An Overview of Arid Grasslands in the Northern Chihuahuan Desert

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ABSTRACT

The intent of this paper is to outline information on four topics regarding grasslands of the Chihuahuan desert: 1) general aspects of their ecological dimensions, 2) recent vegetation dynamics, 3) current threats, and 4) common ground with other desert grasslands. The Chihuahuan desert is a region of about 350,000 square kilometers. There are at least fifteen different definitions of the boundaries of this desert. Figure 1 is from Schmidt (1979) and its boundaries are based on an aridity index. Generally, this index reflects an area of <250 mm of average annual precipitation, an average mean annual temperature of 17 C, and an elevation of >1200 m. This paper will focus on the northern region of the Chihuahuan desert, an area called the Trans-Pecos which extends from Southeast Arizona across New Mexico into Texas. A small portion of the Trans-Pecos occurs in west Texas on the upper Pecos River below the Guadalupe Mountains. The western border of the Chihuahuan Desert in Arizona is defined by the amount of precipitation occurring during the summer monsoonal months. East of this line in the Sonoran desert >55% of the annual precipitation occurs during the summer. West of this line in the Chihuahuan desert <55% of the annual precipitation occurs during the summer months.

ECOLOGICAL DIMENSIONS

The Chihuahuan desert, like the Sonoran, can be referred to as a zone of ecological confusion. The Chihuahuan desert grasslands occur within a very dynamic mosaic of desert shrublands. Grasslands comprise about 10% of this region. The Chihuahuan region is the warm desert area of North America that exists east of the Continental Divide. The other warm deserts in North America are west of the Continental Divide (Figure 1). It is primarily a region of internally drained basins. Very little of this area serves as watershed other than the areas drained by the Rio Grande and the Pecos rivers. Vegetation dynamics are strongly affected by aspects of landform, topography and soils. The region does have a long history, over thousands of years, of herbivory. However, most of that history is associated with invertebrates and small mammals.

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Chihuahuan Desert as delineated by Schmidt (1979).
Marked area of about 350,000 km^2 is based on an aridity index of ≤ 10.
(where I = P mm / T °C + 10)
Region includes scattered mountain masses not classified as desert.

Figure 1. Map of the Chihuahuan Desert region as defined by Schmidt (1979).

Like most deserts these grasslands are water limited but also nutrient regulated. Biomass responses to water additions are based on the availability of soil nutrients, primarily nitrogen. The region supports about 120 mammalian species. Generally, these species are fairly common and are not threatened by any particular human activities. There are, however, some notable exceptions, and reintroductions, in particular the Mexican Wolf, have been proposed. Alien species are not a serious issue though there are local problems with both exotic flora and fauna. This is a significant area primarily because of its large dimensions. One particular concern for the conservation of the desert grasslands is that these grasslands serve as important wintering areas for many species, especially avian species. The region has a distinctive herptofauna and some species are threatened or endangered. Many of these species are linked to riparian habitats that exist throughout the region. Biological features of the Chihuahuan desert have been previously reviewed (see Wauer and Riskind 1977).

Like other deserts, one prominent ecological dimension is the variability inherent to the region. Both temporal (annual and seasonal) variability and spatial variability are common. An example of annual variability is illustrated in Table 1. The fluctuation in biomass productivity presented in this table is for a sandy upland ecological site on the Jornada Experimental Range in southern New Mexico. This variation in annual productivity is not unusual for this or other ecological sites in the Chihuahuan Desert (see Herbel and Gibbens 1996).

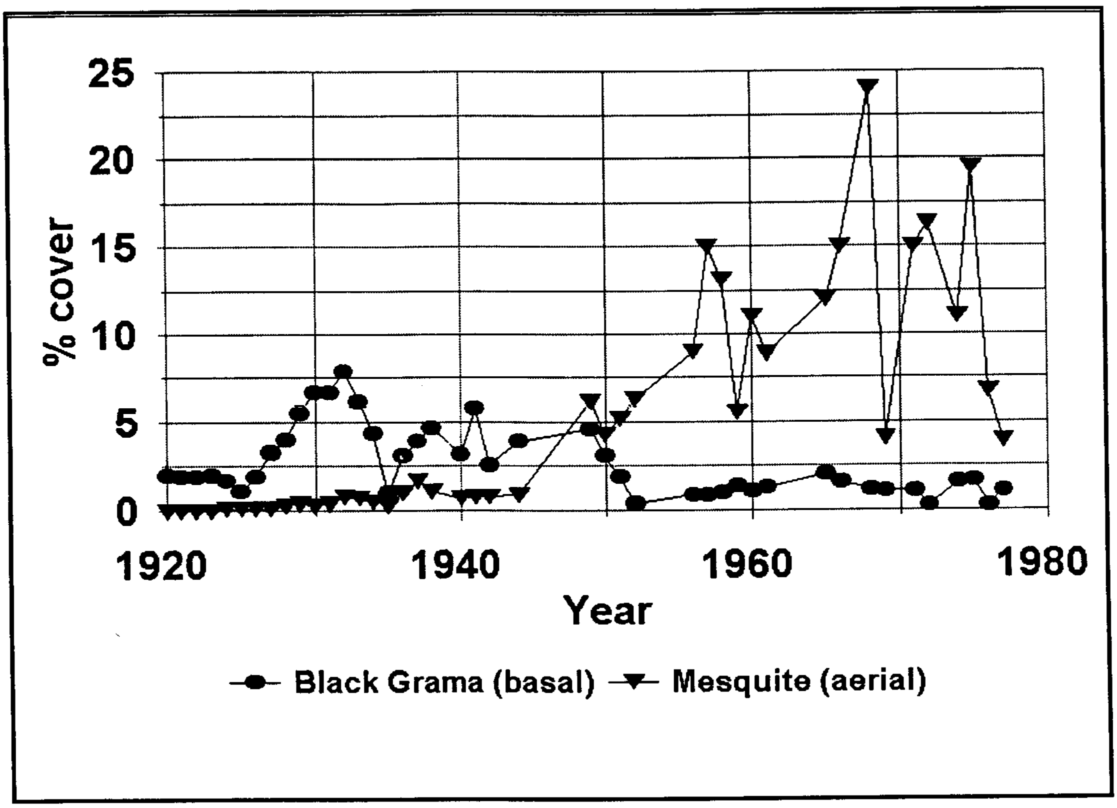

Figure 2. Changes in basal (for black grama) and aerial (for mesquite) cover between 1915 and 1977 on a lightly winter grazed sandy upland ecological site on the Jornada Experimental Range in south central New Mexico.

Year	Precipitation (mm)		Yield ± SE
	Crop-Year[2]	Seasonal[3]	(ka/ha)
1960	105	52	177 ± 21
1961	352	263	644 ± 44
1962	298	212	797 ± 58
1963	199	124	336 ± 47
1964	156	118	302 ± 39
1965	138	85	182 ± 20
1966	199	135	477 ± 40
1967	203	154	145 ± 21
1968	226	122	181 ± 18
1969	164	110	372 ± 29
1970	168	97	174 ± 20
1971	148	93	249 ± 31
1972	284	136	473 ± 57
1973	289	81	195 ± 25
1974	212	187	190 ± 20
1975	297	147	344 ± 48
1976	239	127	354 ± 18
1977	320	219	800 ± 91
1978	157	75	659 ± 72
1979	290	89	156 ± 35
1980	189	91	179 ± 28
1981	229	156	300 ± 38
1982	162	99	99 ± 19
1983	182	41	38 ± 8
1984	194	76	480 ± 53
1985	284	91	526 ± 68
1986	276	122	550 ± 59
1987	349	139	382 ± 51
1988	305	172	500 ± 59
Average	234	131	354

Table 1. Variation in annual forage production from a black grama grassland site in southern New Mexico.[1]

[1] From Herbel and Gibbens (1996).
[2]Crop year = Oct. 1 of previous year through Sept. 30 of indicated year.
[3]Seasonal = July 1 through Sept. 30 of indicated year.

RECENT VEGETATION DYNAMICS

In addition to the dynamics of temporal and spatial variation are the dynamics of vegetation change that are characteristic of this region (see Gibbens and Beck 1988). There are many diverse agents of vegetation change (Grover and Musick 1990). One of the key agents of change has been unmanaged grazing in this region, especially during the post Civil War period. Livestock grazing in the Trans-Pecos region has occurred for over 400 years. However, for the first 300 years that history of grazing was fairly localized (Hastings and Turner 1965). This pattern changed with a number of events after 1865, especially new technologies for pumping water and the availability in the west of transportation systems for shipping livestock to urban markets. Livestock numbers increased dramatically following the Civil War and widespread overgrazing resulted in deteriorated range conditions throughout the region by the early 1900's (Wooten 1908).

The roots of the rangeland management profession actually are in these dynamics and agents of change. A prime motivation for the development of range science and eventually the establishment of principles of range management were the deteriorated conditions of southwestern rangelands around 1900 (Smith 1899). Recognition of the need for scientifically based management practices and improvement techniques was the primary motivation for the establishment of the first rangeland research stations in Texas, Arizona and New Mexico. The first publications from these research stations detailed the influences of grazing management, drought and competition among plant species as principle factors affecting vegetation change throughout the Southwest (see Jardine and Hurtt 1917, and Jardine and Forsling 1922).

We have a few well documented examples of vegetation dynamics during the 20th century as a result of these research stations. For example, Figure 2 presents basal cover dynamics of an important dominant, native perennial grass species, black grama (*Bouteloua eriopida*), that characterizes desert grasslands in the trans-Pecos region. From 1915 through the early 1930's scientists recorded considerable fluctuation in black grama basal cover, primarily due to periodic drought. However, following the intensive drought of the 1950's the cover of black grama drastically declined and has not recovered. Many of these former grasslands are now dominated by native shrubs, such as honey mesquite (*Prosopis glandulosa*). It is currently hypothesized that once mesquite aerial cover exceeds 8% it becomes dominant and effectively initiates soil and surface alterations which restrict redevelopment of black grama cover. Thus, these shrub thresholds (see Archer et al. 1988) result in significant alteration of vegetation structures in these

Vegetation Type	Biomass C aboveground	Biomass C total	Soil Organic Matter C
Grassland	131	190	2112
Mesquite Shrubland	129	235	1804
Creosote Shrubland	102	159	1929
Tarbush Shrubland	82	119	4824

Table 2. Carbon Dynamics © units are g/m^2).
Adapted from Conin et al., 1997.

Time Period	Soil Movement Category	# of Points	Maximum (cm)	Minimum (cm)	Mean (cm)	Net Loss (-) or Gain (cm)
1935-1950	No Change	2				
	Deposition	4	3.2	0.6	5.1	
	Deflation	21	30.5	0.6	4.8	-2.9
1950-1955	No Change	2				
	Deposition	3	3	0.9	1.7	
	Deflation	22	10.5	0.6	3.6	-2.7
1955-1980	Deposition	18	25.1	1.2	7	
	Deflation	9	34.6	0.3	7.1	23

Table 3. Deposition and deflation of soil for an ungrazed area from 1935-1980
(values show change from one measurement to the next).
From Gibbens et al., 1983 (Note: textural changes associated with eolian processes).

deserts. We do not currently have effective remediation technologies to counteract this degradation.

These structural changes are accompanied by other ecologically significant changes. Pilmanis and Schlesinger (1996) have reported an increased spatial heterogeneity in N distribution with increased mesquite encroachment into desert grasslands (Figure 3). Connin et al. (1997) have reported a decrease in the amount of biomass C stored in mesquite dominated communities compared to grasslands (Table 2). The mesquite dominated sites studied by these investigators was a desert grassland until the 1930's. Gibbens et al. (1983) documented significant loss of soil and changes in residual texture for a mesquite duneland (Table 3). Soil losses were discontinuous, with large losses over the 50 year study occurring within a six year span. Finally, Fernandez (per communication, 1996) has reported preliminary results from controlled experiments on physiological differences among grass species, including relative growth rates (Table 4). Obviously, even replacement of perennial grass species by other grass species can create significant differences in biological processes within the desert. These examples illustrate an additional and extremely important dimension to these deserts. Ecological character of the desert is strongly reflected by the dominant species. Changing the dominant species, by whatever combination of causal agents, creates not only new structural features but significant alterations in biotic and abiotic features. These new conditions can be very resistant to regeneration of prior conditions (Schlesinger et al. 1990). In fact, it has been suggested that selecting a standard reference point for these grasslands as the conditions prior to the mid 19th century may be naive. It is probably more appropriate to think of these landscapes, and the rangeland vegetation they support, as highly dynamic (and episodic in their change) and adaptive to evolving environmental conditions. These systems not only have naturally changed, but have been altered through introduction of new biological agents (plants and animals), loss of some agents (predator species reductions), increases in atmospheric concentrations of some gasses (CO_2 and CH_4), and restriction of some habitat factors (control of wildfires). With all of these alterations it is difficult to assume that even removal of all livestock from these deserts will result in regeneration of prior states that existed in the mid 19th century.

Grass Species	Relative Growth Rate (g/d)	Leaf Area Ratio (cm^2/d)
Bush Muhly	0.12	39.7
Mesa Dropseed	0.11	48
Vine Mesquite	0.09	50.5
Black Grama	0.07	13
Tobosa	0.06	11.5
Burrograss	0.03	3.6

Table 4. Physiological aspects of some desert grasses, species not functionally redundant.

From Fernandez, R., pers. comm., 1996.

THREATS

There are many issues that are relevant to current management of these desert rangelands. Several of these issues frequently are energetically debated by opposing parties and are common newspaper and television news stories. These issues include property rights, private equity in public lands and biodiversity. These issues, though, are normal debates about the mechanics of managing these lands. Though there can be strong disagreement on solutions for these issues and though they are very important issues, they should not be viewed as threats to the Chihuahuan Desert grasslands. Rather, they are obstacles to management. There are three basic threats confronting this ecosystem. One threat is desertification. Though this is a global phenomenon, and the definition of desertification has occasionally changed, the issue of degradation of these resources is still very relevant to North America and the Southwest. In many fashions we are still contending with degradation of 100 years ago. Much of our arid rangelands are slow to respond, or the natural recovery mechanisms are no longer functioning. In addition, we lack affordable technologies to remediate landscapes that have degraded. Coupled with this real threat is the need to develop sustainable and affordable technologies for remediating these landscapes (Fredrickson et al. 1996).

Another prominent threat in this region is development. Cities throughout the Southwest, on both sides of the border, are some of the fastest growing population areas in North America. This threat is not so much the need to stop development, but to understand the carrying capacities of the deserts for supporting these concommittent escalations upon resource demands. A basic tenet of rangeland management has historically been the identification of the grazing capacity of the forage resources for an ecological site, and adjusting grazing use to this capacity. This is a difficult limit to quantify, and managers typically rely on historical knowledge of resource use. This historic approach will be difficult to use as increasing population pressures cause exponential increases in resource use. We do not have many reference points for estimating these carrying capacities. Contending with this threat is the very real need to identify carrying capacities for habitation in our deserts. Capacities need to be identified not only for available water resources, but for the full array of resources found within the desert.

The last general threat is one of diatribe. The rhetoric regarding resource use issues has become excessively abusive. All perspectives on these issues seem to have been, at one time or another, engaged in diatribe. If this is not accurate, it is at least a common perception.

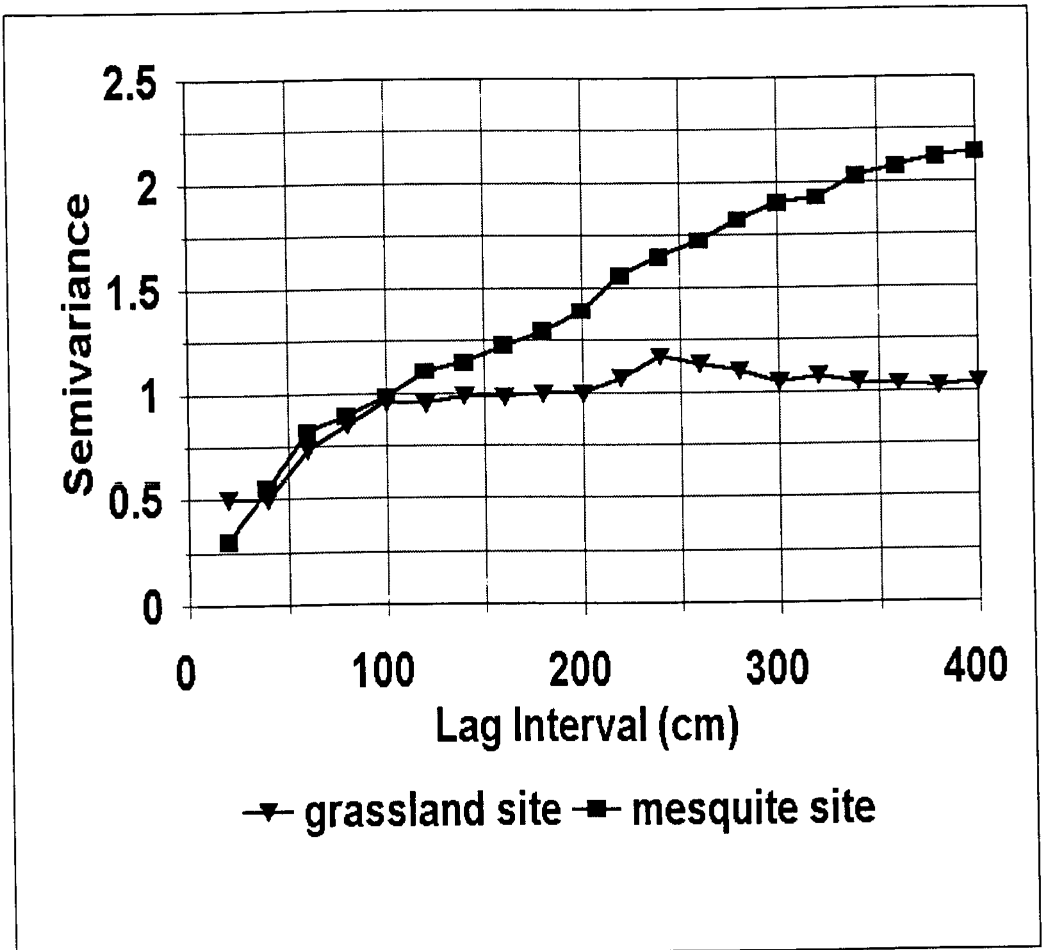

Figure 3. Semivariograph for nitrogen spatial distributions within grass and mesquite dominated sites. The relatively even semivariance for the grass site over 400 cm distances indicates a relatively homogenous distribution of N. The increasing semivariance for the mesquite with increasing distance indicates a more heterogeneous spatial distribution of N. These two sites are adjacent to each other, and the mesquite dominated site has developed on a former grassland. These data are adapted from Pilmanis and Schlesinger (1996).

Unfortunately, there are relatively few people involved in debates about stewardship of our deserts. Realistically, more people will probably attend a sports convention in Tucson some weekend to trade baseball cards than will ever read articles within these proceedings. Thus, diatribe becomes even a larger threat when few people are even engaged in a discussion. We must get past this threat. It is important to argue convictions, but it must be recognized that there are numerous valid and different convictions regarding conservation of our deserts. Individuals that contribute to diatribe are a major threat to effective management of these landscapes.

COMMON GROUND

Other people have recently articulated some very well thought out perspectives on common ground. In particular, Brown and McDonald (1995) have argued for staking out a position at a radical center. Pivotal to this perspective is the philosophy that maintaining and improving the health of these deserts requires keeping rural people on the land. But this use must be balanced with a thorough knowledge of the ecological needs of the desert grasslands. Management is an active, participatory process. Our scientifically based perspectives on deserts have matured today to the point that we understand that abandoning the land will not restore prior conditions. In addition, prior conditions are not ecologically realistic benchmarks for future sustainable landscapes.

Our understanding of the volatile ecological dimensions of our deserts and the real threats they face should reinforce the need for common ground. Our deserts in the Southwest can be managed effectively. We have scientific institutions in place to provide objective information. We have forums for exchanging information and developing reasoned strategies for management. We need to understand what the real threats are and recognize that these problems are solvable. Our deserts, including the grasslands of the Chihuahuan Desert, provide crucial resources for our future and we are in position to find consensus strategies for their management.

One final perception on common ground that surfaces from a review of the dimensions and threats to these desert grasslands is the complexity of these ecosystems. This complexity cannot be easily communicated. Yet, these deserts will continue to provide crucial resources to a significant portion of this region's human population. It is important that we not oversimplify our understanding of this system in our attempts to communicate our knowledge to interested segments of our society. Solutions to today's problems are generally not simple, and we should not create false expectations.

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