Introduction

Domestic livestock have been in the Chihuahuan Desert for more than five centuries. Domestic cattle, sheep, and goats did not evolve on the semidesert grasslands and opposition to their grazing stems largely from real or perceived detrimental impacts to plants, animals, soil conditions and overall watershed condition (Fleischner 1994 and Jacobs 1991).

The foundation for livestock grazing is based on the conversion of herbage to food suitable for humans through the ruminant animal. Livestock grazing can be ecologically as well as economically sustainable (Holechek 1992). Many livestock operators insist that it is in their best interests to maintain productive rangelands since their livelihoods and that of their heirs depend upon it (McSweeney 1995). Ranching communities form the economic back bone of many rural communities throughout the western United States.

While grazing and browsing is nearly universal in all ecosystems, livestock play a unique role since they are nearly completely under human control. Their impacts can range from almost undetectable removal of plant material to severe depletion of vegetational resources and extensive erosion.

Since livestock can have such diverse impacts on rangelands, it is necessary to include their role in any large scale management program aimed at maintaining
maximum biodiversity while considering existing economic, social and political realities in the Chihuahuan Desert. The intent of this paper is to review the historical developments, and the socio-economics of livestock grazing. The paper will also review the current status of livestock production in the U. S. portions of the Chihuahuan Desert, and the ecological role of livestock in the Chihuahuan Desert.

**History of Livestock Industry in the Chihuahuan Desert**

*Early Spanish Exploration and Settlements*

Livestock were introduced into the New World through Mexico. Large land holdings or *haciendas* were formed as the main component of livestock operations from 1530 to the 1920s (Jordan 1993, Molinar-Holguin et al. 1998, LaBaume and Dahl 1986, Wagoner 1952). The number and distribution of livestock throughout the New World during this 500 year period is poorly documented. The Mexican Revolution of 1910 resulted in a series of land reforms whereby the *haciendas* were broken up and communal farms, called *ejidos*, were formed. Under the *ejido* system several families were assigned to the *ejido* and their support was dependent on agricultural income from the land. In spite of the various land reforms since the 1920s, some Mexican families were able to maintain fairly large, private land holdings.

Spanish explorers such as Cortez and Coronado brought livestock into what is now the U.S. portion of the Chihuahuan Desert during the 1500s (Schickedanz 1982). Father Eusebio Kino is credited with introducing livestock into what is now southeastern Arizona, in 1691, to support the missions he established (Bahre 1995). By 1680, over
9,000 head of cattle grazed along the Rio Grande near El Paso (Jordan 1993). These cattle were probably associated with the Spanish missions of the area. Only 5,000 head of cattle were reported in the entire state of New Mexico in 1850. Livestock numbers in New Mexico were never as high as during the expansion of the industry following the Civil War, approximately 1862-1893 (Schickedanz 1980). In Texas, most livestock operations prior to 1820 were present in eastern Texas and the productive coastal areas on the Gulf of Mexico. Texans from these regions eventually expanded into the Big Bend and Trans Pecos regions (Jordan 1993). Expansions into southern New Mexico and Arizona occurred later (around 1850 and again, following the Civil War, in 1862).

**Westward Expansion After Civil War**

The major expansion of livestock into the Chihuahuan Desert in the U. S. occurred after 1862 (Schickedanz 1980 and Wagoner 1952). Development of the livestock industry in southern Arizona and New Mexico was fueled by gold discoveries in California, the need for beef to feed soldiers in military forts built to protect settlers from native Americans, and the development of the rail system which provided access to eastern beef markets. By 1879, cattle prices were as high as $15.39 per head and had increased to $23.52 by 1884 (Crouch 1989).

In addition, land disposal acts such as the Homestead Act (1862), and later the Enlarged Homestead Act (1909) and the Stockraising Homestead Act (1916) provided individuals with title to the land provided prescribed conditions were met such as making improvements and living on the land (Holechek et al. 1998). In most cases these acreages were insufficient to provide an economically viable livestock operation due to low
producing soils and climate conditions. Consequently, it was necessary to combine several homesteads to include sufficient land for a family to make a living.

**Concern About Heavy Livestock Grazing**

The influx of cattle to the U.S. portion of the Chihuahuan Desert after the Civil War often resulted in heavy grazing pressure on these fragile rangelands. There were several reasons for heavy stocking during this period. Much of the range was “open”, not fenced or controlled, and restrictions were few. The range was grazed as a commons and there was little incentive for conservative grazing: forage went to those who had their livestock there first (Hardin 1968 and Hardin and Baden 1977). In addition, early ranchers were accustomed to more productive areas of east Texas or the mid West and probably overestimated the productive capacity of desert rangelands. There was little experience or knowledge of the long-term consequences of heavy stocking in this region of unpredictable rainfall. In New Mexico, cattle numbers peaked in the late 1800s and again about 1920 (Figure 1). In the southern counties of Arizona, cattle numbers also peaked at these two times (Figure 2). Bahre (1995) showed that cattle numbers peaked in 1900 in Pima, Cochise, and Santa Cruz Counties in Arizona. He reported that 150,000 head of cattle likely grazed in Pima County, Arizona in 1890 compared to less than 60,000 after World War II.

Early botanists and foresters became alarmed about rangeland conditions in southern New Mexico and Arizona near the turn of the century. Wooton (1908) wrote that "Examination of the range shows it to be run down and not nearly as productive as it might be and as it once was”. Thornber (1910) warned of dire consequences of heavy
stocking in Arizona. He estimated that stocking was about double the appropriate carrying capacity of the rangeland. Many range scientists recognized that considerable range deterioration occurred during this period of uncontrolled grazing (Blaisdell and Sharp 1979, Krueger 1988, Laycock 1994, and Miller 1994). Rangeland deterioration due to heavy cattle grazing was probably not evenly distributed across the landscape, however, specific case studies in the Chihuahuan Desert from this period are lacking.

Conservation Movements

Concern over deteriorating conditions of many western rangelands convinced the U.S. Congress to investigate. The result was a comprehensive study conducted by knowledgeable scientists and managers and publication of Senate Document 199, titled "The Western Range." This document led to passage of the Taylor Grazing Act whereby remaining portions of the public domain came under control of the Bureau of Land Management in the Department of Interior (Fairfax 1984). To foster sustainable grazing practices, both the BLM and the U.S. Forest established seasons of grazing and stocking rates for those granted grazing permits.

Setting and Background for Livestock Production

Ecological Setting

Several characteristics of the Chihuahuan Desert influence livestock production practices in major ways. First, the climate is extremely variable in time and space. Range vegetation (grasses and other herbaceous plants) grows mainly during the summer
hot season when precipitation reaches a peak. During other times some plant species provide forage for livestock, but they are less reliable than perennial grasses. Long-term precipitation records (50-60 years) at several locations in southern New Mexico varied from 5.9 to 23.2 inches annually. In southern Arizona the documented variation ranges from 4 to 21.4 inches annually (Nichols et al. 1996) (Fig. 3). Interspersed within these yearly variations are periodic droughts. Tree-ring records indicate droughts from 1667-81, 1730-1750, and the recent drought of the 1950s (Betancourt et al. 1993). After the drought of the 1950s, perennial grasses recovered on shallow soils but did not recover on deep, sandy soils (Herbel et al. 1972 and Herbel and Gibbens 1996).

Not only is precipitation in the Chihuahuan Desert extremely variable, it is also low, resulting in low plant production. Comparative studies of North American grasslands reveal that Chihuahuan Desert grasslands have the lowest plant productivity of any U. S. grassland except for some Palouse grasslands in the state of Washington (Lauenroth 1979, Sims and Singh 1978). Paulsen and Ares (1962) reported that biomass of perennial grass never exceeded 700 lbs/acre and was as low as 150 lbs/acre on the Jornada Plain between 1939 and 1953. Pieper and Herbel (1982) reported that plant standing crop varied from 582 lbs/acre during a year with high precipitation to 281 lbs/acre during a year with low precipitation. Low production means that livestock operators need extensive rangeland holdings for an economic unit and must maintain a flexible operation. Part of the flexibility probably means conservative stocking to minimize financial emergencies, such as purchasing hay, during drought (Martin 1975).

Stocking rates of about three animal units yearly per “section” (which is 640 acres, or 1 mile x 1 mile) in southern New Mexico resulted in average utilization of 25%
of the perennial grasses (Beck 1978). This is a conservative stocking rate and seems to cause minimal impacts to soils, plants, and other animal species. An animal unit is usually a 1000 pound cow or her equivalent, such as 5 sheep or 8 goats). In southern Arizona, Reynolds and Martin (1968) reported that a stocking rate of 4 animal units per section on a year-round basis resulted in 40% utilization of grass species. The higher utilization caused by one cow indicates that the carrying capacity, or grass production, in the Arizona site, was substantially less than the New Mexico site.

The basic vegetational change during the past 150 years has been one of increasing shrublands at the expense of grasslands. Grasslands shifted into shrublands on the Jornada Experimental Range from 1958 through 1963 (Table 4). A number of factors may be involved in these changes: direct effect of defoliation by livestock on perennial grasses, which leaves the grasses vulnerable to competition from shrubs; dispersion of shrub fruits and seeds by livestock in their feces; influence of native small grazing mammals such as jackrabbits; climatic change and variability; increasing atmospheric CO2 concentrations; reduction in wildfire frequency and intensity; and several other possible mechanisms (Allred 1996, Archer 1994, Betancourt et al. 1993, Brown and Heske 1990 Buffington and Herbel 1965, Conley et al 1992, Gibbens et al. 1993, Grover and Musick 1990, Humphrey 1958, Johnson et al. 1993, Neilson 1986, Paulsen and Ares 1962, York and Dick-Peddie). It is likely that several factors were involved in these change from grassland to shrubland, and perhaps different ones occurred at different times and places (Pieper 1996a, 1996b).

The ecological characteristics of the Chihuahuan Desert might suggest that livestock grazing is not a viable use here. However, these environments offer certain
advantages for livestock production if sufficient area is available to support economic units (sufficient income to support a family). Desert rangelands provide nutritious forage on an annual basis. Because some green feed is usually available throughout the year, supplemental feeding can be minimized. Snow cover does not prevent livestock from reaching forage. Parasites and disease are not important constraints for livestock production as in more humid climates. In addition, conservative livestock grazing appears to be ecologically sustainable for relatively long periods of time (Pieper et al. 1992). Long-term studies on the Jornada Experimental Range and the Chihuahuan Desert Rangeland Research Center shows that herbage production could be maintained for periods as long as 50 years under conservative stocking.

While a number of factors shaped the current status of Chihuahuan Desert rangeland, a comprehensive evaluation of range conditions is not available. In the United States, range condition has traditionally been evaluated on an ecological basis - how far the present vegetation deviates from the perceived “climax” which is the vegetation composition before settlement by Europeans (Dyksterhuis 1949). No comprehensive survey of rangeland conditions or status has been made for the Chihuahuan Desert using this ecological basis, however, the Society for Range Management (1989) summarized the data available for the states of Arizona, New Mexico, and Texas. These data indicate that rangelands are in several ecological categories. Much of the BLM, private and Indian Land is below excellent condition, but this classification does not indicate how well the present condition meets needs of specific uses (Table 1).
Grassland might occur under certain environmental conditions, but that when shrub density became high enough a threshold is passed and grassland would not return without direct intervention (brush control, grass seeding, etc.) (Archer 1989).

Two independent efforts incorporated these concepts in range condition classification (Busby et al. 1994 and RISC 1995). These reports suggested the use of terms such as healthy, at risk, and unhealthy (Busby et al. 1994) and satisfactory and unsatisfactory (RISC) depending on whether or not the present status of the site met criteria for the desired situation. These terms replaced the value-laden stages excellent, good, fair and poor used in the older system.

Federal land management agencies such as the Natural Resource Conservation Service (formerly SCS), Forest Service, and BLM have embraced these concepts. The NRCS is in the process of revising their range site guides to conform to ideas of multiple states for each range site rather than a single climax state.

One study in the Chihuahuan Desert in southern New Mexico indicated that plant species diversity was often higher under grazing compared to areas inside exclosures (Table 2). Detailed analyses indicated that plant species diversity is a function of length of time an area has been subjected to livestock grazing (Milchunas and Lauenroth 1988, 1993). These studies suggest that for semiarid rangelands, with short grazing history, plant diversity increases slightly as grazing intensity increases and then declines sharply. On areas with a long history of livestock grazing, plant species diversity declines gradually as grazing intensity increases.

Data on Mexican rangeland conditions and status are not available. However, observations by trained observers indicate that heavy livestock grazing has resulted in
deterioration throughout the Chihuahuan Desert regions (Buller et al. 1960, Soltero-Gardea and Negrete-Ramos 1997, Molinar et al. 1998). Chapela (1996) stated that "arid rangelands in Mexico suffer from a degradation process where overgrazing results in less vegetation cover, less water infiltration and soil runoff, less forage production, more overgrazing and so on." There is some indication that deterioration may be greater on ejidos than on private ranches, but exceptions probably occur (Molinar et al. 1998).

**Economic Setting**

In the western U.S., livestock ranches are generally large, often comprising tens of thousands acres. Investments for a minimal economic ranch operation (300 unit breeding herd) is more than $750,000 (Workman and King 1982). In southwestern New Mexico, average investment per animal unit year was $3,300 (Torell et al. 1998). Often net returns are negative for a given year depending on feed costs, weather variables, and livestock prices. For example, in 1996 medium-sized ranches in southwestern New Mexico showed a -6.44 % return on investments (Torell et al. 1998). Historically, return on investments has been low for public land ranchers (about 2% without consideration of land appreciation) (Fowler and Torell 1987 and Workman 1986). Fowler and Gray (1988) reported negative net returns to operator labor, management, and total capital for New Mexico ranchers for three out of twenty years between 1950 and 1969. In Texas, return to land, labor, management and risk was over $11,000 annually for a 100 cow-calf unit and $15,000 for a 100 cow-yearling operation (Sharp and Boykin 1967).

Many ranchers in New Mexico and Arizona lease grazing land from federal or state agencies. For example on medium-sized ranches in southwestern New Mexico,
42% of the grazing land was private, 40% state leased land, and 18% leased from the Bureau of Land Management (Torrell et al. 1998). In Texas most rangeland is in private ownership.

In New Mexico, variable costs for medium-sized ranches in the southwestern portion of the state, were $42,800 annually compared to $23,086 in fixed costs (Torell et al. 1998). The largest item of fixed costs was equipment depreciation of over $10,000 per year. Purchased feed costs (hay, grain, liquid feed, protein supplements, salt and minerals) were the largest variable cost items (over $23,000 annually). In contrast, grazing fees for state and BLM lands were less that $5000 annually. Costs for small and large ranches were proportionately smaller and larger than those for medium ranches (Torell et al. 1998).

Two rather recent changes in ranching in the U.S. portions of the Chihuahuan Desert have impacts on livestock operations here. The first is change in ownership from those depending on ranch income for their livelihood to absent owners (termed “gentlemen ranchers” by Fowler and Torell (1987)) who do not depend upon the ranch for main income and may only use ranches as an income tax advantage or for recreational purposes. An example is the purchase of the Ladder and Armendariz Ranches in central New Mexico by the millionaire Ted Turner. Mr. Turner has removed livestock from these ranches and introduced bison. These ranches are to be operated on a commercial basis with bison as the product and not livestock.

The second trend is part-time ranchers. Seventy five percent of small ranches in New Mexico have people working off the ranch contributing 44% of the family income. For medium ranches, 55% have family members working off the ranch, contributing 20%
of the family income (Fowler 1994). Ranch income has declined to the point where it is not possible to make sufficient income to support a family.

Another factor in livestock ranching has been a recent decline in ranch values (Torell and Kincaid 1996). Ranch values increased at a steady rate during the 1950s and 60s, accelerated sharply during the 1970s and then declined as much as 30% between 1982 and 1987 in New Mexico (Torell and Doll 1991). Initially ranch values were determined mostly by estimated grazing capacity with little distinction between private and leased grazing permits. A ranch was valued based on total grazing capacity. Thus, ranchers were reluctant to reduce the permitted numbers on their state or federal grazing lease since this reduced the value of the ranch. However, during the past 10 years leased state or federal grazing lands have had a ranch market value of about 20 to 40% of deeded (private) land. In Texas, with essentially all private land, market forces have determined ranch value.

Social Setting

Ranching has a long history in the Chihuahuan Desert beginning with the haciendas established in Mexico in the 1500s and 1600s. In the southwestern U.S., ranches were established during the 1800s with major expansion after the 1862. These ranches represented a rural way of life and often supported local communities. In New Mexico, the average rancher spends over $16,000 annually for local goods and services (Fowler 1994). With multiplier effects these expenditures represent substantial contributions to the economy of these rural communities (Beutler 1992).
Ranchers contend that they are good stewards of the land, and contribute to wildlife habitat through water developments and “range improvements” such as grass seedings or shrub eradication. These ranchers have a strong interest in maintaining sustainable livestock operations for their heirs.

During the last several decades people without livestock backgrounds have invested in ranches. The ranch may be a financial investment, or used for tax purposes, or simply purchased for its open spaces and esthetic values.

In addition to those who use Chihuahuan Desert areas for commercial enterprises, there are many who have other interests. These include off-road vehicle enthusiasts, hikers, hunters, and bird watchers. The main concern of some of these groups is access to the land and restrictions on use of fragile desert areas may not be supported.

While some would argue that ranching in the Chihuahuan Desert is not economically viable, ranchers would counter that their main concern is not necessarily economics per se. McSweeney (1995) found, after interviewing 18 ranchers in northern New Mexico, that the main reason for these ranchers staying in the ranching business was satisfaction with the life style. The same reason may prevail for Chihuahuan Desert ranchers. Favorable economic return was secondary.

**Political Setting**

As mentioned, the Taylor Grazing Act established what was to become the Bureau of Land Management. In 1976, the U.S. Congress passed the Federal Land Policy and Management Act, an Organic Act for the management of public lands under the BLM. FLPMA, as the Act became to be known, provided that "the public lands be
managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use.”

Another congressional act in the U.S. was the National Environmental Policy Act of 1969. This act required preparation of Environmental Impact Statements or Environmental Assessments for every BLM activity on the land. Resource Management Plans are now used to guide activities on the public lands.

These and many other acts present regulations for ranchers and agencies to follow. Many rancher groups argue that land should be controlled locally and not from the nation's capital or by those not directly connected to the land. Disputes have been common between ranchers and land management agencies, between ranchers and environmental groups, and between environmental groups and land management agencies.

**Current Debate**

The current debate about livestock grazing in the Chihuahuan centers around grazing impacts. The basic argument is that livestock remove plant material during the grazing process and the grazed plants have a reduced competitive ability (Caldwell 1984 and Pieper 1994). Thus palatable plants gradually decline in abundance and less palatable plants tend to increase. Often less palatable plants are shrubs or other undesirable forage plants. Eventually, under continued heavy stocking, even some of the
unpalatable plants are grazed and erosion accelerates. Fleischner (1994) reviewed grazing studies in the western U. S. (including three in Chihuahuan Desert locations in Arizona and New Mexico) and concluded that "The ecological costs of this nearly ubiquitous form of land use can be dramatic. Examples of such costs include loss of biodiversity; lowering of population densities for a wide variety of taxa; disruption of ecosystem functions, including nutrient cycling and succession; change in community organization; and change in the physical characteristics of both terrestrial and aquatic habitats." Later Brown and McDonald (1995) disputed many of the conclusions made by Fleischner, stating "We detect a dangerously one-sided presentation of data and opinions on livestock grazing...." In the southwestern U.S., results of exclosure studies have presented somewhat variable results (Table 3). In some cases, density of grasses was higher under protection and in other cases under livestock grazing. The problem with such studies is that we seldom know the grazing pressure just outside the exclosure where vegetational measurements are made. At least these studies suggest that livestock grazing may not be detrimental in the Chihuahuan desert. Three long-term grazing studies in the Chihuahuan Desert in southern New Mexico (one nearly 50 years and the other one nearly 40 years) suggest that conservative livestock grazing is sustainable (Pieper et al. 1992).

Much of the current debate in the southwestern U. S. centers on riparian systems. These systems tend to attract both livestock and people. Livestock concentrations have been blamed on deterioration of riparian. Federal judges have upheld requests from environmental groups to fence riparian areas from livestock grazing. Although detailed studies comparing vegetation on grazed and ungrazed riparian areas are lacking for the
Southwest (Bock et al. 1993) studies in other regions have linked heavy livestock concentrations with degraded riparian habitats (Chaney and Elmore 1993 and Fleischner 1994). Limited studies in southwestern New Mexico indicate that cattle do not prefer riparian areas during all seasons. Near Fort Bayard, NM, on the northern edge of the Chihuahuan Desert, cattle spent 95% of their time in upland areas and only 5% of their time in riparian areas during the dormant season (Goodman 1987). These data suggest that control of grazing on riparian areas could minimize detrimental impact of grazing on these important areas.

**Grazing Fees**

Another controversial subject on public lands in the U.S. has been grazing fees charged to livestock operators for grazing privileges. Grazing fees have been set by a formula based partly on livestock prices, grazing leases on private land and costs of beef production (Torell et al. 1995). Opponents of livestock grazing on public lands argue that these fees are much lower than comparable fees on private lands and therefore public land ranchers are being subsidized. Ranchers counter that public land grazing permits do not include many amenities routinely included in private leases. Detailed analyses by several economists in the western states indicated that perhaps current fees are slightly undervalued, but the problem is complex and determining fair fees is not an easy task (Torell et al. 1992, Torell et al. 1995).
Endangered Species Management

Management of endangered species is another problem on U.S. rangelands. According to the Endangered Species Act, endangered species and habitats must be protected. In many cases livestock grazing is identified as the main threat for endangered species. An example in Arizona and New Mexico is the southwestern Willow Flycatcher that inhabits riparian areas. Environmental groups have listed current and historic livestock grazing as one factor responsible for low population densities. On the other hand rancher David Ogilvie reported that nest densities, number of young and adult birds were higher on grazed riparian areas on the U Bar Ranch in southwestern New Mexico than on comparable protected areas (Ogilvie 1998). Apparently, necessary habitat components for the flycatcher (e.g. willows and cottonwoods) could be maintained under the grazing regime practiced on the ranch.

Some areas of public ranges have been grazed by the same family for several decades. These ranchers view livestock grazing as a "right" and not a privilege. Such contentions fly in face of the idea that public lands belong to all the people and all have a "right" to enjoy and use these lands.

Conclusion – A Plea For Planning at Coarse Scales

Vegetational patterns in the Chihuahuan Desert are complex with a variety of plant communities occurring on different soils and topographic positions. Plant species diversity is different for each of these communities. Animals also correspond to vegetational patterns. In the Chihuahuan Desert planning at the landscape level would entail determining goals for size and arrangement of grassland, mixed grass-shrub, and
shrubby communities. Each of these communities support a unique assemblage of animals although there may be overlap and use of more than one community by some species. Biodiversity might best be served by creating mosaics of vegetational patches of different shapes and sizes. Livestock at low densities could play a role in maintaining some of these patches, could be neutral or contribute to large degraded states. Such planning might involve passive restoration of some plant species in the mix to favor certain animal species and to increase vegetational diversity or reduction in density and size of others (Fulbright 1996). The key is to manage habitats and species will follow.

**Literature Cited**


Ogilvie, D. 1998. The southwestern willow flycatcher and me. The Quivera Coalition Newsletter. 2:1,18-19. The Quivera Coalition, Santa Fe, NM.


Society for Range Management. 1989. Assessment of rangeland condition and trend of


Tucson, AZ.


permits and the grazing fee dilemma. New Mex. State Univ., Agr. Exp. Sta. RIFT
Rep. 31.

and J. Coen. 1995. The value of public land forage and the implications for

726.


rangelands not in equilibrium. J. Range Manage. 42:266-274.

