decision to improve cattle breeds was the importation of improved seeds for pasture grasses from Africa and India that could increase the production of pastures in Sonora and elsewhere (Camou-Healy 1994; Parsons 1972).The consequences of improved breeds and seeds had a remarkable effect on the industry and transformed cattle-ranching in northern Mexico, and in Latin America in general.

As noted, one of the most visible landscape changes in the Sonoran Desert has been the introduction of buffelgrass (*Pennisetum ciliare*), an exotic pasture grass introduced via Texas; it made its way into northern Mexico after extensive testing at Texas A&M University (Holt 1985). This exotic, along with many others, was introduced in an effort to slow erosion and boost feed production on cattle pastures. Buffelgrass, like other African perennial grasses, is an efficient plant for its rooting structure and its tenacious hold on soils (Bock and Bock 1995; Martin et al. 1998). Buffelgrass is also fire-tolerant and will expand into annual grasslands, at the expense of native grasses (Cox et al. 1990; Ibarra et al. 1995).

In addition, buffelgrass cultivars are also flood-tolerant, another effective adaptation when sudden rains strike Sonora in the summer rainy seasons (Anderson 1974). At the time of introduction in the 1940s and 1950s, few botanists were aware that either of these grasses might have deleterious effects on biodiversity. Botanists and ranchers were merely concerned about the effects of droughts on pastures in the American West (Cox et al. 1983). The use and popularity of buffelgrass with ranchers and United States government agencies in the American Southwest spread to ranchers in Mexico, who shrewdly evaluated the grass for use on their own rangelands. The diffusion of buffelgrass was promoted by both Sonoran state officials and local rancher **[end p. 132]** associations in the United States and in the small towns of the Río Sonora (Camou-Healy 1994; Cota and Robles 1996; Perramond 1999).

Since the 1970s, buffelgrass introductions have occurred along the Río Sonora, although the pace of adoption was slow (see Figure 2). Subsidies from the state of Sonora, and lowinterest loans from banks, made funds available for more widespread plantings of buffelgrass in the 1980s (Camou-Healy 1994). Thus, there is widespread evidence that Sonoran ecosystems have been transformed in the 20th century, as new animals and technologies are diffused (Sanderson 1986; Pérez López 1993). Across these semiarid landscapes, however, new research suggests that these plant mosaics are constantly shifting (Behnke et al. 1993; Sullivan 1996). Much of the recent evidence using a perspective grounded in the so-called "new ecology" comes from African savanna environments (Turner 1998). This new line of research has not revolutionized our concepts about ecology (cf. Zimmerer 1994). Their suggestive findings, however, would indicate that semi-arid lands in the Americas merit reconsideration (Cohn 1996). By the time field-work was completed along the Río Sonora in late 1997, few new buffelgrass pastures were present along the river, as the latest currency crisis was felt throughout Mexico.

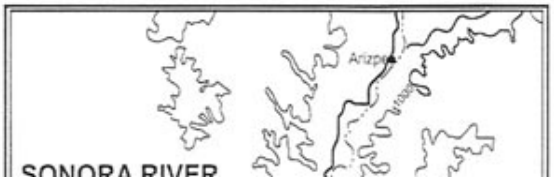

Figure 2. The author standing in a buffelgrass pasture during the 1997 (June) dry season.[1] Source: Courtesy of W.E. Doolittle.

Methodology

This study reports findings from three test plots of buffelgrass pastures in the municipio of Baviácora. To understand the differential impacts of buffelgrass stands, three separate pastures planted with the exotic were studied and monitored for soil erosion after 14 precipitation events during the summer season of 1997. These rainfall events all occurred during the months of July, August, and September. This time of the year is known locally as *las aguas*, a time of sudden and violent thunderstorms. The precipitation occurs on the heels of the extremely dry **[end p. 133]** months of April, May and June. The sudden nature of these rainstorm events creates tremendous slopewash on steep and mountainous terrain, common along the Río Sonora. Because of the difficulty in working with Sonoran soils, precise volumetric measurements of soil erosion were not possible. Soils at the study sites were simply too coarse (sands/gravels) to allow for effective trenches to measure volumetric quantities. Trenches dug along slopes, or at the bottom of slopes, quickly caved in.

Instead, a set of ten-inch nails with washers were used in each pasture, arranged to record proxy measures of soil erosion (See Ffolliott et al. 1995 for this method). These nails were placed through the washers to ground level. Subsequent erosion lowered the washer around the upper portions of the nail, and further erosion lowered washers after each precipitation event. In some cases, excavation of the nail/washer was necessary, as sedimentation occurred. The three pastures were all accessible by vehicle after precipitation events, and each site's pins were monitored after each single precipitation event, and the new level of the washer was recorded (see Figure 1 for location of pastures).

Site number one was located on the private ranch of La Compuerta located 15km from the town of Baviacora, and this site has the most mature buffelgrass stand, eight years old at the time of fieldwork in 1997 (see Figure 3). Site number two was located three miles to the southwest of La Compuerta, on new *ejido* buffelgrass pastures, communal pasture held in common by *ejidatarios*. This second site was planted with buffelgrass during the spring of 1995, and was already yielding some pasture and effective soil cover. The third site, located parallel to the Río Sonora in San José de Baviácora (see Figure 1), was recently cleared of vegetation during the summer of 1997, had just been seeded, and thus provided no soil cover.

In each site, a total of six placements were used for the nails with washers, to monitor soil erosion. Pins and washers were placed on various slope angles of 0, 15, and 30º in each pasture, three placements under buffelgrass cover, and three under "control" (native vegetation) conditions. For a summary of the placement of pins at

each site, see Table 1.

Native vegetation on each "control" site largely consisted of thornscrub species such as *Acacia* and *Prosopis* (juniper spp.) For each of the six placements, under control and buffelgrass conditions, six nails with washers were placed into the soil against the contour. In other words, each site had a total of 36 nails and washers, which were all monitored after precipitation events. Etchings were placed on each nail with a small pocket knife after the level was recorded. No nails or washers were lost as a result of this study. Each nail's individual events were aggregated into tables, compiling the total amount of erosion recorded by the pins, to ensure that microtopographic differences did not skew the data. Each "control" and buffelgrass pin-site was averaged for the total amount of erosion after rainfall events. These are among the first data recorded on soil erosion in buffelgrass pastures, and although by no means conclusive, they are suggestive of several testable hypotheses. These preliminary data indicate that buffelgrass may be an effective ground cover on rangelands after at least two years of establishment.
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Table 1. Summary of Soil Erosion Sites and Placements

Site Location	Control Site Pins			Buffelgrass Pasture Pins		
Degree of Slope	0°	15°	30°	0°	15°	30°
Site 1: Private ranch La Compuerta	6 pins	6	6	6	6	6
Site 2: *Ejidos* of Baviácora	6	6	6	6	6	6
Site 3: San José	6	6	6	6	6	6
Total Pins: 108	54 control pins			54 buffelgrass pins		

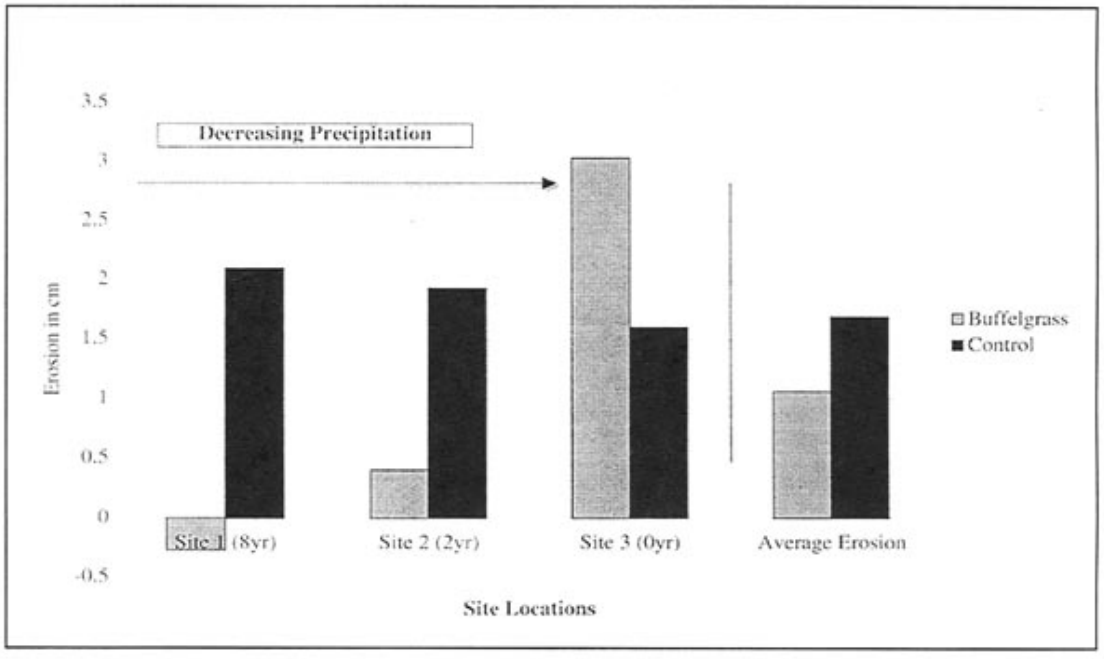

Figure 4. Average Soil Erosion by Site after 14 Rainfall Events in 1997.[3]

Discussion of Results

As Figure 4 indicates, the presence of buffelgrass and soil erosion increases do not directly correlate. In the old stands of buffelgrass on site number one, slight erosion under buffelgrass cover becomes sedimentation at the lower slope angles (0º), hence the negative integers on the bar graph of compiled averages. Sedimentation was obvious because excavation of the pins was necessary. Sedimentation was also evident at site two, just due west of site one,

under buffelgrass stands that have been extant for two years. Erosion, to be sure, was slightly higher on the buffelgrass pastures in site one. As the slope angles were equal in all three pasture sites, the difference in erosion rates may be attributed to the effectiveness of buffelgrass ground cover, related to the age of the exotic grass stand. The most severe erosion under buffelgrass was found in the newly cleared fields of seeded buffelgrass near San Jose de Baviácora (site three). This is unsurprising, as there is no soil cover on the**[end p. 135]** buffelgrass plots. Thus, erosion rates are higher in the newly seeded buffelgrass plots at site three (San José) than in the "control" plots with native vegetation that parallel the slope angles. This last pasture site is also owned by *ejidatarios*, and those who worked on this clearing and seeding of grasses were roundly criticized by the other *ejidatarios*. They claimed that the pasture tracts for buffelgrass were too wide, and that the bulldozer had cleared too much ofthe standing thornscrub vegetation. These critics also claimed that the buffelgrass pastures at San Jose should have been planted during November and December, to take advantage of the gentle winter rains known as *equipatas*. The *equipatas* fall as a lighter rain, and presumably would have less deleterious effects for soils recently seeded with the exotic grass.

Conclusion

Although state-level promotion for buffelgrass seeding was aggressive and remains in place, there are limitations to buffelgrass that ranchers are quick to explain. It does poorly at elevations approaching 1000 meters (Martin et al. 1998). It is frost-intolerant, which limits its potential use in the north of the state where frosts and snow are not uncommon (Cox et al. 1988). Its elevation barrier (1000 m) also ensures that the highest elevations in Sonora will not be planted to buffelgrass. The success of this exotic, especially at lower elevations and with the presence of fire, is especially apparent during moist rainy seasons (Ibarra et al. 1995). By the early 1990s, buffelgrass stands were present on 1.2 million hectares of Sonoran rangeland (Yetman and Burquez 1994).

The effects of buffelgrass on both wildlife and native vegetation are unknown, although tentative suggestions have been made that the grass is not favorable to hosting native wildlife (Martin et al. 1998). It is already known that other exotics, such as Lehmann lovegrass (*Eragrostis lehmanniana* Nees), can reduce the habitat and numbers of wildlife such as the scaled quail (*Calipela squamata*). Many native quails thrive on grazed ranges, but cannot tolerate seeded grasses, such as Lehmann lovegrass. Habitat destruction or replacement, then, is a critical issue for native fauna in semi-arid grasslands (Bock and Bock 1988). In addition, the use of fire by ranchers to clear buffelgrass pastures of native weeds and invasive shrubs is expanding the boundaries of the exotic's original planted range. And despite occasional inroads by *Acacia cochliacantha* (*chirahui* in Spanish), buffelgrass stands are rarely submerged by native thomscrub species. Native vegetation clearance for buffelgrass pastures is providing small-scale charcoal industries across the Sonoran landscape a sudden livelihood, a trend which may threaten rare species of Sonoran plant life (Yetman and Búrquez 1994).

The effect of buffelgrass on soil erosion is unclear. Because of the data limitations of this study, no clear generalizations can be made about the impacts of buffelgrass on soil erosion in the seeded pastures of Sonora. The initial findings presented, however, may be used as a working hypothesis. The data suggest that this exotic grass is an effective retardant of soil erosion once mature (after several years). Initial rates of soil erosion, however, appear higher in cleared and seeded buffelgrass pastures than in uncleared stands of native vegetation. Further field experiments and volumetric measurements, where possible, should explicate the dynamics of soil erosion under buffelgrass cover.

Notes

1. Despite the absence of a standing crop of grass, buffelgrass leaves a dense mat of root systems that retained soils even on steep slopes (30º).

2. Note that the slopes with bufflegrass in this photo are rather steep. Sonoran state officials are now discouraging the practice of initial pasture clearance, due to the growing awareness that soil erosion may be severe upon clearing.
3. Negative integers reflect sedimentation under mature buffelgrass stands. Note, however, the increased erosion under newly cleared buffelgrass stands at site three. Average erosion rates under native vegetation ("control") versus buffelgrass plots are noted on the last bar graph.

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Acknowledgements

This research was generously funded by the IIE Fulbright-Garcia Robles scholarship, and supplemented with funds by the NSEP Graduate Enhancement Fellowship. Smaller sums from the C. B. Smith Award from the Center for Mexican Studies at the University of Texas-Austin and a Tinker Foundation summer grant are also gratefully acknowledged. I wish to thank my advisor, W. E. Doolittle, for his support throughout field research in 1996 and 1997. I also thank the anonymous reviewers, César Caviedes, and David Keeling for their helpful comments. Most of all, I thank the Corrales family of Baviacora, Sonora. This article is dedicated to the memory of Ricardo Loera. An earlier version of this paper was presented at the Boston meetings of the AAG in 1998.

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Resumen

Un asunto ecológico principal en el norte de México es el uso y expansión del zacate buffel (*Pennisetum ciliare*). Un zacate Africano y Índico, fue importado a los Estados Unidos para ameliorar la productividad de las praderas semiaridas. Su uso es discutido por causa de los impactos presumidos sobre los ecosistemas nátivos, y su papel posible en la erosión de los suelos en el Desierto Sonorense. Este trabajo examina la controversia sobre el zacate buffel en el estado mexicano de Sonora. Los resultados indican que el zacate buffel puede ser eficaz contra la erosión del suelo, pero que la erosión en praderas nuevas de buffel es alta.
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