VEGETATION CHANGES ON ARID RANGELANDS OF THE SOUTHWESTERN UNITED STATES

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HIGHLIGHT

Vegetation changes on arid rangelands of the southwestern United States in the last 100 years are described. Reasons and solutions to the problems resulting from these changes are discussed. Shrubs have increased dramatically with a corresponding reduction of herbaceous plants. Encroachment of woody plants into previously shrubless areas is closely correlated with man's activities combined with drought. Man has been a disturber of natural systems and his ability to create disturbances has increased as technology has increased. Increased use of arid rangelands of the southwestern United States is possible with intensive practices such as brush control, revegetation where needed, and improved grazing management.

Change, an inherent characteristic of ecosystems, is a recognized feature of vegetation in the arid and semi-arid portions of the southwestern United States. Parts of Arizona, New Mexico, and Texas are included in this review. Territorial surveys in the 19th century (e.g., Buffington and Herbel 1965, York and Dick-Peddie 1969) and terrestrial photography in the 19th century and early 20th century (e.g., Hastings and Turner 1965, Martin and Turner 1977) have been used to establish a base for vegetation conditions and then for recording variations from this base. All evidence indicates a dramatic shift from a high proportion of grassy vegetation to one dominated by shrubs in the last 50-100 years. This paper describes these changes, and attempts to discuss the reasons and solutions to problems resulting from these changes.

CHANGES

There is little doubt that shrubs were invading grasslands slowly before man's influence as evidenced by small pockets of shrubs. With the increase of man's activities in the late 19th and 20th centuries, there has been a rapid increase of shrubs.

Vegetational history would indicate a slow drying of the Southwest since Tertiary with some intervening pluvial periods (Axelrod 1979). Wells (1977) showed that some of the more xerophytic species, such as creosotebush (*Larrea tridentata*), either entered or re-entered the Chihuahuan Desert Region during the Holocene, after having survived the Wisconsin glacials elsewhere.

Populations of native Indians and herbivores varied in prehistoric times, primarily in response to climatic factors (Martin 1975). Expansion of Spanish ranching operations from northern Mexico into Arizona, New Mexico, and western Texas probably reached its peak about 1830. Nearly all of the ranches established during this time were abandoned by 1846 when the United States came into possession of the southwest. Many of the livestock from these operations were abandoned when the Spanish settlers left. Only small numbers of cattle were present in the southwest by 1870. However, movements of cattle from Sonora and south Texas rapidly increased in the 1880's. Severe droughts in 1891-92 resulted in high starvation rates of cattle (Martin 1975).

Hastings and Turner (1965) reported that the current arroyo cutting cycle and the initiation of dramatic vegetation changes in the southwest began about 1890. This coincides with a warming and drying trend (1875-90), and heavy livestock use. Rangelands in New Mexico and southern Arizona were seriously depleted as a result of prolonged overstocking before 1900 (Wooton 1908, Griffiths 1901).

Woody plants were present under pristine conditions but they rarely migrated from very specific sites into grassland communities. Formerly restricted primarily to the waterways and drainages or occurring as scattered individuals, woody plants now form an almost continuous cover over large parts of the arid and semi-arid rangelands of the southwest. Table 1 shows the rapid increase of shrubs from 1858 (livestock water was developed about 1900) to 1963 on 58,500 ha of the Jornada Experimental Range in southern New Mexico (Buffington and Herbel 1965). The relatively recent occupation of grasslands by shrubs should be attributed to increases in the stature and cover of woody species, and a limited expansion of their distribution, generally within an ecosystem (Johnston 1962).

Table 1. Vegetation changes (area dominated) on the Jornada Experimental Range (from Buffington and Herbel 1965)

Species	1858	1963
	%	
Honey Mesquite (*Prosopis glandulosa*)	4.8	50.3
Creosotebush (*Larrea tridentata*)	0.4	14.2
Tarbush (*Flourensia cernua*)	0.4	8.6

Man and his activities influenced mammalian distribution in the Chihuahuan Desert (Schmidly 1977). Of the detrimental influences, overgrazing by domestic livestock has destroyed optimal habitat for some species. Man kills some mammals both for food and recreation. In some cases man improved habitat conditions for certain mammals. The construction of rock fences, water development, introduction of new plants, and reduction of some predators and other pests are examples of the latter.

Photographs of velvet mesquite (*Prosopis juliflora* var. *velutina*) stands in southern Arizona indicated that they will not decline due to natural causes as occurred with burroweed (*Haplopappus tenuisectus*) and jumping cholla cactus (*Opuntia fulgida*) (Martin and Turner 1977).

The Arizona chaparral was more open prior to livestock grazing in the 1870's than it is today (Bolander 1981). The heavy, yearlong grazing depleted the perennial grasses. Introduced annual grasses and forbs largely replaced the native perennial grasses that grew in openings between shrubs and as under-story plants. Suppression of fires has resulted in thicker stands of shrubs in recent years.

Chaparral is maintained by instability, such as fire, flood, or erosion (Vogl 1981). Increasing site stability allows chaparral to be replaced by woodland, savanna, or grassland depending upon the degree of stability, frequency of fire, and location.

REASONS

Man's mobility and agricultural activities make him the single most influential factor in the dispersal of plants. Also, man is a disturber of natural systems, and his ability to create disturbances has increased as technology has advanced. A high value was placed on grazing lands for settlement purposes (Scifres 1980). Encroachment of woody plants into previously shrubless areas is closely correlated with the intensification of the activities of modern man (Scifres 1973). 'People pressure' has complemented fluctuations in climate and local weather allowing increases in cover of shrubs. Before the influence of white man, the mobility of native grazers naturally deferred grasslands during dry periods. Today, fences restrict the movement of grazing animals, making grazing management a part of man's responsibility (Herbel 1982). Thus, man is the primary biotic factor that determines the fate of the earth's natural resources.

Some influences of man in changing the plant cover of grasslands include:

1. Restriction or elimination of naturally occurring fires where fuel is adequate. Fires were not an important factor in reduction of shrubs in arid grasslands because there was insufficient fuel (Buffington and Herbel 1965). Where there is sufficient fuel, fires will kill some plants.
2. Attempts to cultivate lands unsuited for crops.
3. Continual grazing pressure on grasslands by an increase in the number of grazers and timing of grazing use.
4. The increased mobility of man and his domesticated animals which has resulted in greater seed dispersal. The propagules of several unwanted shrubs (e.g., mesquite (*Prosopis glandulosa*), *Larrea tridentata*, and tarbush (*Flourensia cernua*)) have been widely distributed within ecosystems in the southwestern United States and await only the proper environmental conditions for establishment.

All these factors must not be eliminated, but recognized as causal ingredients for vegetation changes.

Great weather fluctuations have been present in the Southwest for centuries. These perturbations cause tremendous vegetation changes (Herbel et al. 1972), even in the absence of livestock grazing. The constant, very slow warming trend of the climate, coupled with livestock grazing, increased desertification.

Man's perturbations have reduced livestock production from most of the world's rangelands. Climax vegetation on rangeland is based largely on conditions prevalent before man's intervention. Is there a grassland climate? I propose the following sequence for humid and subhumid grasslands:

Forest + fire (man) = grassland; grassland — fire = forest

On arid and semi-arid grasslands we have:

grassland + heavy grazing (man) + drought = desert

The following prevails:

Good condition range → poor condition range = weeds + erosion

Removal of a moderate amount of plant material, by grazing or fire, prevents stagnation of desirable plants.

SOLUTIONS

Range is a biological system and physical laws do not always apply. We must use a holistic approach to the management of rangeland. We must consider the relations among weather, soils, plants (native and introduced), and animals (native and introduced). Pristine conditions should not be confused with site potential. Secondary succession is very slow or non-existent on arid rangelands of the southwest.

Because the increase of unwanted shrubs in the southwest is irreversible, we must prescribe a remedy that is to man's benefit. This might include a combination of some of the practices used in range management (Herbel 1983). Shrubs are more efficient in the use of environmental resources than herbaceous plants. Therefore, a positive approach is needed to replace unwanted plants with those that are more useful to man. Useful, but expensive, practices may include: 1) mechanical, chemical, and/or biological control of unwanted plants, 2) fires to control unwanted plants where fuel is adequate, 3) revegetation to replace unwanted plants with useful plants, and 4) introduction of additional species of animals to use the range ecosystems more efficiently.

Man introduced a 'shock' treatment when he colonized a fragile environment in the 19th and 20th centuries. Therefore, a drastic treatment, such as brush control, is required to increase the stand of desirable herbaceous plants. Following brush control, improved grazing management will maintain or prolong a sparse cover of unwanted shrubs for sustained livestock productivity of rangelands of the southwestern United States. Revegetation may be necessary in selected areas without a remnant of desirable plants or where man desires change in plant composition.

History indicates, and present demography dictates, an increase in intensification in use of agricultural lands. Man must take a positive approach to maintain or improve production from rangelands.

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DEVELOPMENT AND STRUCTURE OF SAGEBRUSH STEPPE PLANT COMMUNITIES

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HIGHLIGHT

Data spanning more than three decades indicate that succession on sagebrush-dominated rangelands does not proceed in a deterministic, directional manner to some climax composition. Through time, there is stability in terms of what species are present, but the relative abundances of those species vary unpredictably. As a result, community structure differs widely among stands.

Most observers agree that recovery from overgrazing may be very slow for arid or semi-arid ecosystems, but range scientists often assume that succession to a stable climax community is inevitable in the absence of further disturbances (e.g., Stoddart et al. 1975, Huschle and Hironaka 1980, Passey et al. 1982). This paper examines 33-year trends in vegetation development on sagebrush steppe rangeland in south-eastern Idaho, U.S.A., after release from grazing. The results suggest that the traditional model of range succession is not useful for interpreting vegetation change within time frames of importance to range managers. An alternative point of view, based on the concept of inertia, is proposed.

STUDY AREA

Over 1700 km^2 of cold-desert rangeland on the upper Snake River Plain were withdrawn from public use in 1950 for the placement of nuclear facilities. The area, at an elevation of about 1500 m, lies in the rain shadow of mountain ranges to the west; mean annual precipitation is 21 cm. Average annual temperature is about 5.5°C; the frost free period averages 91 days. Soils are mostly shallow, calcic *Aridisols* of eolian origin lying over basalt.

The vegetation is heavily dominated by *Artemisia tridentata* (big sagebrush). Other common shrubs include *Chrysothamnus viscidiflorus* (green rabbitbrush), *Atriplex spinosa* (spiny hopsage), *Ceratoides lanata* (winterfat), and *Tetradymia canescens* (horsebrush). Perennial grasses, such as *Sitanion hystrix* (bottlebrush squirreltail), *Oryzopsis hymenoides* (Indian ricegrass), *Stipa comata* (needle-and-thread), and *Agropyron dasystachyum* (thick-spiked wheatgrass), typically dominate the understorey.

The grazing history of the study area was not well documented, but much of the area had been grazed by sheep and cattle since the late 1800's. Harniss and West (1973) concluded that the area was severely overgrazed prior to 1950. The low cover of perennial grasses in 1950 (see Results) supports that conclusion.

METHODS

Permanent vegetation plots were established at the study area in 1950. This analysis is based on data from 35 of those plots representing relatively homogeneous vegetation (see Anderson and Holte 1981 for details). These plots have been free from livestock grazing or major disturbances since 1950. Crown cover of shrubs and basal cover of perennial grasses were measured by line interception in 1950, 1957, 1965, 1975, 1978, and 1983. Forb cover was not estimated in the original sampling design and therefore could not be included in the trend analyses. However, forbs are relatively minor