Vegetative Changes on Protected versus Grazed Desert Grassland Ranges in Arizona

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Highlight: *Comparison of vegetative changes between a protected and closely grazed desert grassland range in southeastern Arizona showed that velvet mesquite was rapidly invading both ranges at almost equal rates. Arizona cottontop, sideoats grama, and wright buckwheat were dominant in the understory on the protected range while rothrock grama, poverty threeawns, burroweed, and annuals dominated the understory on the grazed range. The grazed range was classed in a low stage of range condition, the protected range in an intermediate stage. Without a change in treatment and management, it is postulated that mesquite will continue to increase on both ranges.*

Conservative stocking is one of the practices recommended to improve depleted desert grassland ranges to a higher state of forage productivity. The question is: How effective is conservative stocking or even complete protection without other treatment in improving desert grassland ranges?

In 1941, Haskell (1945) measured the contrast between a desert grassland range conservatively grazed since 1923 and an adjacent heavily grazed range. Haskell concluded that the conservatively grazed range was in a subclimax stage, undergoing progressive succession toward the climax.

The present study, a follow-up of Haskell's study, was designed to measure the contrast between the same two desert grassland ranges in 1969 and to interpret the effects of grazing, competition, fire, drought, soil, and time on the vegetation.

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Study Areas

The study areas are northwest of the Santa Catalina mountains in southeast Pinal County, approximately 8 miles west of Oracle, Ariz., at an elevation of 3,700 feet.

The areas consist of two half sections of land, 320 acres each. One of the half sections, a part of the Page-Trowbridge Experimental Ranch, was conservatively grazed from 1923 to 1941 and has been protected from grazing since. The other half section is part of a heavily grazed range on the east.

The areas were mapped as desert grassland by Nichol (1952) and Brown (1973). Presently the vegetation consists of an overstory of trees and shrubs, predominantly velvet mesquite,[1] and an understory of half-shrubs, perennial grasses and forbs, and numerous annuals such as filaree (*Erodium cicutarium*).

The climate of the desert grassland is characterized by low cyclic precipitation and usually high temperatures. Humidity is generally low and water evaporation from soils and surface water is high. Gusty winds accentuate drought conditions in early summer before the summer rainy season begins.

Comparison of longterm rainfall records for Oracle, Ariz., and short-term records on the Page-Trowbridge ranch, indicate that precipitation at the study site averages 15 to 16 inches per year (Haskell, 1945). Approximately half of this precipitation falls during the summer and half in the winter (Smith, 1956). Summer precipitation comes from the Gulf of Mexico in the form of convective thunderstorms during the months of July, August, and September. Winter precipitation comes from the Pacific Ocean in the form of frontal systems during the months of December, January, and February.

Temperatures on the desert grassland are usually adequate for some plant growth. This makes vegetative growth almost entirely dependent on rainfall during the summer months for warm-season plants and during the winter and early spring months for cool-season plants.

The study areas are located on a flat to nearly flat alluvial fan, with a westerly slope not exceeding 5%. Soils are reddish-brown, friable, mostly deep upland loams or sandy loams of granitic origin, slightly acid in reaction and underlain by a distinctly calcareous layer at a depth of 2 to 3 feet (Haskell, 1945).

Soils on the grazed range are undoubtedly in a lower state of productivity than on the protected range due to overgrazing and exposure of the surface horizon to erosion of soil, organic matter, and nutrients. It was

[1] See tables for scientific names of species measured.

observed that filaree dried up quicker on the grazed range than on the protected range. It was also noted that soils on the grazed range were much more compacted due to trampling by livestock.

Methods

To provide more uniform sampling, each area was divided into eight 40-acre blocks and samples taken in each block. Samples were systematically taken from a random start. Fifty-foot line transects were used. Within each block 10 samples were taken, making a total of 80 samples per pasture. Measurements were made by the line intercept method of Canfield (1941). Perennial grasses and forbs were measured at ground level, trees and shrubs at the crown intercept. Basal cover of perennial grasses and forbs and crown cover of trees and shrubs were used to calculate percentage of cover and percentage composition for each group of plants. A species presence on a line transect was used to determine percentage frequency.

Results and Discussion

Trees and shrubs produced the highest cover measurements, followed by grasses then forbs (Fig. 1). However, the higher tree and shrub measurements can not be directly compared to the grass and forb measurements since tree and shrub measurements are crown cover measurements and grasses and forbs are basal cover measurements.

Crown cover of shrubs and trees was greatest on the grazed range, while basal cover of grasses was greatest on the protected range. Both grasses and trees and shrubs increased significantly over time, being higher on both grazed and protected ranges in 1969 than in 1941. However, part of these differences over time could be due to climatic differences prior to and during the years of each measurement (Martin and Cable, 1974). The basal cover of forbs was insignificant on both protected and grazed ranges on both dates.

Trees and Shrubs

The crown cover of trees and shrubs on the protected range was more than twice as great in 1969 as in 1941 (Fig. 1). This resulted because velvet mesquite was nearly six times and wright buckwheat four times as abundant in 1969 (Fig. 2). In contrast to these species, burroweed and other shrubs made no significant changes or decreased in crown cover. Because of these changes, velvet mesquite tripled, wright buckwheat doubled, and burroweed declined 60% in species composition (Table 1).

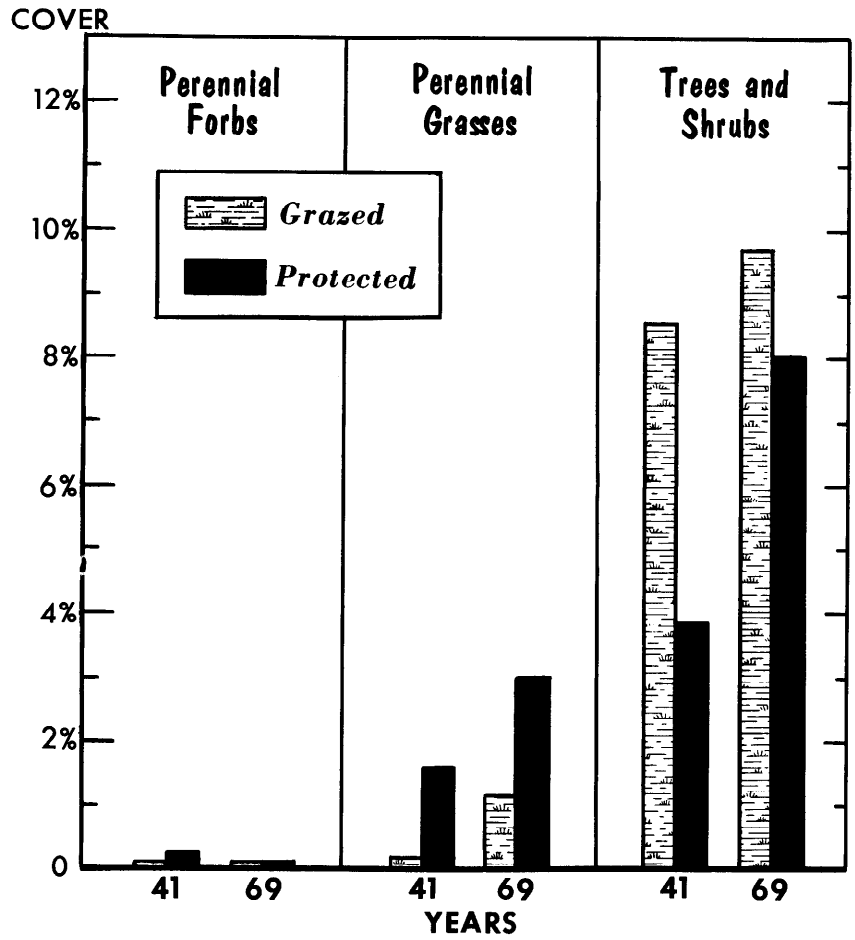

Fig. 1. *Basal cover of perennial forbs and grasses and crown cover of trees and shrubs on grazed and protected desert grassland ranges in 1941 and 1969. The 1941 data is from Haskell (1945).*

On the protected range mesquite made up only 17% of the tree and shrub cover in 1941 but had increased to 48% in 1969, becoming the dominant species (Table 1). This indicates that protection from grazing alone will not control mesquite and that some other factor such as fire is needed to control mesquite under

Table 1. Percentage composition and frequency of tree and shrub on the protected and grazed desert grassland ranges in 1941[1] and 1969.

Species	Range	Composition 1941	Composition 1969	Frequency 1941	Frequency 1969
Burroweed (*Haplopappus tenuisectus*)	Grazed	74.9	23.8	98.0	62.5
	Protected	52.1	21.2	59.3	37.5
Sticky snakeweed (*Gutierrezia lucida*)	Grazed	9.9	11.4	45.0	51.2
	Protected	–	T	–	7.5
Velvet mesquite (*Prosopis juliflora* var. *velutina*)	Grazed	8.9	55.0	16.2	31.2
	Protected	17.4	47.7	13.1	26.2
Wright buckwheat (*Eriogonum wrightii*)	Grazed	.2	1.6	1.2	3.8
	Protected	16.8	31.1	25.0	6.2
Others	Grazed	6.1	8.2	3.3[2]	3.0[2]
	Protected	13.7	T	2.5[2]	2.8[2]
Total	Grazed	100.0	100.0	–	–
	Protected	100.0	100.0	–	–

[1] 1941 data is from Haskell (1945).
[2] Average of species recorded.

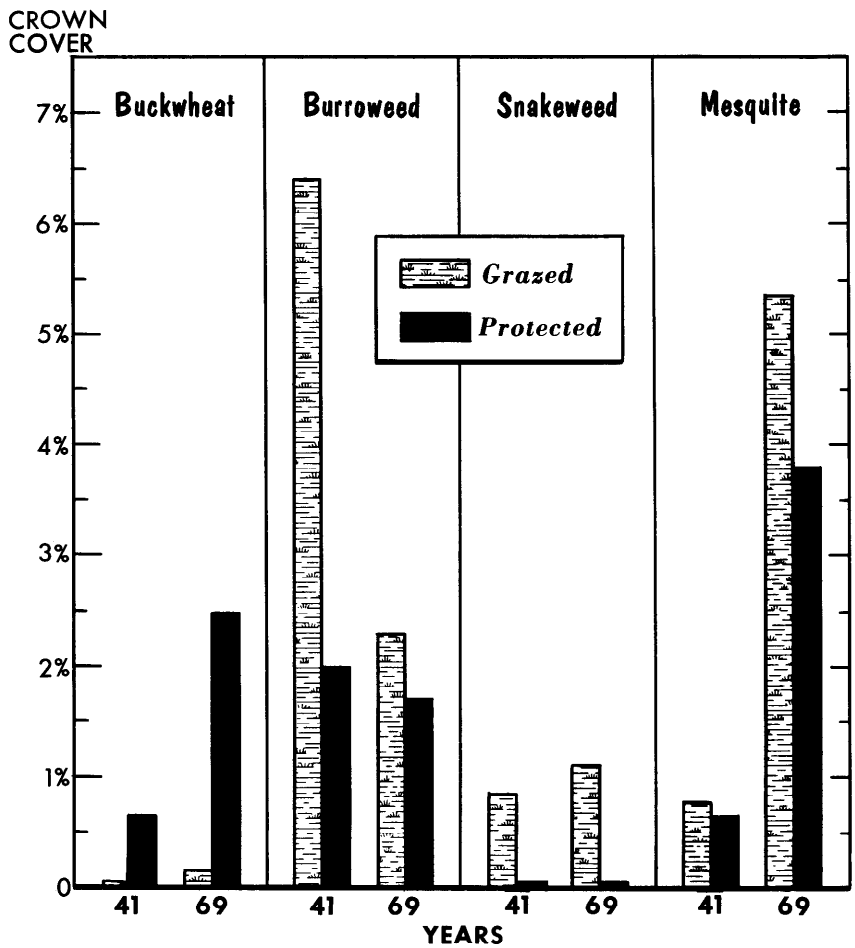

Fig. 2. *Crown cover of tree and shrub species on grazed and protected desert grassland ranges in 1941 and 1969. The 1941 data is from Haskell (1945).*

pristine conditions (Humphrey, 1949; Parker and Martin, 1952; Glendening and Paulsen, 1955; Reynolds and Bohning, 1956). However, after mesquite gets established and over 1 to 2 inches in diameter, fire is not very effective (Glendening and Paulsen, 1955; Blydenstein, 1957; Cable, 1961) and the mesquite plants increase rapidly because of their extensive, competitive root system and height dominance.

On the grazed range burroweed was the dominant shrub in 1941 making up 75% of the tree and shrub composition (Table 1). By 1969 composition of burroweed on the grazed area had declined to 24%. This resulted because burroweed declined about two-thirds in crown cover and other trees and shrubs, particularly mesquite, increased in crown cover. As a result, in 1969 mesquite was the dominant shrub on both the grazed and protected range and was increasing at a faster rate than any other tree or shrub.

The sharp decline in crown cover of burroweed on the grazed range, while only slightly declining on the protected range (Fig. 2), is the complete reverse of what usually happens (Humphrey, 1937; Tschirley and Martin, 1961). Reasons for this reversal are not apparent. Grass competition was certainly not a major factor since that would have caused a greater decline on the protected range. Also, Cable (1969) found only moderate competition between grass and mature burroweed plants because of differences in root systems and growing seasons. However, Humphrey (1937) found severe competition between seedling burroweed plants and perennial grasses in the dry spring months when both root systems occupy the same root zone and compete for the same moisture. Mesquite competition could have been a factor in reducing burroweed cover on the grazed range, but mesquite cover was almost as high on the protected range. Furthermore, mesquite and burroweed commonly grow together because the burroweed begins growth on winter and early spring moisture and is well established before the mesquite begins growth. Fire could have caused a difference in burroweed reaction if it burned the grazed range and not the protected range, but this is unlikely since the protected area would have burned more readily. Burroweed stands are known to decline after maturity (Reynolds and Martin, 1968) but greater reductions would be expected on the protected range. Drought could have had a greater effect on burroweed on the closely grazed range than the protected range because of greater runoff and evaporation from more barren soil, but no measurements were made to determine these effects.

Wright buckwheat was insignificant on the grazed range in both years but increased greatly on the protected range both in crown cover and percentage composition (Fig. 2 and Table 1). This response would be expected since it is an aggressive, moderately palatable plant. This would favor an increase in composition on the protected range in the lower stages of improvement and slow or prevent its recovery on the grazed range.

On the protected range both crown cover and percentage composition of sticky snakeweed were insignificant in both 1941 and 1969 (Fig. 2 and Table 1). However, on the grazed range it made up about 10% of the shrub composition in 1941 and had increased only slightly by 1969. From this it appears that close grazing increased the snakeweed, and plant competition, probably competition from the perennial grasses, crowded it out and/or prevented its establishment on the protected range.

The frequency data (Table 1) shows that burroweed was the most widely distributed shrub, occurring on 98% of the transects on the grazed range in 1941 and 62% of the transects in 1969. Burroweed was also most prevalent on the protected range, occurring on almost 60% of the transects in 1941 and almost 40% in 1969. Sticky snakeweed was second in frequency on the grazed range but nearly absent on the protected range. Velvet mesquite was third in frequency, being about evenly distributed on the protected

and grazed range; wright buckwheat was fourth in frequency of distribution. Most frequency data were correlated with crown cover. However, on the protected range, buckwheat frequency declined sharply with an increase in crown cover, indicating that its density increased on restricted areas and died out on other areas.

Perennial Grasses

On the protected area the cover of perennial grasses was twice as high in 1969 as in 1941 (Fig. 1). This was due primarily to an increase in the midgrasses Arizona cottontop, sideoats grama, cane beardgrass, and the poverty threeawns (Fig. 3). These are generally considered climax plants on this site. Another grass increasing was the introduced Lehmann lovegrass, a plant well adapted to reseeding in the area. This plant is spreading from areas in the southern part of the Page-Trowbridge ranch, where it was seeded in experimental trials during the 1950's. Red threeawn decreased significantly on the protected range in both cover and percentage composition (Fig. 3 and Table 2). This is expected on an improving range. The cover of Rothrock grama on the protected range remained about the same (Fig. 3), but there was a marked decrease in composition as the other grasses increased (Table 2).

Perennial grasses also increased markedly on the grazed range (Fig. 1). However, the big change resulted from an increase in Rothrock grama and the poverty threeawns (Fig. 3), species that appear in the earlier stages of improvement on this site. Substantiating this observation is the fact that both these species were more abundant on the protected range than on the grazed range in 1941. Red threeawn was also more abundant on the protected range in 1941 but had declined by 1969 (Fig. 3). This indicates that it was a pioneer species in the early stages of improvement on this site. Cane beardgrass and sideoats grama were also more abundant on the protected than the grazed range in 1941. However, they continued to increase from 1941 to 1969, indicating that they become established in the early stages of range improvement, and continue through the intermediate stages. Arizona cottontop, not found on any transects in 1941, was abundant in 1969, indicating that it becomes established in an intermediate

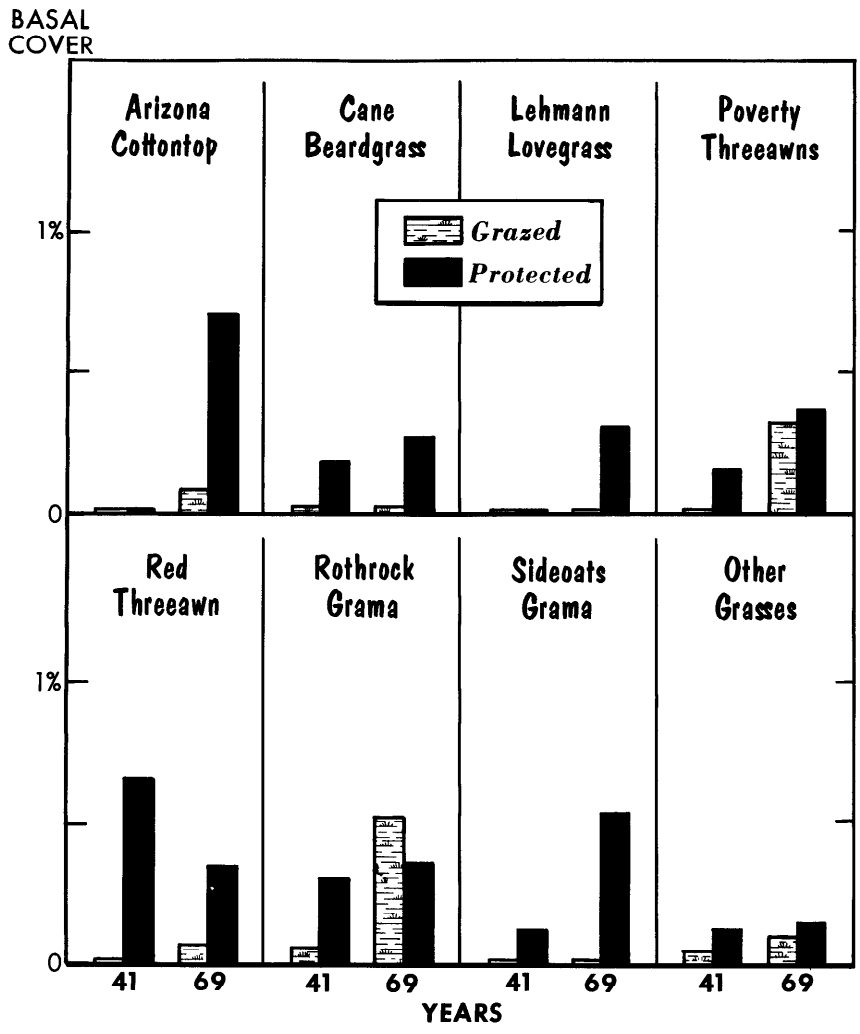

Fig. 3. *Basal cover of perennial grasses on grazed and protected desert grassland ranges in 1941 and 1969. The 1941 data is from Haskell (1945).*

Table 2. Percentage composition and frequency of perennial grass on the protected and grazed desert grassland ranges in 1941[1] and 1969.

Species	Range	Composition 1941	Composition 1969	Frequency 1941	Frequency 1969
Arizona cottontop (*Digitaria californica*)	Grazed	–	7.1	–	11.2
	Protected	–	23.3	–	35.0
Cane beardgrass (*Bothriochloa barbinodis*)	Grazed	16.7	1.8	1.9	3.7
	Protected	11.8	9.0	24.4	30.0
Lehmann lovegrass (*Eragrostis lehmanniana*)	Grazed	–	0.9	–	2.5
	Protected	–	10.0	–	15.0
Poverty threeawns (*Aristida divaricata* and *hamulosa*)	Grazed	T	28.6	1.2	47.5
	Protected	9.9	12.3	21.9	35.0
Red threeawn (*Aristida longiseta*)	Grazed	T	6.2	3.7	12.5
	Protected	42.8	11.3	85.3	36.2
Rothrock grama (*Bouteloua rothrockii*)	Grazed	50.0	46.4	39.4	51.2
	Protected	19.7	11.7	75.6	53.7
Sideoats grama (*Bouteloua curtipendula*)	Grazed	–	.9	–	1.2
	Protected	7.9	17.7	10.6	27.5
Others	Grazed	33.3	8.1	2.0[2]	3.4[2]
	Protected	7.9	4.7	2.4[2]	3.7[2]
Total	Grazed	100.0	100.0	–	–
	Protected	100.0	100.0	–	–

[1] 1941 data is from Haskell (1945).
[2] Average of species recorded.

stage of improvement and becomes more abundant in the higher stages of succession.

Grass frequency data (Table 2) are difficult to interpret at these stages of range condition. Distribution of species on an improving range may be largely restricted to areas in close proximity to a seed source so it is difficult to tell whether establishment is limited to this cause or to site restrictions such as on ridgetops in the case of red threeawn or in swales in the case of cane beardgrass and sideoats grama. However, it is quite clear that the reduction in distribution of red threeawn on the protected range is due to a similar reduction in plant cover. On the other hand Rothrock grama showed a substantial reduction in distribution on the protected range without any substantial change in basal cover. This indicates that it was being crowded out of some sites by the taller perennials but continuing to increase on other sites on about one-half of both areas. In fact the data indicate that it was the most widely adapted grass species on both areas under 1969 range conditions. This contrasts with the two other most abundant species, Arizona cottontop and sideoats grama, which occurred on only about one-third of the protected area. These species became most abundant in the swales and better soil areas, where they rapidly increased in basal cover and percentage composition on limited areas. This was probably due to their growth in favored site conditions and in close proximity to seed source.

Perennial Forbs

Fleabane was the most abundant perennial forb in 1941, making up over 70% of the forb composition (Table 3). However, no perennial forb occurred in more than a trace in 1969. Although occurring in only insignificant amounts, perennial forbs were most widely distributed on the protected range. Ragweed, fleabane, and gaura were the most widely distributed species on the protected range; senna, ragweed, and fleabane were most widely distributed on the grazed range.

Conclusions

Both grazed and protected ranges showed signs of improvement toward and deterioration from the desert grassland climax. The grazed range was in a seriously depleted stage of development in 1941. It was dominated by trees and shrubs (particularly mesquite, burroweed, and snakeweed) and annuals (not recorded in the survey) and had virtually no perennial forbs or grasses, (Fig. 1 and 2). By 1969, Rothrock grama and the poverty threeawns had increased significantly in cover and distribution, indicating an improving trend. Decline in the undesirable burroweed and the moderate increase in the moderately palatable buckwheat between 1941 and 1969 also indicate an improving trend. However, between 1941 and 1969 the more desirable plants, such as Arizona cottontop, cane beardgrass, and sideoats grama, did not increase in significant amounts, indicating a static condition. In contrast, the moderate increase in snakeweed and rapid increase in mesquite indicate a declining condition. Therefore, in 1969 the close-grazed range was still low in range condition although improving slowly. Furthermore, it is not likely to improve much more without the control of mesquite and/or installation of an improved grazing system.

The protected range is in better condition. It has gone through the early stages of improvement where the pioneer species red threeawn and Rothrock grama have increased and are now decreasing or leveling off. The poverty threeawns, are still increasing in cover and distribution but haven't leveled off or decreased. Also, the midgrasses, sideoats grama, cane beardgrass, and Arizona cottontop, are increasing in cover and frequency; the moderately palatable buckwheat is increasing in locally adapted niches; the undesirable burroweed is decreasing in cover, composition, and frequency; and the undesirable snakeweed is not invading. All of these conditions indicate that the range is intermediate in range condition and improving.

The major sign of deterioration on the protected range is the continued rapid increase in velvet mesquite. Although not quite as rapid as on the grazed range, it still represents a threat to continued range improvement. Another threat to climax succession is the invasion of Lehmann lovegrass. On this site it has the ability to grow in association with mesquite better than the native grasses (Cable, 1971). These two species, mesquite and Lehmann lovegrass, may eventually take over the site unless mesquite is controlled. What will happen to the lovegrass if the mesquite is controlled is uncertain at this point on this site, although studies at the Santa Rita Experimental Range indicate that at this elevation on grazed desert grassland ranges the lovegrass will eventually crowd out the native grasses (Cable, 1971). However, lovegrass may not be able to replace the native climax species as readily on a protected range.

Table 3. Percentage composition and frequency of perennial forb on the protected and grazed desert grassland ranges in 1941[1] and 1969.

Species	Range	Composition		Frequency	
		1941	1969	1941	1969
Fleabane	Grazed	T	T	1.9	8.7
(*Erigeron* sp.)	Protected	71.4	T	8.7	32.5
Gaura	Grazed	T	–	.6	–
(*Gaura* sp.)	Protected	17.9	–	24.4	–
Senna	Grazed	50.0	T	10.6	2.5
(*Cassia bauhinioides*)	Protected	–	–	–	–
Western ragweed	Grazed	–	T	–	10.0
(*Ambrosia psilostachya*)	Protected	T	T	.6	42.5
Others	Grazed	50.0	T	1.4[2]	1.6[2]
	Protected	10.7	T	1.2[2]	4.3[2]
Total	Grazed	100.0	T	–	–
	Protected	100.0	T	–	–

[1] 1941 data is from Haskell (1945).
[2] Average of species recorded.

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