Successional Classification of Plants on a Desert Grassland Site in Arizona

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Highlight: *Vegetative cover, composition, and frequency studies on protected and grazed desert grassland ranges in Arizona provided quantitative data on the reaction of plants to protection and grazing. These data were used to classify plants as decreasers, increasers, and invaders on a deep upland desert grassland site. In the absence of fire or mesquite control, velvet mesquite, Arizona cottontop, sideoats grama, cane beardgrass, and poverty threeawns reacted as decreasers; Wright buckwheat, red threeawn, and Rothrock grama acted as increasers; and burroweed, sticky snakeweed, and Lehmann lovegrass were classified as invaders. Annuals were not measured, and perennial forbs were too limited in abundance to classify. Under climax conditions with recurring fires, all native species apparently reacted as above except mesquite, which reacted as an increaser on bottomlands and an invader of uplands.*

Stages in plant succession are a useful tool in determining range condition. Essential to the quantitative-climax system of classifying range condition is the classification of plant species as decreasers, increasers, and invaders for each site (Dyksterhuis, 1949). Studies by Haskell (1945), Smith (1970), and Smith and Schmutz (1975) of long-term changes on protected versus grazed ranges near Oracle, Ariz., provided some useful data on the successional classification of plants on a deep upland desert grassland site.

In this paper decreasers are defined as plant species of the original or climax vegetation that decrease in relative amount with continued overuse; increasers are plant species of the original or climax vegetation that, under continued overuse, increase in relative amount for a time then decrease; and invaders are plant species that were absent, or present in very small amounts, in undisturbed portions of the original or climax vegetation and invaded following disturbance or continued overuse (Dyksterhuis, 1949; Range Term Glossary Committee, 1974). On an improving range these species act in reverse, the decreasers steadily increase; increasers increase in low condition then decrease in high condition, and invaders steadily decrease. However, the classification of an individual species as decreaser, increaser, or invader may be due to its reaction to such influences as changes in the habitat (caused by grazing effects on soil compaction, soil aridity, plant and mulch cover, etc.) or changes in burning effects (due to fire suppression) rather than to direct grazing of the plant itself. In these instances palatability of the plant may have little effect on its reaction and classification.

Study Areas

The study areas consist of two half sections of land approximately 8 miles west of Oracle in southern Arizona at an elevation of 3,700 feet. One of the half sections is a part of the Page-Trowbridge Experimental Ranch that was conservatively grazed from 1923 to 1941 and that has been largely protected from grazing since. The other half section is part of an adjoining, closely grazed range.

The areas, once open grassland, are now dominated with 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 is intermediate between that of Tucson and Oracle, Ariz. Temperatures are generally mild, and precipitation averages 15 to 16 inches per year, approximately half of which falls in the summer and half in the winter.

The 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).

Methods

Both Haskell (1945) in 1941 and Smith (1970) in 1969 used 50-foot line transects to measure the vegetation. Each half section was divided into eight 40-acre blocks and 10 samples were taken in each block, making a total of 80 samples per pasture. Samples were taken systematically from a random start by the line intercept method of Canfield (1941). Basal cover of perennial grasses and forbs and crown cover of trees and shrubs were used to calculate percentages of cover and percentage composition for each group of plants. Species presence on the lines was used to determine frequency, an indicator of distribution (Range Term Glossary Committee, 1974). Annuals were not measured.

Results and Discussion

Trees and shrubs produced the highest cover measurements, followed by perennial grasses (Tables 1 and 2). However, the higher tree and shrub cover cannot be directly compared to the grass cover since tree and shrub cover was based on crown cover and the grasses on basal cover measurements.

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

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

Species	Range	Cover		Composition		Frequency	
		1941	1969	1941	1969	1941	1969
Velvet mesquite (*Prosopis juliflora* var. *velutina*)	Grazed	.76	5.32	8.9	55.0	16.2	31.2
	Protected	.66	3.80	17.4	47.7	13.1	26.2
Burroweed (*Haplopappus tenuisectus*)	Grazed	6.38	2.30	74.9	23.8	98.0	62.5
	Protected	1.98	1.69	52.1	21.2	59.3	37.5
Wright buckwheat (*Eriogonum wrightii*)	Grazed	.02	.16	.2	1.6	1.2	3.8
	Protected	.64	2.48	16.8	31.1	25.0	6.2
Sticky snakeweed (*Gutierrezia lucida*)	Grazed	.84	1.10	9.9	11.4	45.0	51.2
	Protected	–	T	–	T	–	7.5
Others	Grazed	.52	.79	6.1	8.2	3.3[2]	3.0[2]
	Protected	.52	T	13.7	T	2.5[2]	2.8[2]
Total	Grazed	8.52	9.67	100.0	100.0	–	–
	Protected	3.80	7.97	100.0	100.0	–	–

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

Crown cover of trees and shrubs was greatest on the grazed range while basal cover of perennial grasses was greatest on the protected range. Also, 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 measurement (Martin and Cable, 1974). The basal cover of perennial forbs was insignificant on both protected and grazed ranges on both dates.

The increase in palatable perennial grasses on both ranges indicates that both ranges are improving. However, this improving trend may eventually be stopped or reversed by the continuing rapid increase in velvet mesquite.

Also, making some assumptions based on species composition, soil conditions, and past experience, range condition was estimated for the various stages of succession by pastures and dates. Based on four range condition classes—excellent, good, fair, and poor—the grazed range was estimated to be in mid-poor range condition in 1941 and in upper-poor condition by 1969. The protected range was estimated to be in mid-fair range condition in 1941 and mid-good condition by 1969. This provided four benchmarks about which to judge the successional role of the various plant species.

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

Species	Range	Cover		Composition		Frequency	
		1941	1969	1941	1969	1941	1969
Arizona cottontop (*Digitaria californica*)	Grazed	–	.08	–	7.1	–	11.2
	Protected	–	.70	–	23.3	–	35.0
Sideoats grama (*Bouteloua curtipendula*)	Grazed	–	.01	–	.9	–	1.2
	Protected	.12	.53	7.9	17.7	10.6	27.5
Cane beardgrass (*Bothriochloa barbinodis*)	Grazed	.02	.02	16.7	1.8	1.9	3.7
	Protected	.18	.27	11.8	9.0	24.4	30.0
Poverty threeawns (*Aristida divaricata* and *hamulosa*)	Grazed	T	.32	T	28.6	1.2	47.5
	Protected	.15	.37	9.9	12.3	21.9	35.0
Rothrock grama (*Bouteloua rockrockii*)	Grazed	.06	.52	50.0	46.4	39.4	51.2
	Protected	.30	.35	19.7	11.7	75.6	53.7
Red threeawn (*Aristida longiseta*)	Grazed	T	.07	T	6.2	3.7	12.5
	Protected	.65	.34	42.8	11.3	85.3	36.2
Lehmann lovegrass (*Eragrostis lehmanniana*)	Grazed	–	.01	–	0.9	–	2.5
	Protected	–	.30	–	10.0	–	15.0
Others	Grazed	.04	.09	33.3	8.1	2.0[2]	3.4[2]
	Protected	.12	.14	7.9	4.7	2.4[2]	3.7[2]
Total	Grazed	.12	1.12	100.0	100.0	–	–
	Protected	1.52	3.00	100.0	100.0	–	–

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

Trees and Shrubs

Velvet Mesquite

Velvet mesquite was seven times as abundant on the grazed range and six times as abundant on the protected range in 1969 as in 1941 (Table 1). Also, on both ranges there was a similar but not quite as spectacular increase in mesquite composition and a doubling of frequency or area covered by mesquite. These rapid increases on both protected and grazed ranges indicate that protection alone will not control mesquite and that some other treatment such as fire was needed to control mesquite under pristine conditions (Humphrey, 1949; Parker and Martin, 1952; Glendening and Paulsen, 1955; Reynolds and Bohning, 1956). However, after mesquite becomes 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. These data show that in the absence of fire mesquite is reacting as a decreaser, that the mesquite type is the climatic-climax, and that the former desert grassland was a fire-subclimax polyclimax condition.

Burroweed

In 1941 burroweed was the dominant shrub on both areas (Table 1). By 1969 there was a marked decrease in cover, composition, and area covered on the grazed range. On the protected range there was a slight decline in cover of burroweed and a marked decline in composition and frequency. This high concentration of burroweed in low range condition and its rapid decline in cover composition and frequency as the range improved indicates that it is reacting as an invader on this site. Since it is susceptible to control by fire as well as grass competition (Humphrey, 1937 and 1949; Tschirley and Martin, 1961), it also probably acted as an invader in the pristine grassland.

Wright Buckwheat

Wright buckwheat was insignificant

in cover, composition, and frequency on the grazed range in both years (Table 1). On the protected range it had increased significantly in cover, composition, and distribution by 1941 and had increased spectacularly in cover by 1969. However, between 1941 and 1969, composition on the protected range had only doubled and distribution had declined sharply. This indicates that Wright buckwheat is reacting as an increaser, being grazed out in poor range condition, was most abundant in middle range condition and beginning to decline on most areas (as indicated by frequency index) in the higher range condition.

Sticky Snakeweed

In both 1941 and 1969 sticky snakeweed was moderate to high in cover, composition, and frequency on the grazed range but was insignificant on the protected range (Table 1). This indicates that on this site it is most abundant in poor range condition and acts as an invader.

Perennial Grasses

Arizona Cottontop

Arizona cottontop was not found on the line transects on either range in 1941 (Table 2). By 1969 small amounts were present on the grazed range and it was the most abundant, but not the most widespread, grass on the protected range. This indicates that it is sensitive to grazing and is reacting as a decreaser. Also, its high abundance under good range conditions indicates that it is one of the most important climax grasses on this site.

Sideoats Grama

Sideoats grama was insignificant on the grazed range in both 1941 and 1969 (Table 2). However, on the protected range it had made an important appearance by 1941 and had increased significantly in cover, composition, and frequency by 1969. This indicates that it is acting as a decreaser and is an important climax plant on this site.

Cane Beardgrass

Cane beardgrass was one of the earliest grasses to appear on the grazed range in 1941, but its cover was low and it did not increase between 1941 and 1969 (Table 2). However, due to the scarcity of grasses, it made up a considerable portion of the grass composition in 1941. By 1969, because it did not increase in cover and the other grasses did, it made up only a small percentage of the composition on the grazed range. However, it had increased somewhat in distribution.

On the protected range it was considerably more abundant in 1941 and was more widespread than on the grazed range. However, it made up a smaller percentage of the grass composition. By 1969 it had increased in cover and frequency but had declined in composition as other grasses increased more rapidly. This lack of increase in cover and small increase in distribution under the poor range conditions of the grazed range and the steady increase in cover and distribution as the condition improved on the protected range indicates that cane beardgrass is a climax decreaser on this site.

Poverty Threeawns

The poverty threeawns made up only a trace of the cover on the grazed range in 1941 (Table 2). However, by 1969 they had made a very significant increase in cover, composition, and area covered. On the protected range they made up an important part of the cover, composition, and frequency in 1941 and had made moderate increases in all three categories by 1969. The rapid increases in cover in the lower condition classes and moderate increases in the middle condition classes indicate that these species might be reacting as increasers. However, until more data is available they would have to be classed as decreasers.

Rothrock Grama

Rothrock grama was the most widespread grass and made up 50% of the composition on the grazed range in 1941 (Table 2). It continued to increase in cover and frequency on the grazed range between 1941 and 1969 but remained about the same in composition as other grasses increased more rapidly. On the protected range it made up a significant part of the grass cover in 1941 but had increased only slightly by 1969. Also, it decreased in composition and frequency between 1941 and 1969. This shows that Rothrock grama was most abundant in the middle range condition classes and is acting as an increaser.

Red Threeawn

Red threeawn was present as a trace on the grazed range in 1941 and had only moderately invaded the grazed range by 1969 (Table 2). On the protected range it was the most abundant grass in 1941, having the highest cover, composition, and frequency. However, it had markedly decreased in all three categories by 1969. This marked decrease as range condition changed from fair to good indicates that it is reacting as an increaser. However, if it should disappear from the composition before climax condition, it would be classed as an invader.

Lehmann Lovegrass

Lehmann lovegrass is an introduced grass that was seeded on a portion of the Page-Trowbridge ranch south of the study area in the 1950's (Table 2). By definition, since it was not in the climax, it would be classed as an invader. However, it is well adapted to this portion of the desert grassland and grows in association with mesquite better than most native grasses (Cable, 1971).

From a management standpoint desirable introduced species should not receive a blanket classification of invader but should be classified as to how they react with other associated species growing on the site. In this study (Table 2) the more rapid invasion of Lehmann lovegrass on the range in higher condition indicates that it will react as an increaser or decreaser.

Perennial Forbs and Annuals

Perennial forbs made up such a small and erratic percentage of the vegetation cover that no conclusions could be drawn from their reactions as to whether they are decreasers, increasers, or invaders.

Annuals were not recorded, so no definite conclusions could be made. However, general observations indicated that annuals were much more abundant on the grazed than on the protected range. This indicates that they were reacting as invaders or increasers at this elevation. At higher elevations most annuals act as invaders; at lower elevations the more palatable annuals act as increasers or decreasers.

Conclusions

The data from Haskell (1945), Smith (1970), and Smith and Schmutz (1975)

offered an unusual opportunity to study plant reactions to grazing and plant succession. While not completely definitive, these data led to some conclusions based on quantitative data. It is hoped that this analysis will stimulate similar studies on this and other sites so that more definite conclusions can be drawn based on a broader base of knowledge.

Literature Cited

Blydenstein, John. 1957. The survival of velvet mesquite (*Prosopis juliflora* var. *velutina*) after fire. MS Thesis, Univ. Arizona, Tucson. 21 p.

Cable, D. R. 1961. Small velvet mesquite seedlings survive burnings. J. Range Manage. 14:160-161.

Canfield, R. H. 1941. Application of the line interception method for sampling vegetation. J. Forest. 39:388-394.

Dyksterhuis, E. J. 1949. Condition and management of range land based on quantitative ecology. J. Range Manage. 2:104-115.

Glendening, G. E., and H. A. Paulsen. 1955. Reproduction and establishment of velvet mesquite as related to invasion of semidesert grasslands. U.S. Dep. Agr. Tech. Bull. 1127. 50 p.

Haskell, H. S. 1945. Successional trends on a conservatively grazed desert grassland range. J. Amer. Soc. Agron. 37:978-990.

Humphrey, R. R. 1937. Ecology of the burroweed. Ecology 18:1-9.

Humphrey, R. R. 1949. Fire as a means of controlling velvet mesquite, burroweed, and cholla on southern Arizona ranges. J. Range Manage. 2:175-182.

Martin, S. C., and D. R. Cable. 1974. Managing semidesert grass-shrub ranges: vegetation responses to precipitation, grazing, soil texture, and mesquite control. U.S. Dep. Agr. Tech. Bull. 1480. 45 p.

Parker, K. W., and S. C. Martin. 1952. The mesquite problem on southern Arizona ranges. U.S. Dep. Agr. Circ. 908. 70 p.

Range Term Glossary Committee. 1974. A glossary of terms used in range management. 2nd ed. Soc. for Range Manage., Denver, Colo. 36 p.

Reynolds, H. G., and J. M. Bohning. 1956. Effects of burning on a desert grassland shrub range in southern Arizona. Ecology 37:769-777.

Smith, David A. 1970. Successional trends on protected versus grazed desert grassland ranges in Arizona. MS Thesis, Univ. Arizona, Tucson. 62 p.

Smith, David A., and E. M. Schmutz. 1975. Vegetative changes on protected versus grazed desert grassland ranges in Arizona. J. Range Manage. 28:453-458.

Tschirley, F. H., and S. C. Martin. 1961. Burroweed on southern Arizona ranges. Arizona Agr. Exp. Sta. Tech. Bull. 146. 34 p.