CHAPTER 20

The Desert Grasslands

Walter G. Whitford

CHARACTERISTICS OF THE DESERT GRASSLAND ECOSYSTEM

The desert grasslands are widely distributed in North America, occupying much of southeastern Arizona, the southern half of New Mexico, and west Texas in the United States and extending southward through 13 states in Mexico, from Sonora to Puebla. They represent more than 500,000 km^2 of basin and valley lands that skirt the hills and mountain ranges of southwestern North America (McClaran 1995). The entire geographic range of the desert grasslands has seen a rapid decline in grass cover and an increase in cover by woody shrubs, especially mesquite (*Prosopis* spp.) and creosotebush (*Larrea tridentata*). Traditionally, the desert grasslands have supported extensive stands of perennial bunch grasses, known colloquially as the grama grasses, which reproduce primarily by stolons. Other, smaller bunch grasses occupied habitat patches such as infrequently inundated swales that support a cover of tabosa grass, *Hilaria mutica*.

The grasses of the desert grasslands are all C4 (referring to the type of photosynthetic pathway) grasses that thrive in the warm season. Warm-season grasses do not produce leaves until the night-time temperatures remain higher than 10°C. As a result, rainfall during the winter and spring is ineffective for primary production of these grasses.

The woody shrubs that have invaded the desert grasslands are C3 (a photosynthetic pathway) plants that are considered cool-season vegetation. These shrubs have deep root systems and redistribute intercepted moisture efficiently via stem flow to the root channels and to deep storage. Water that is redistributed by shrubs lies largely out of the root zone of grasses (Whitford et al 1995).

At the present time, the desert grasslands exist as small patches of perennial grasses in a sea of woody shrubs or shrub-grass mosaics.

HISTORY OF DEGRADATION

Much of the degradation of the world's arid and semi-arid grasslands has occurred within the last century. In North America, reports of degradation of the desert grasslands surfaced as early as the 1880s (Bahre and Shelton 1993). These early reports appeared during the same decades as similar reports from Australia and southern Africa. Thus, the changes experienced by the desert grasslands do not represent a situation that is unique to North America. The coincidence of timing and the dominant land-use of the desert grasslands strongly suggests that the causes of degradation may be similar across the world's desert grasslands.

In the southwestern United States, human land-use prior to settlement by Europeans consisted of light harvesting of plants and animals by indigenous hunter-gatherers. The first settlement by Europeans began in the late sixteenth century, when small groups of Mexican-Spanish settlers entered the region. Initially they lived in the perennial river valleys, where the Europeans learned about irrigated agriculture from the pueblo tribes. At that time, only limited livestock grazing occurred in the desert grasslands adjacent to the farm settlements. By the 1820s, small Mexican settlements were scattered throughout the region. These settlements' size remained limited by the small amount of rangeland within reach of perennial water and by the depredations by bands of Apaches, a situation that persisted until the 1870s. After the American Civil War, large herds of cattle moved into the unfenced grasslands of the southwestern United States.

By 1900, ranchers in the area had clearly recognized the detrimental effects of grazing by large herds of cattle. The U.S. government sent an agricultural scientist, David Griffiths, to the area in 1900. Griffiths collected data on the environmental degradation by direct observations and by questionnaires sent to local ranchers. He also set up experiments on forage grasses. The following are excerpts from his report to the U.S. Department of Agriculture.

H. C. Hooker, one of the earliest and most successful ranchers in southeastern Arizona, wrote:

> The San Pedro Valley in 1870 had an abundance of willow, cottonwood, sycamore, and mesquite timber, also large beds of sacaton and grama grasses, sagebrush and underbrush of many kinds. The river bed was shallow and grassy and its banks were beautiful with a luxuriant growth of vegetation. Now the river is deep and its banks are washed out, the trees and

> underbrush are gone, the sacaton has been cut out by the plow and grub hoe, the mesa has been grazed by thousands of horses and cattle and the valley has been farmed. Cattle and horses going to and from feed and water have made many trails or paths to the mountains. Browse on the hillsides has been eaten off. Fire has destroyed much of the shrubbery as well as the grass giving the winds and rains full sweep to carry away the earth loosened by the feet of the animals. . . . (Griffiths 1901)

In response to a question about maximum numbers of grazing animals and current carrying capacity, Hooker wrote, "There were fully 50,000 head of stock at the head of Sulphur Spring Valley and the valley of the Aravipa in 1890. In 1900 there were not more than one-half that number and they were doing poorly."

In his survey work, Griffiths (1901) learned that the grazing potential of much of southeastern Arizona had been diminished to less than half the stock that had grazed in the same area in 1880. The pattern of degradation of southeastern Arizona desert grasslands was documented in a letter from C. H. Bayless of Oracle, Arizona, to Griffiths:

> . . . the San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of water and prevented the cutting of a channel. Trappers exterminated the beavers and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. . . . Of the rich grama grasses that originally covered the country so little now remains that no account can be taken of them. . . . Where stock water is far removed, some remnants of perennial grassses can be found. Grasses that grow only from seed sprouted by summer rains are of small and transitory value. The foliage of the mesquite and catsclaw bushes is eaten by most animals and even the various cacti are attempted by starving cattle. . . . No better pasture was ever found in any country than that furnished by our native grama grasses, now almost extinct. . . . The present unproductive conditions are due entirely to overstocking. . . . Twelve years ago, 40,000 cattle grew fat along a certain portion of the San Pedro where now 3,000 can not find sufficient forage for proper growth and development. If instead of 40,000 head, 10,000 had been kept on this range, it would in all probability be furnishing good pasture for the same number today. Very few of these cattle were sold or removed from the range. They were simply left there until the pasture was destroyed and the stock then perished by starvation.

The words of both Bayless and Hooker paint a graphic picture of rapid conversion of a grassland Eden to a desert hell. The degradation processes that Griffiths (1901) described in the San Pedro drainage in southeastern

Arizona did not cease in the early 1900s, however. Data from Landsat (multispectral scanner) imagery of the San Pedro watershed show that the desert grassland fragments continued to diminish in size and become more isolated in the increasingly degraded rangeland (Kepner et al 1995, personal communication). In a comparison of images from 1974 and 1987, the evaluation showed that extensive grassland areas with high connectivity were the ecosystems most vulnerable to fragmentation caused by the expansion of woody shrubs and cacti. In their preliminary analysis, Kepner and Ritters found that the number of grassland patches increased 61% and the average grassland patch size decreased 60% over this period (Figure 20.1). The continuing degradation involved the loss of vegetative cover, which holds soil in place and retains water on-site, and a replacement of grasses with shrubs that are not palatable to livestock. The consequences included increased run-off and sediment input into the major drainage system (the Gila River), reduced groundwater recharge, loss of economic production potential, loss of habitat for grassland specialists like pronghorn antelope, and conflicts between ranchers and other users of the land (including hikers, wildlife viewers, and recreational users from the nearby cities such as Tucson).

Detailed data on changes in vegetation and soils, carrying capacity for livestock, and efficacy of various restoration treatments are available from several research stations that were established in the early 1900s. The Jornada Experimental Range in southern New Mexico, for example, provides data for

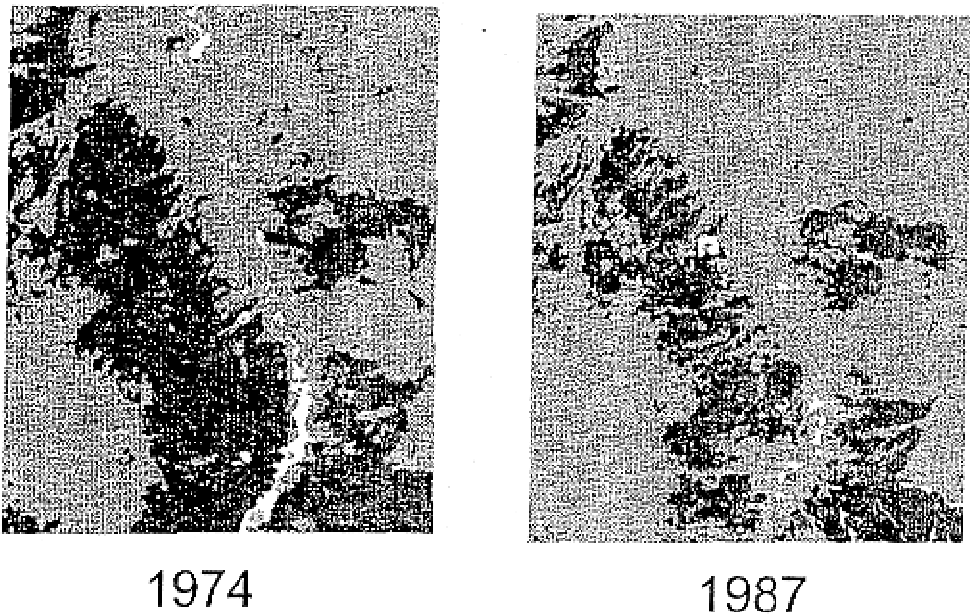

FIGURE 20.1. *Landsat multispectral scanner imagery of the grasslands (black), woodland–shrublands (gray), and irrigated agriculture (white) in the San Pedro river basin.*

the period described by Griffiths (1901) in southeastern Arizona as well as the period from those decades to the present. It encompasses most of the 58,492 hectares in the San Andreas Mountains basin named by the early Spanish settlers as *Jornada del Muerto* (journey of death). In the 1880s, ranches were established around springs in the San Andreas Mountains. The Jornada Basin was not developed until 1901, when ranchers drilled deep wells to provide year-round water for their livestock. Soon after ranches were established in the area, the stockmen began to become concerned about the loss of livestock-carrying capacity and petitioned the government for assistance. The Jornada Experimental Range (originally the Jornada Range Reserve) was established in 1912 with the stated mission of carrying out research designed to improve grazing in the region.

Despite the conservative management of the Jornada Experimental Range, vegetation change continued, as documented by Buffington and Herbel (1965). As in the San Pedro watershed and all other valleys in the desert grassland rangelands of the United States and Mexico, the trajectory of reduction in vegetative cover, replacement of C4 grasses with C3 shrubs, and soil loss has occurred at varying rates over the decades since the Jornada Experimental Range was established.

In the Jornada Basin, desert grasslands (Figure 20.2) have been replaced by creosotebush shrublands on the piedmont slopes of the mountains (Figure

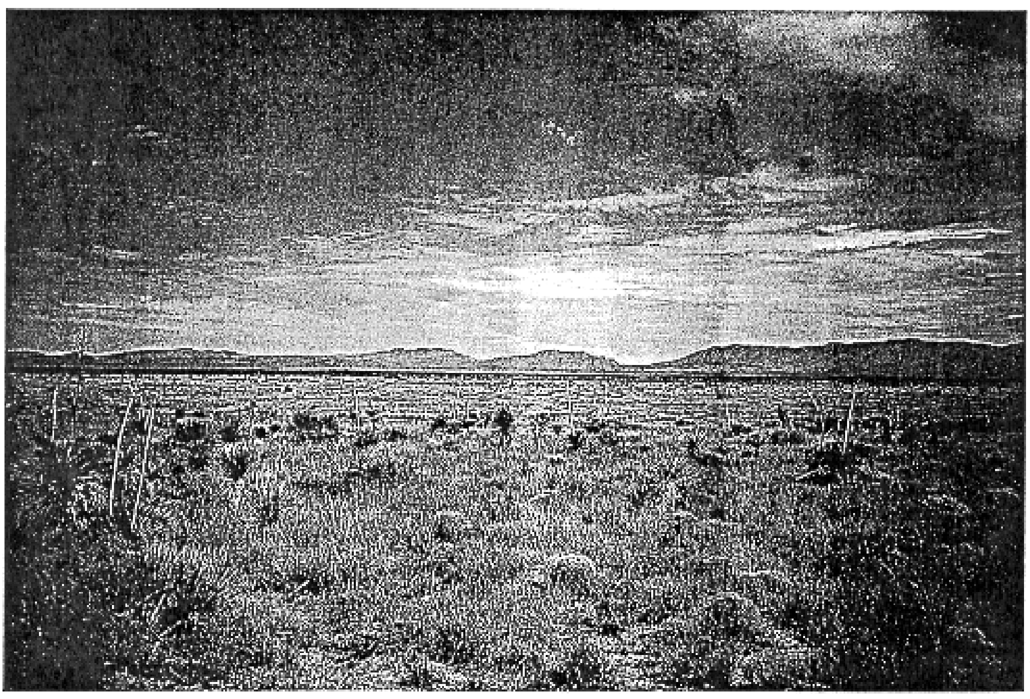

FIGURE 20.2. *Desert grasslands in southern New Mexico. The dominant grasses are black-grama (*Bouteloua eriopoda*) and dropseeds (*Sporobolus *spp.).*

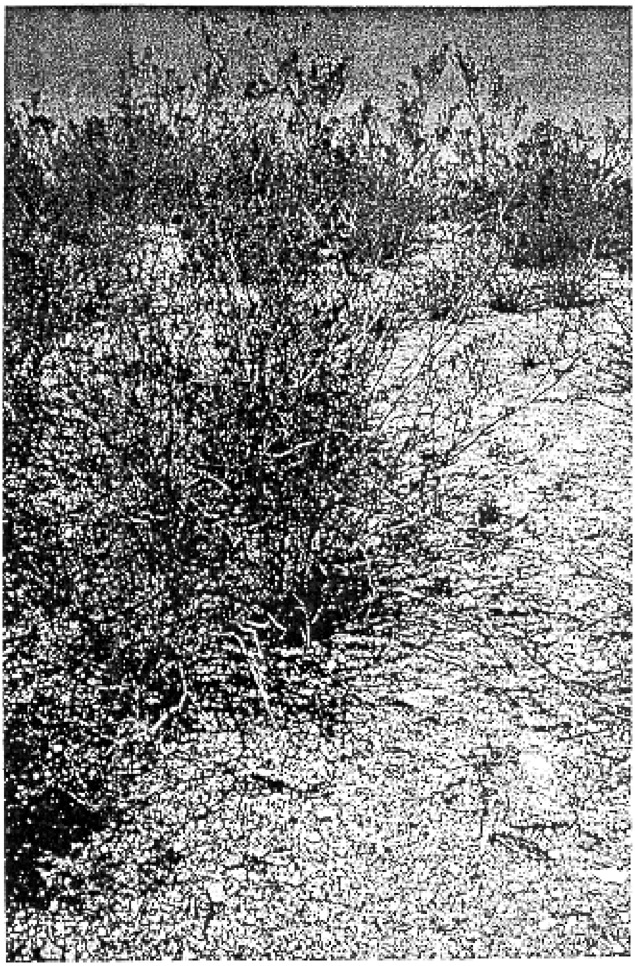

FIGURE 20.3. *Creosotebush (*Larrea tridentata*) shrubland, a vegetation type that has replaced black-grama grassland on piedmont slopes in much of the desert grassland region of the southwestern United States and Mexico.*

20.3) and by mesquite coppice dunes in the badly degraded sites in the basin (Figure 20.4). This pattern has been repeated in Mexican rangelands as far south as the desert grasslands extend and throughout west Texas and southeastern Arizona. Most of the public grazing land administered by the U.S. Bureau of Land Management, for example, has suffered some degree of degradation. In the worst cases (those involving grazing allotments in mesquite coppice dunes), the ranchers have not renewed their allotments because insufficient forage exists to support livestock.

Consequences of Degradation of Desert Grasslands

The economic consequences of the continuing degradation of desert grasslands are the root cause of social conflicts in the rangelands of the West.

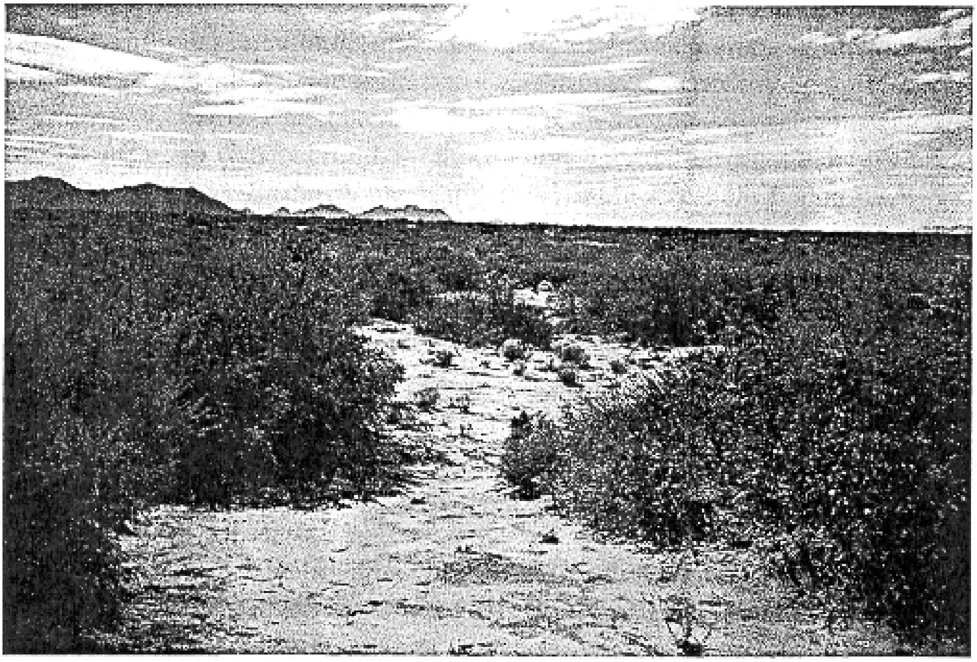

FIGURE 20.4. *Mesquite (*Prosopis glandulosa*) coppice dunes, the most degraded and resistant ecosystem that has replaced desert grasslands in the grassland regions of the southwestern United States and Mexico.*

Ranchers in the desert grassland region of the southwestern United States typically realize a return on investment of 1% to 3% (Holechek 1992). "From an investment standpoint Chihuahuan Desert cattle ranching would be considered unprofitable and risky by any Wall Street analyst" (Holechek 1992).

The desert grasslands of New Mexico are in much better condition than their Mexican counterparts. According to assessments by the U.S. Department of the Interior, 15% to 18% of New Mexico desert grassland range is in poor condition, 45% is in fair condition, 35% is in good condition, and only 5% to 10% is in excellent condition. Rangeland in poor to good condition is at risk of degrading to a lower condition. Changes in wholesale cattle prices, government policies such as drought subsidies, and climatic fluctuations all combine to influence ranch management decisions that frequently produce further degradation. Ranches in the poor to fair condition category are frequently "hobby ranches" where the desirable "cowboy lifestyle" is subsidized by employment in another profession (Holechek 1992). Because much of the rangeland exists in an unhealthy state, the present-day cattle grower is forced by economic necessity (the need to repay loans, feed a family, and so on) to maximize herd size. The economic situation compels ranchers to make decisions based on short-term financial returns rather than those that could improve the long-term health of the rangeland resource.

Economic peril is not the only consequence of unhealthy rangelands. Environmental organizations frequently come into conflict with ranchers over management of the most fragile and most biologically diverse parts of the rangeland ecosystems (the riparian zones along creeks and streams). Degradation of the riparian systems followed immediately upon the introduction of the livestock industry into the desert grasslands and continues virtually unabated today. Healthy riparian systems are characterized by grassy banks, no evidence of channel cutting, and reproduction of dominant riparian species such as willows (*Salix* spp.), cottonwoods (*Populus* spp.), and seep willow (*Baccharis* spp.). When they are given access to these areas, domestic livestock tend to concentrate their activity in riparian zones. In their grazing, these animals consume both seedling trees and grass.

In one study, a healthy 1-km stretch of riparian woodland along a dry stream bed was found to support 25 species of breeding birds; in contrast, a 1-km stretch of an adjacent heavily grazed riparian system supported only 6 species of breeding birds (W. G. Whitford, unpublished data). The unhealthy stretch of stream bed had a deep (30–50 cm) incised channel, long stretches of 20–50 m with no fringing vegetation, and no grass or tree shrub seedlings along the channel margins. Because of such findings, environmental activists and other groups of concerned citizens are pressuring the ranching industry to change their management practices so as to protect and perhaps heal damaged riparian ecosystems.

While degradation of desert grassland riparian systems has undoubtedly reduced biodiversity, a growing body of evidence suggests that degradation of the desert grasslands has actually increased biodiversity. That development probably reflects the greater structural diversity of the rangeland ecosystems, which has been transformed from the uniform height and density grassland to shrublands and shrub-grasslands with varying heights and densities. These changes, however, have also produced adverse effects for grassland specialists such as the banner-tailed kangaroo rat and the pronghorn antelope. Other activities that have probably affected biodiversity on desert grassland include the extirpation of the prairie dogs, wolves, and mountain lions by U.S. government animal damage control specialists over most of the U.S. desert grasslands. As a consequence of past management decisions and the continuing loss of habitat, it is clear that many species of desert grassland specialists have disappeared or are at risk of becoming extinct.

RANGELAND REHABILITATION

Efforts to rehabilitate the degraded rangelands have focused on a variety of methods of shrub removal, including herbicide application, root plowing, and burning. These efforts have frequently been combined with seeding either a mixture of seeds of native grasses, a mixture of seeds of native and exotic grasses, or seeds of exotic grasses (Call and Roundy 1991). The reasoning behind these efforts was based on interpretations of the Clementsian conceptual model of succession (Clements 1916, 1928). This model concluded that woody shrubs were invasive and out-competed grasses, thereby creating conditions promoting a decline in grass production and eventual soil loss. More recently constructed conceptual models of vegetation change in semiarid and arid ecosystems focus on discontinuous and irreversible transitions and alternative stable states (Westoby et al. 1989).

Attempts at rehabilitation of degraded rangelands have been both extensive and expensive. For example, between 1940 and 1981, an average of 600,000 hectares of brush infested rangeland in Texas was treated annually by herbicides, fire, and mechanical means such as root plowing, chaining, and discing (Rappole et al 1986). Despite the intensity of treatment, land managers realized only a transitory and short-term benefit. Regrowth of shrubs occurred in a short period of time, and retreatment became necessary within 15 years of root plowing, 2 years after chaining, and 8 years after treatment with herbicides (Rappole et al 1986).

Similar results were recorded in other parts of the desert grassland rangelands (Herbel et al 1983). Even when combined with livestock exclusion and root plowing, herbicide treatment has not resulted in the reestablishment of grasslands (Roundy and Jordan 1988; Chew 1982). On the Jornada Experimental Range, the shrub vegetation in three 290-hectare grazing exclosures that were built in the early 1930s has remained the same as that in the surrounding grazed areas. Thus, the desert shrublands that now dominate most of the land area that consisted of desert grasslands in the 1820s appear to be both resistant and resilient to efforts to reduce shrub cover and restore grasslands.

Desert shrublands differ from desert grasslands in many key features, such as water infiltration and storage, period of photosynthesis, predictability of growth period, spatial redistribution of water and nutrients, and spatial distribution of the seed bank. In their own unique way, the shrublands are actually healthy ecosystems. At present, the shrublands that replaced the desert grasslands have limited usefulness to humans—thus, they are often considered unhealthy and largely incurable.

Although the attempts to restore native desert grasslands to areas now dominated by woody shrubs have failed both ecologically and economically, partial success in restoring some of the functions of desert grassland has been achieved by seeding and spread of non-native grasses. These grasses have revegetated watersheds and reduced damage by flooding. They also provide forage for livestock at certain times of the year and on some microsites.

After initial screening by the U.S. Department of Agriculture, Lehmann's lovegrass (*Eragrostis lehmanniana*) was seeded on selected sites in southeastern Arizona and New Mexico. Between 1940 and 1980, land managers in Arizona established Lehmann's lovegrass on 70,000 hectares; the grass has since spread to an additional 130,000 hectares (Cox and Ruyle 1986; Anable et al 1992). In New Mexico, *E. lehmanniana* appears to be replacing native grama grasses and dropseed grasses. Despite the benefits of having this perennial grass provide soil cover and forage for livestock in shrub dominated ecosystems, the diversity of the fauna remains severely reduced (Anable et al 1992). Lehmann's lovegrass continues to spread into both shrub-dominated areas and areas of native grassland. The spread of this exotic plant has spurred considerable debate about the costs and benefits of a partial cure.

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