Name: George P. Ellis Date of Degree: July, 1967

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Title of Study: FACTORS INVOLVED IN THE INVASION OF WOODY SHRUBS AND RESTORATION OF THE RANGE IN THE DESERT GRASSLAND ASSOCIATION OF THE SOUTHWEST

Pages in Study: 22 Candidate for Degree of Master of Science

Major Field: Natural Science

Scope and Method of Study: Some of the literature concerning factors that have been associated with the deterioration, the invasion of woody shrubs, and possible restoration of range lands in the desert grassland association of the Southwest has been reviewed.

Findings and Conclusions: Overgrazing, effects of rabbits and rodents, fire or cessation of fire, competition, and change in climate appear to be the major factors involved in the invasion and deterioration of range lands in the desert grassland association of the Southwest. Restoration, in view of cost of implementing presently known to control techniques and lack of knowledge of lasting effects, does not seem to be economically feasible except, perhaps, on a moderate, graduate scale.

ADVISER'S APPROVAL L. Herbert Bruneau

FACTORS INVOLVED IN THE INVASION OF WOODY SHRUBS AND RESTORATION OF THE RANGE IN THE DESERT GRASSLAND ASSOCIATION OF THE SOUTHWEST

By

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Bachelor of Science

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FACTORS INVOLVED IN THE INVASION OF WOODY SHRUBS AND RESTORATION OF THE RANGE IN THE DESERT GRASSLAND ASSOCIATION OF THE SOUTHWEST

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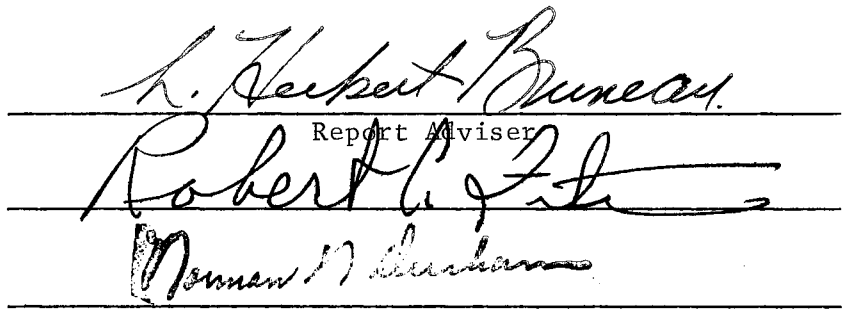

Report Adviser

Dean of the Graduate College

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CHAPTER I

GENERAL DESCRIPTION

The desert grasslands of the Southwest cover an area that extends discontinuously from southwestern Texas, through southern New Mexico, into southeastern Arizona, and South into Mexico (Humphrey, 1953). This association is bound on the West by a desert shrub community, on the North by woodland and montane associations, on the Northeast and East by mixed prairie grasslands, and on the South by the Chihuahuan Desert.

The desert grassland could be described as a semi-arid region with generally high temperature, low humidity, high wind velocity, low rainfall, and high evaporation rate. The precipitation ranges from 12 to 18 inches in the West and from 20 to 30 inches in the East (Humphrey, 1958). Precipitation occurs chiefly during two seasons of the year, summer and winter. The summer rains are usually local, torrential, and of short duration. They usually occur in the space of one to three weeks during the months of July, August, or September. The winter rains are more widespread, less torrential, and of longer duration. They usually occur during the months of November, December, or January (Whitfield and Beutner, 1958).

The following mean temperatures are averages taken from sixty years of data by Campbell (1928).

Jan.	Mar.	May	July	Sept.	Nov.
42.2	53.1	69.1	80.5	72.5	49.3

The evaporation rate ranges from more than 100 inches in the West to about 80 inches in the East with a mean as given by Campbell (1928) of 87.39 inches.

The elevation averages from 3,000 to 5,000 feet, with the lower elevation along the Pecos and the Rio Grande river basins, and the higher elevations on the slopes of the Guadalupe, Davis, and Santiago mountains.

The soils can be described as highly variable; ranging from clay to localized sand dunes. In the upland swales soil is moderately heavy.

CHAPTER II

A HISTORY OF VEGETATIONAL CHANGE

The desert grassland, originally an area of open grassland or grassland with scattered shrubs, now supports a mixture of shrubs and grasses with shrubs dominant (Humphrey, 1958). In many of the shrub-dominated areas grasses are almost non-existant.

Early Descripitions of the Vegetation

Evidence strongly suggests that there was once an abundance of grasses over the whole desert grassland region, and that shrubs at most were sparce. Gardner (1951) writes of communicating with long time residents of Socorro, New Mexico, who remember when hay was cut and baled in areas now covered with creosotebush or mesquite, and many of the washes, instead of being gullies as they are today, were clothed with grass.

According to the tombstone epitaph of May 18, 1895: "The San Simon Valley is covered with a luxuriant growth of grass and in consequence affords fine grazing." (Chew and Chew, 1965).

These accounts and others leave little doubt that areas of the desert grassland region, now covered with woody shrub growth, were once valuable range lands.

The Shrub Invasion

Desert shrubs probably always existed within desert grasslands, in the limited areas of shallow soil on the crests of hills and the lower slopes of mountains where conditions are unfavorable for grasses (Chew and Chew, 1965). These areas were evidently centers for dispersal of these shrubs, which later invaded the grasslands.

Of the shrubs that have invaded the grasslands, the invasion of creosotebush (Larrea divaricata) and mesquite (Prosopis juliflora) has been the most extensive.

According to Gardner (1951) the belt along the Rio Grande Valley which was once covered with grass now supports a cover, of which 84 percent is creosotebush, 10 percent mesquite, and the basal area of grasses is less than 0.1 percent.

Humphrey (1958) writes that the mesquite invasion now covers 70 million acres of the Southwest, half of which has taken place during the past century.

Glending (1952) states: "Several species of woody plants which are important natural constituents of desert shrub associations in the warmer and drier parts of Arizona, New Mexico, and Texas are invading and increasing in abundance on more mesic sites formerly occupied by grasslands vegetation. Within the Rio Grande plains of Texas, 15,000,000 acres of former grasslands are now occupied by a maximum invasion of subtropical thorny trees and shrubs."

As indicated by these accounts, one can conclude that these shrub communities now cover extensive areas of the desert grassland association. Creosotebush communities are found mostly on well drained, alluvial soils,

especially along the northern reaches of the Rio Grande Valley. Mesquite communities are more prominant along the southern regions of the Rio Grande Valley, and extensively occupy the sand hills area of southern New Mexico and southwest Texas. Interspersed between and among these shrub communities are other less prominant shrub communities of which the most prevalent are probably the tarbush (Flourensia cernua) community and the salt bush (Atriplex spp.) community.

The encroachment of shrubs was probably initiated, at least in part, by grazing pressure. Reduction of the more palatable grasses increases the possibility of establishment of pioneer bushes which act as nuclei around which colonies can form. As the colonies thicken, merge with others, and become incorporated in the main body, it becomes increasingly difficult to follow the process and discern the nuclei (Gardner, 1951).

As this process proceeds the environment is significantly altered. Changes in the vegetation are accompanied by the immigration of various species of small rodents which perhaps aid in the reduction or virtual disappearance of the grasses. This is followed by the eventual deterioration of the range.

Climax Vegetation

The true climax dominants of the desert grassland association as described by Weaver and Clements (1938), are grasses of the genera Bouteloua, Aristida, and Hilaria. The major dominant species are: Bouteloua eripoda, B. rothrocki, B. filiformis, B. gracilis, and B. hirsuta; Aristida divaricata, A. purpurea, A. californica, and A. arizonica; and Hilaria cenchroides. Muhlenbergia porteri is the only midgrass that belongs to this group although several others are found

in depressions or other postclimax situations. The same point of view is held by Gardner (1951) when he describes shrub dominated areas as "a grazing disclimax or stages in the primary succession".

There seems to be, however, some controversy concerning the true climax vegetation. Humphrey (1953) writes that there is considerable evidence to support the idea that the desert grassland is a fire subclimax, and that with the cessation of fire, shrubs, the true dominants, are moving in.

Brown (1950) states: "It would seem that the shrubs, rather than the grass, were natural dominants of the area, and that the grass was present because of some factor that was unfavorable to the shrubs."

This could be considered from the standpoint of the two major shrub types, creosotebush and mesquite.

Livingston (1910) describes creosotebush as, "best fitted to withstand prolonged drought".

In a study conducted in a creosotebush dominated area by Shreve and Hinkley (1937), it was found that grasses (particularly Hilaria mutica and Muhlengergia porteri) increased markedly after 20 years of grazing protection.

Gardner (1951) states: "On conservatively grazed grassland of the New Mexico Agricultural College ranch, isolated plants (creosotebush) occur in good grassland but are apparently not forming colonies." In view of this and other information it would seem that creosotebush is not a climax dominant, but rather indicative of a subclimax or disclimax.

Mesquite, even though quite tolerant of drought, seems to be somewhat more mesic than creosotebush. In the more arid regions of the association mesquite seems to be found primarily on the more mesic sites.

On a majority of the sites in the Eastern regions of the association, mesquite is the principal dominant species and has invaded regions of the great plains grassland. According to Humphrey (1952) mere grazing management and maintaining good grassland conditions are not sufficient to prevent invasion of mesquite. It would seem therefore that mesquite might be a natural climax dominant at least in some regions of the desert grassland association.

CHAPTER III

FACTORS CONCERNING SHRUB INVASION

Several factors seem to have been involved in the invasion of woody shrubs in the desert grasslands. According to Humphrey (1958) the following five factors are significantly involved; grazing by livestock, competition or lack of it, effects of rodents, changes in climate, and supression of grassland fires.

Reynolds (1950) writes: "Livestock grazing practices and climatic variations are known to affect the character and abundance of range vegetation." In some instances small mammal populations are suspected of affecting florstic composition.

Overgrazing

Very little is known about the grazing effects of the natural grassland herbivores that might have inhabited this area. General opinion is that there was very little disturbance of the vegetation by these animals except where these animals might tend to congregate such as areas around water holes.

Humphrey (1962) says that the rocky mountain elk (Cervus canadensis) show that the greatest preference for grasses that are the most palatable to cattle. There is very little evidence, however, that elk populations ever reached very high numbers in the desert grasslands. Neither have the pronghorn (Antelocarpa americana) nor the blacktailed deer (Ococoileus

hemionus) been shown to have any severe effect on range vegetation in the Southwest. Very little is known about the effects of the bison (Bison bison).

The introduction of domestic livestock has been shown to have the most severe effect with respect to overgrazing. Gardner (1951) states that throughout the area, in those places where bodies of creosotebush adjoin grassland with a history of overgrazing, the bush is advancing into the grassland.

Campbell (1928) states: "Injudicious grazing may result in transformation of grama grass (Bouteloua) range into the Prosopis sand dune type.

Dissemination of shrubs especially mesquite seems to be enhanced by livestock. Appearance of mesquite around watering places and along trails is often ascribed to animals ingesting seeds and subsequently dropping them.

Gardner (1951) mentions that "old ranchers" had related to him that in the early days it was common practice to carry a bag of mesquite pods to feed horses, much as the farmers of the Mid-west carried corn.

Over stocking and subsequent reduction of the more palatable dominant grass species serves both to disseminate and reduce competition resulting in a hastening of the deterioration of the grassland and the dominance of shrubs.

Effects of Rabbits and Rodents

Most investigators appear to agree that rodents and other small mammals are more often a result of range deterioration rather than a cause of it. Studies on jack rabbits, kangaroo rats, wood rats, and

various other small rodents seem to indicate that these animals increase as overgrazing progresses.

Once established, however, rodents seem to help perpetuate the shrub community. Norris (1950) states: "Rodent and rabbit pressure on perennial grasses reduces competition with less desirable species."

Rodents and rabbits are known to transport mesquite seeds. According to Glending (1952), the merriam kangaroo rat (Dipodomys merriami) stores mesquite seeds in the soil and these seeds often remain unexcavated and later produce seedlings.

Reynolds (1950) writes: "Detrimental effects of merriam kangaroo rat will probably be most pronounced on ranges in poor condition where density of perennial grasses is so low that most of the seed is consumed.

Effects of Fire

There is evidence to support the idea that the desert grassland is a fire subclimax. Since grasses are morphologically better adapted than shrubs to withstand the effects of fire, fire could have at least been a major factor in perpetuating grasses in a well established area.

According to Humphrey (1949), burning seems to be much more effective in killing seedlings of most woody shrubs than in killing larger more mature plants. Grazing, by removing combustible ground cover, reduces the effectiveness of fire.

The cessation of fire, associated with overgrazing, was probably a contributing major factor in the invasion of shrubs in the desert grassland.

Competition

Competition for moisture or light has long been believed by many ecologists to be one of the prime factors restricting the invasion of shrubs into grassland areas. According to Humphrey (1958), in those localities where a true grassland climax exists, competition may be important. On the other hand, where shrubs are the climatic climax its value as a controlling factor would appear to be slight.

Bray (1901) indicates that much of the brush invasion in grasslands was due to reduction of competition through breaking down of sod under continued overstocking.

Data from a study by Glending and Paulsen (1955) indicate that establishment of mesquite seedlings is markedly curtailed by the perennial grasses.

One might conclude that the reduction of perennial grass cover by overgrazing has reduced competition and probably contributed to the invasion of shrubs into the grasslands.

Change of Climate

Climate has long been assumed to be one of the chief factors responsible for the presence of a grassland type of vegetation. A change of climate could then bring about a change in the vegetation. One might be curious then as to whether or not the changes being observed in the vegetation of the desert grassland are being brought about in part by a change in climate.

Most ecologists agree that grass dominated areas are generally indicative of a less mesic situation than are shrub dominated areas.

This would indicate that an increase in annual precipitation would reduce competition for available moisture and favor shrub invasion. The invasion of mesquite could perhaps be related to this. Creosotebush on the other hand, being very drought resistant, would seemingly be favored by a reduction in annual precipitation.

Both of the previously mentioned situations have undoubtedly occurred periodically in the past. According to Humphrey (1958), however, there is no evidence that would seem to link the consistant and widespread increase of shrub species that has been taking place during the last hundred years or so in the Southwest to a change in climate.

CHAPTER IV

RESTORATION

There is little doubt that much of what was once valuable range land in the Southwest is now deteriorated desert shrub with little range value. As the demand for meat and other livestock products increase, range lands will become increasingly more valuable. Under these considerations, restoration of these deteriorated range lands to productive grasslands would be highly desirable.

Restoration if possible could prove to be very difficult. Whitfield and Anderson (1938) concluded: "The return of the vegetation from its present state to the former climax will be a series of time consuming stages of plant succession." They do indicated, however, that possibilities exist to help speed up this process.

Existing Problems

The factors previously discussed, have not only been involved in initiating the invasion of woody shrubs in the desert grasslands but together with other factors help perpetuate conditions detrimental to the reinstatement of grasses.

The reduction of ground cover due to overgrazing and troding by livestock gives rise to errosion of soil and invasion of woody shrubs. Once these shrubs become established they effectively compete for available soil moisture thus retarding the growth of grasses. Cessation of

fire associated with the removal or reduction of ground cover probably favors the maintaining of a shrub community.

There is evidence that some of these shrubs produce germination or growth inhibitors that may retard the reinstatement of desirable grass species. According to Bonner (1950), certain legume roots excrete sizable quantities of organic acids and amino acids.

In a study by Bennett and Bonner (1953) it was found that toxic extracts could be obtained from Thamnosma montana, Sarcobatus vermiculatus, Prosopis juliflora (mesquite), and Viguiera reticulata that would significantly retard or prevent germination and growth of tomato seedlings.

Knipe and Herbel (1966) conclude: "Aqueous extracts from creosotebush plant material, preparated in relatively high concentration, significantly reduced the germination of black gramma caryopses. Radicle growth of black gramma and bush muhly was greatly reduced by even the least concentration of extracts. The effects of creosotebush extracts on initial growth of black gramma and bush muhley plus the reduction in infiltration rate observed in potted soils treated with extracts could be contributing factors in the degeneration of grassland areas where creosotebush is invading."

Rodents and rabbits seem to have an effect on the vegetation that favors shrubs when shrubs are already established. Rodents are known to aid in the dissemination of seeds of certain desert shrubs and to consume considerable amounts of grass when in excessive numbers.

In light of this information, it would seem that intensive management and control measures will be required if the desert grassland is to be restored to its former value in any reasonable length of time.

Management

As Humphrey (1952) has pointed out, mere grazing management and maintaining grassland in good condition are not sufficient to prevent invasion of mesquite in the desert plains grassland. This would indicate that some type of control will probably have to be implemented before effective restoration and use of range lands in the Southwest can be attained.

Platt (1959) points out that careful consideration must be given to physical factors, cost, livestock adaptations, and conflicts of interest before a control program is put into effect.

Control of Shrubs

Carter (1958) points out that brush control has been carried out by ranchers on three million acres in south Texas. The most common methods of control have been chaining, chopping, treating with kerosene, or herbicidal sprays, and dozing. Occasionally brush work of some kind has been effective in killing mesquite only to release more obnoxious species.

The results of a study by Schmutz (1967) showed that certain desert shrubs can be effectively controlled by applications of 2 to 4 pounds per acre of 2,4-D or 2,4,5-T, 1/4 to 1 pound per acre of picloram, or 2 or more pounds per acre of fenuron or monuron. These rates mean that treatment will be high and herbicidal treatments will be economically feasible only on the better soils where an understory of grass will be released to provide large increases of forrage.

Wagle (1963), with respect to brush control, concludes: "Large amounts of fenuron are required and in terms of present cost-benefit

relationships, the cost of treatment would be prohibitive.

Platt (1959) states that the total costs of control greatly exceed the economic capacity of the range industry to undertake except on a gradual basis.

Control of Rabbits and Rodents

From evidence presented, it would seem that reduction of small rodent and rabbit populations might aid in the restoration of range lands. Norris (1950) has shown that in southern New Mexico, the pressure of rodent grazing alone may be sufficient to prevent recovery of a grass stand on low rainfall sites occupied by mesquite. He also indicated that control may involve brush removal and cattle protection for several years, both of which are costly.

Anything short of complete kill of all rodents over a large area is doubtful of value, since populations can build up rapidly from low residual numbers.

Most writers agree that neither rabbits nor rodents are of significant importance in well managed grassland areas. This seems to imply that if the brush problem were solved the rabbit and rodent problem would subsequently be solved.

Economical Implications

Restoration of desert grassland seems to be a question of economics. All presently known techniques are costly and most are associated with protection from grazing which increases the cost. Even then, as Platt (1959) points out, "no matter what control technique is applied to start with the same problem is faced in the end: How to use the area

without bringing about re-establishment of the former pest plants or take-over by other undesirables."

CHAPTER V

SUMMARY

The desert grassland association of the Southwest extends over an area from southwestern Texas, through southern New Mexico, into southeastern Arizona and South into Mexico.

This semi-arid region, originally a valuable range land dominated by highly palatable grasses of the genera Bouteloua, Aristida, and Hilaria, has been severly invaded by several species of obnoxious woody shrubs. Of these shrubs, the two most prevalent are creosotebush (Larrea divaricata) and mesquite (Prosopis juliflora).

Factors associated with the invasion of these woody shrubs seem to be primarily; overgrazing, effects of rodents and rabbits, fire or cessation of fire, competition, and change of climate.

The restoration of grasses of these bush invaded areas seems to be a complex problem which will probably involve the removal and control of shrubs, the control of rodents, and protection from grazing. Remaining, even then, is the problem of managing the range so that it can effectively be utilized without the re-invasion of shrubs.

In view of cost involved in implementing presently known control techniques and lack of knowledge of lasting effects, a large scale restoration program does not appear to be economically feasible.

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