The Page Ranch Story — its Vegetative History and Management Implications[1]

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Preface

The Page-Trowbridge Experimental Ranch is a 640-acre tract of desert grassland located 35 miles north of Tucson and 8 miles west of Oracle in Arizona. Its formation began in 1923 when Joseph Timothy Page, a retired street car conductor, utility company worker and dirt farmer from Kansas City and his wife Sarah (Figure 1) purchased a half section (320 acres) of "butchered" rangeland to live on. They fenced the land (Figure 2) and raised chickens, turkeys, rabbits and goats for food and sale; had a milk cow, horse or mule and a working dog to keep out stray cattle; and raised a garden, cultivated fruit trees and cut Mesquite trees for fuel (see Figures 3, 4). The annual rainfall was about 15 to 16 inches, hardly enough for irrigated agriculture, so they built check dams to hold rain on the land to grow grass and channeled runoff to irrigate fruit trees, grapevines and a garden. They hauled their drinking water from the resort town of Oracle where Mrs. Page often cooked at the hotel on weekends to supplement their income. Page's efforts were so successful that his little green patch was referred to as "God's Little Acre" by visitors. Stories of his efforts at soil and water conservation and grass improvement were featured in local and national publications and Mr. Page became a celebrated oracle on conservation (see Figure 5 and references).

In 1939 Mr. Page's tract was purchased by the University with money provided by ex-senator Trowbridge. This and another half-section to the south was provided to the University to do experimental work in range conservation and management. The tracts were officially known as the Page-Trowbridge Ranch but were more commonly referred to as the Page Ranch.

For a number of years after its acquisition the university and the Research Division of the Soil Conservation Service used the area for ecological studies and for extensive experiments on grass seeding, brush control, water catchments, wildlife management and honeybee culture.

In Mr. Page's time his tract was lightly grazed by livestock but since 1941 the ranch has been largely protected from grazing by livestock. The vegetative cover varied with climatic cycles but generally increased with time. Its lush vegetation attracted and supported a variety of wildlife—quail, deer, javelina, song birds, rabbits, rodents, etc.—and was referred to by the Arizona Game and Fish Department as the "best square mile of Gambel's and Scaled Quail habitat in the world."

Ecological studies comparing vegetative conditions on the Page half-section with an adjoining outside half-section (see Figure 6) were started in 1941 by H.S. Haskell. His study documented changes since 1923 when the Page Ranch was fenced. This comparison was repeated in 1969 by D.A. Smith and in 1980 by M.K. Sourabie. These and related studies are listed in the References and their results and implications for management of simliar desert grassland ranges are discussed in the following sections.

In 1983 the Page Ranch ecological oasis was lost as a natural range and wildlife study area when the arid lands program at the University of Arizona took over the Ranch to create the Page Ranch International Center for Arid Lands Agricultural Systems. It is now being used to install practices and treatments which can be used to study and teach ways of growing crops and livestock in arid countries that have small scale technologies.

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Fig. 1. Mr. Page and wife Sarah about 1923.

Abstract

This report compares and evaluates vegetation changes occurring between 1923 and 1980 on the Page Ranch, a protected desert grassland range in southern Arizona, and on adjacent grazed range. Crown cover of trees and shrubs increased rapidly on both ranges, increasing from 3.8 in 1941 to 8.0 and 18.8% in 1969 and 1980, respectively, on the protected range and from 8.5 to 9.7 and 19.7%, respectively, on the grazed range. Basal cover of perennial grasses was 1.52, 3.0 and 1.54% in 1941, 1969 and 1980, respectively, on the protected range compared to 0.12, 1.12 and 0.01% on the grazed range. Basal cover of perennial forbs was 0.30, trace and 0.27% in 1941, 1969 and 1980, respectively, on the protected range and a trace in all three years on the grazed range. The differences between the vegetation classes on the grazed vs protected ranges in 1941 represent the changes up to that time from 1923 when the protected range was fenced out and grazing controlled. Also, a study on the effects of 1973 wildfires on a part of the protected range showed that trees and shrubs had largely recovered by 1980 but many perennial grasses had not recovered, presumably because of subsequent summer droughts. These responses are discussed in relation to causes and how they affect management of desert grassland ranges.

Introduction

Despite intensive management practices and research, the desert grassland of the Southwest is changing to a desert shrub type, presumably because of grazing pressures, frequent droughts and lack of fire and competition to control shrub invasion. Vegetation surveys of 1941, 1969 and 1980 were compared to study these effects. The 1941 study was made by Haskell (1945), the 1969 study by Smith (1970) and the 1980 study by Sourabie (1982).

The Study Area

The studies were conducted on and adjacent to the University of Arizona Page-Trowbridge Experimental Ranch, 13 km (8 miles) west of Oracle, in southern Arizona, at an elevation of 1135 m (3700 ft.). The area comprises two half-sections in a desert grassland range. One area about 129.6 ha (320 acres) has been largely protected from grazing since 1923. The other half-section is an adjoining heavily grazed area. In 1973, three separate fires burned about 60% of the western portion of the protected area. Although the area had largely recovered from fire by the time of the 1980 study it was analyzed separately to determine the long-term effects of fire.

Soils of the study area were formed from old alluvium high in granitic rock material. Most of the area is dominated by the Whitehouse-Caralampi association with the Whitehouse Series dominant on both the protected and the grazed ranges. Topography is nearly flat with a westerly slope less than 5%.

The type of vegetation encountered in the study area indicates a deteriorated desert grassland with a dominance of shrubby vegetation over grasses. Smith (1970) suggested that the area could be classified as an ecotone, a transitional zone between the desert grassland and the southern desert shrub. Temperatures are mild and plant growth is largely determined by precipitation.

The climate is semi-arid with the annual precipitation averaging 380 to 400 mm (15 to 16 inches) (Haskell, 1945). It is distributed about equally between summer and winter (Smith, 1956). However, the major plant growth occurs during the summer (Culley, 1943; Cable, 1975).

Methods

So that direct comparisons could be made with previous studies, the 1969 and 1980 sampling plans of Smith and Sourabie, respectively, followed that of Haskell in 1941. In all three studies each of the study areas was divided into eight blocks of equal size. Within each block ten 50-ft. (about 15 m) line transect samples were taken making a total of 80 samples per area analyzed. In all three studies a comparison was made between the grazed and protected areas. In addition, the 1980 study assessed the effects of the 1973 fires on a part of the protected area. Measurements on the vegetation were made using the line interception method outlined by Canfield (1941). Basal cover (basal intercept) of perennial grasses and forbs and crown cover of trees and shrubs were used to calculate percentage of cover and percentage of composition

Fig. 2. Aerial view (about 1936) of the Page portion of the Page-Trowbridge Ranch looking southwest. Page's headquarters is in the left central part of the photo. Note the sparseness of mesquite, part of which may be due to woodcutting, but since mesquite is sparse in adjoining areas except along drainages, it may be in an early stage of invasion. The other half-section of the Page-Trowbridge Ranch can be seen in the upper left part of the photo and a part of the "grazed" half section in the lower left corner.

Fig. 3. Mrs. Page acquainting a young visitor with the "cattle dog," "milk cow" and ranch.

Fig. 4. Mr. Page and his mule plowing the garden.

Fig. 5. Tucson Mayor Jastead and other admirers congratulating Mr. Page for his conservation achievements. Photo by J. Robert Burns.

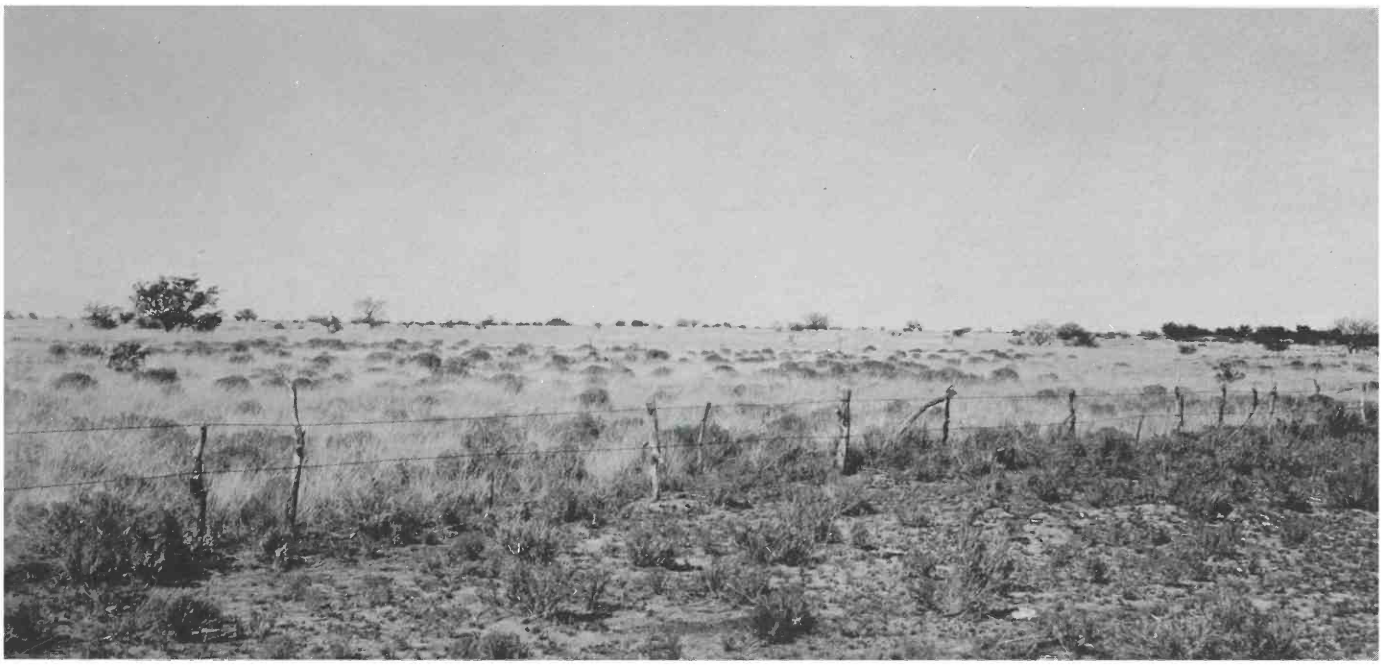

Fig. 6. Side view (about 1941) of Page's environmental "oasis" in the background, the grazed half-section in the foreground.

for each category of plants. Species presence on a line transect was used to determine percentage frequency. Annual forbs and grasses were not included in the survey procedure.

The two-sample T-test was used to determine significance of differences in species cover and frequency between protected and grazed areas and between protected unburned and burned areas.

Results and Discussions

Data showed that marked changes in vegetation occurred throughout the study period. Since both areas were presumably similar in 1923, the 1941 study showed the changes up to that date. Later changes were shown in the 1969 and 1980 studies. In general total basal cover of perennial grasses and forbs was greater on the protected area than on the grazed area (Fig. 7), although differences were not always statistically significant. In contrast, the crown cover of trees and shrubs was higher on the grazed area compared to the protected area, again not always being significant. These relationships are typical and can be due to such environmental factors as relative palatability, drought, plant competition, grazing and/or fire effects. In this case, all of the above factors appear to have had an effect at one time or another.

Effects of Precipitation, Grazing and Plant Competition. Precipitation, grazing and plant competition had significant and varied effects on all classes of plants—trees, shrubs, grasses and forbs—and individual species.

EFFECTS ON CLASSES OF PLANTS. In general, perennial forbs increased on the protected area from 1923 to 1941, decreased between 1941 and 1969, and then increased back to the 1941 level by 1980. In contrast perennial grasses increased between 1923 and 1969 then decreased back to the 1941 level by 1980. The grass changes appear to have resulted primarily from weather conditions since they occurred on both grazed and protected areas. Also, this conclusion is substantiated by an analysis of weather records from Oracle, Arizona prior to 1980. These records show that, while average precipitation was near normal, 5 of the 6 years prior to the 1980 study were below average in precipitation during the July-Agusut summer growing season (Sourabie, 1982). These results are similar to those of Cable (1967) and Paulsen and Ares (1962) who found marked declines in perennial grass cover following several years of deficient seasonal rainfall. Perennial forb changes on the proteced area appear to have been a reverse response due to the presence or lack of grass competition. On the grazed area the perennial forb level remained low in all three years, apparently predominantly affected by grazing pressure.

In contrast, trees and shrubs increased rapidly throughout the study period on both grazed and protected areas, particularly between 1969 and 1980. These effects appear to be primarily due to dominance by the trees and shrubs but were also affected in part by grass competition, or lack of it, since the increase in trees and shrubs between 1941 and 1969 was slower when grass cover doubled and more rapid between 1969 and 1980 when grass cover declined. Also the possibility exists that the decline in perennial grass cover between 1969 and 1980 was due in part to competition by trees and shrubs but this appears secondary at this level of crown cover since grass cover declined in open areas as well as among the trees and shrubs.

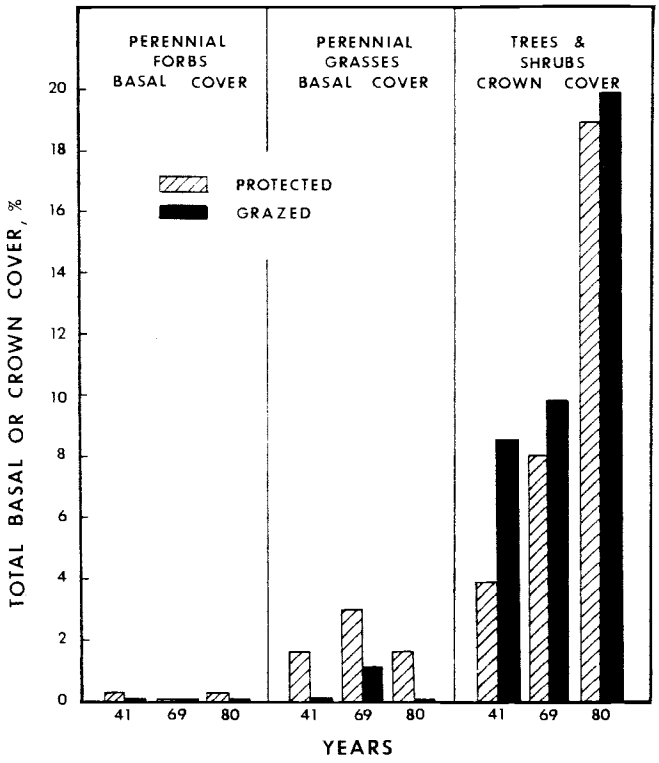

Fig. 7. Basal cover of perennial forbs and grasses and crown cover of trees and shrubs on protected and grazed ranges on the Page Ranch study area in 1941, 1969 and 1980.

The effect of grazing on total crown cover of trees and shrubs was negligible since crown cover increased rapidly on both areas. However, it is interesting to note that the increase in total crown cover of trees and shrubs was faster on the protected area than on the grazed area. This was mainly due to the rapid increase in the palatable buckwheat (see Table 1 in the following section), which was apparently caused by protection from grazing, and burroweed, which apparently resulted from a decrease in grass competition combined with favorable winter moisture (Cable, 1967). In contrast the total basal cover of perennial grasses was significantly greater on the protected area than on the grazed area in all three years, indicating an effect of grazing. The basal cover of perennial forbs was too low for significant analyses.

EFFECTS ON INDIVIDUAL TREES AND SHRUBS. Dominant trees and shrubs found on the study area were Buckwheat, Burroweed, Mesquite and Snakeweed (see Table 1 for results and scientific names).

Buckwheat. Crown cover of buckwheat increased steadily over time on the protected range from 0.6% in 1941 to 5.9% in 1980. In contrast the percentage on the grazed range remained little more than a trace. These differences were also reflected by similar change in species composition and plant frequency. These results indicate that grazing pressure was the dominant influence on this moderately palatable plant and that influences of drought and plant competition were negligible.

Burroweed. Cover, composition and frequency of burroweed showed that it was a dominant and widely distributed shrub on both grazed and protected ranges but was significantly more abundant on the grazed range. On the protected range, crown cover of Burroweed declined slightly in 1969 over 1941 and then increased considerably in 1980. A similar but more significant pattern occurred on the grazed range.

Part of the decline in Burroweed on both areas from 1941 to 1969 probably was due to increased grass competition. Conversely the increases in Burroweed on both areas from 1969 to 1980 was due in part to decreased grass competition but may have also been increased by higher winter moisture favoring increased germination of Burroweed (Sourabie, 1982). Also, the higher level of Burroweed in the grazed area over the protected area probably was due primarily to lower grass competition.

Mesquite. Between 1941 and 1980 crown cover and frequency of Mesquite rapidly increased on both protected and grazed areas. Species composition of Mesquite also increased in both areas from 1941 to 1969 but declined in 1980 due to more rapid increases in associated shrubs. The increase was primarily due to the aggressiveness of Mesquite but was also affected by grass competition (as evidenced by the slower increase on the protected range in 1969) and fire (to be discussed later). Drought and grazing have indirect effects on Mesquite abundance through their influence on grass cover, but have little direct effects because of the high drought tolerance and low palatability of Mesquite.

Snakeweed. Snakeweed had a relatively low crown cover and composition compared to other trees and shrubs but had a comparatively high frequency, especially on the grazed area, indicating wide distribution. Also, its cover, composition and frequency increased with time, especially from 1969 to 1980, and in all years they were higher on the grazed area than on the protected area. This indicates that grazing favors Snakeweed, probably by reducing grass cover. Also, summer drought (which reduces grass cover) and favorable winter moisture (which increases Snakeweed growth) undoubtedly helped to increase snakeweed, especially during the period 1969 to 1980.

Other Trees and Shrubs. These plants, predominantly cacti, generally increased over time. They were little affected by grazing or plant competition but were affected by fire as noted later.

EFFECTS ON INDIVIDUAL PERENNIAL GRASSES. Perennial grasses varied widely in basal cover, composition and frequency (see Table 2 for results and scientific names). Grazing and drought appeared to be the dominant factors affecting cover, composition and frequency of perennial grasses. However, cover of trees and shrubs, always a contributing factor, may be reaching a density which may exert a dominating influence on the grasses, except the shade tolerant and cool-season growing species which endure or avoid direct competition, respectively.

The 1941 data show that the dominant grasses on the protected range at the end of Mr. Page's tenure were Red Threeawn and Rothrock Grama, two intermediate species. Other grasses in significant amounts were the more productive Cane Beardgrass, Poverty Threeawns and Sideoats Grama.

Arizona Cottontop. Under protection this palatable midgrass increased significantly in cover, composition and frequency between 1941 and 1969. A similar but less pronounced pattern occurred on the grazed range. However, below normal summer precipitation between 1969 and 1980 resulted in a drastic reduction in this valuable plant on the protected range and eliminated it on the grazed range.

Cane Beardgrass. This moderately palatable midgrass was relatively abundant on the protected range in 1941 and had made moderate increases in cover and frequency by 1969. However, it also was drastically reduced by summer droughts between 1969 and 1980. On the grazed range, it was a minor constituent in 1941 and 1969 and was eliminated by 1980.

Lehmann Lovegrass. Lehmann Lovegrass was introduced on the adjoining section south of the protected area in the 1930's and is moving northward. By 1969 it had established itself on limited areas in the western part of the protected range but hadn't invaded the grazed area, probably more because of distances involved than from grazing effects. This was evidenced by its absence from the unburned eastern part of the protected area which is adjacent to the grazed area. The presence of significant amounts on the protected area in 1980 indicates a recovery from fire regardless of the series of summer droughts prior to 1980. This indicates that it reseeds readily and is one of the more drought tolerant grasses.

Poverty Threeawn. These moderately palatable midgrasses more than doubled in basal cover on the protected area between 1941 and 1969 and increased from a trace to 0.32% on the grazed area. However, by 1980 they had decreased to their 1941 levels, apparently due to the summer droughts. Similar changes occurred in species composition and frequency except that they were the only perennial grasses surviving on the grazed range. These results indicate that they are influenced by both grazing and drought, but more by drought since they were about equal in basal cover on both protected and grazed ranges in 1969.

Red Threeawn. This moderately palatable shortgrass, the most abundant grass on the protected area in 1941, declined steadily in basal cover to a trace in 1980. Similar declines occurred in species composition and frequency. It was generally insignificant in all three years on the grazed range. This indicates that in the absence of cool-season grasses this warm-season grass with cool-season growth tendencies was grazed heavily enough in the spring to practically kill it out. On the protected range competition from the taller midgrasses apparently crowded it out indicating that it is susceptible to both competition and grazing effects. It also appears to be moderately susceptible to drought since it did not increase in 1980 after competing species declined.

Rothrock Grama. This short-lived shortgrass, which was moderately abundant on the protected range in 1941 and 1969, had declined to a trace in 1980. On the grazed range it increased from 0.06% in 1941 to 0.52% in 1969, and then had disappeared by 1980. Similar changes occurred in composition and frequency. These data indicate that this species is affected by both drought and grazing but more by drought. It is also a weak competitor with other species but this disadvantage is partially offset by its prolific propagation habits.

Sand Dropseed. This warm season midgrass was not found in either area in 1941, only in small amounts in 1969, and essentially absent in 1980. These data indicate little response of Sand Dropseed to grazing and small response to drought,

Table 1. Crown cover, composition and frequency of trees and shrubs on protected and grazed ranges in the Page Ranch study area in 1941, 1969 and 1980.

Species	Range	Crown Cover %			Species Composition %			Plant Frequency %		
		1941	1969	1980	1941	1969	1980	1941	1969	1980
Buckwheat *(Eriogonum wrightii)*	Protected	0.6	2.5	5.9	16.8	31.1	31.4	25.0	6.2	54.5
	Grazed	T	0.2	T	0.2	1.6	0.2	1.2	3.8	2.5
Burroweed *(Haplopappus tenuisectus)*	Protected	2.0	1.7	5.1	52.1	21.2	27.1	59.3	37.5	76.0
	Grazed	6.4	2.3	9.6	74.9	23.8	48.9	98.0	62.5	90.0
Mesquite *(Prosopis juliflora* var. *velutina)*	Protected	0.7	3.8	5.3	17.4	47.7	28.2	13.1	26.2	42.0
	Grazed	0.8	5.3	5.9	8.9	55.0	29.8	16.2	31.2	51.2
Snakeweed *Gutierrezia microcephala*	Protected	—	T	1.1	—	T	6.0	—	T	38.0
	Grazed	0.8	1.1	2.6	9.9	11.4	13.0	45.0	51.2	60.0
Others	Protected	0.5	T	1.4	13.7	T	7.3			
	Grazed	0.5	0.8	1.6	6.1	8.2	8.1			
Total	Protected	3.8	8.0	18.8	100.0	100.0	100.0			
	Grazed	8.5	9.7	19.7	100.0	100.0	100.0			

T indicates a trace.

which is contrary to this species in other areas. It appears that the response of this species in this area is more affected by soil factors than other environmental influences.

Sideoats Grama. This palatable midgrass was found in moderate amounts on the protected range in 1941, had increased significantly by 1969, and had declined to a trace in 1980. It was found only in trace amounts in all three years on the grazed range. Similar results occurred in species composition and frequency. These data indicate that this species is strongly affected by both grazing and drought. It also appears that this species can compete successfully on this site with other species under normal rainfall and proper grazing conditions.

Other Perennial Grasses. Other perennial grasses were of minor importance on both the protected and grazed areas in 1941 and 1969. In 1980 they had made substantial increases on the protected area but were found only in trace amounts on the grazed area. Principal species on the protected area in 1980 were Bush Muhly, Purple Threeawn, Squirreltail and Vine-Mesquite (see Table 4 in the following section). Increases by these palatable grasses were due primarily to protection from grazing but increases by cool-season growers was also influenced by favorable winter moisture, shade tolerance, and fire.

Effects of Fire. The 1980 study on the effects of fires seven years after burning produced some interesting results on both classes and individual species of plants.

EFFECTS ON CLASSES OF PLANTS. The overall effect of fire on the protected area, seven years after burning, was to decrease total crown cover of trees and shrubs from 21.6% on the unburned area to 17.1% on the burned area (Table 3), which was not statistically significant. Also, the basal cover of grasses was 1.36% on the unburned area compared to 1.67% on the burned area (Table 4), again not significant. The basal cover of perennial forbs was too low for analyses of fire effects.

EFFECTS ON INDIVIDUAL TREES AND SHRUBS. The long-term

Table 2. Basal cover, composition and frequency of perennial grasses on protected and grazed ranges in the Page Ranch study area in 1941, 1969 and 1980.

Species	Range	Basal Cover %			Species Composition %			Plant Frequency %		
		1941	1969	1980	1941	1969	1980	1941	1969	1980
Arizona cottontop *(Digitaria californica)*	Protected	0.00	0.70	0.08	0.0	23.3	5.2	0.0	35.0	8.0
	Grazed	0.00	0.08	0.00	0.0	7.1	0.0	0.0	11.2	0.0
Cane beardgrass *(Bothriochloa barbinodis)*	Protected	0.18	0.27	0.02	11.8	9.0	1.3	24.4	30.0	1.0
	Grazed	0.02	0.02	0.00	16.7	1.8	0.0	1.9	3.7	0.0
Lehmann lovegrass *(Eragrostis lehmanniana)*	Protected	0.00	0.30	0.19	0.0	10.0	12.3	0.0	15.0	7.0
	Grazed	0.00	0.01	0.00	0.0	0.9	0.0	0.0	2.5	0.0
Poverty threeawns *(Aristida divaricata and hamulosa)*	Protected	0.15	0.37	0.17	9.9	12.3	11.1	21.9	35.0	11.0
	Grazed	T	0.32	0.01	T	28.6	100.0	1.2	47.5	1.0
Red threeawn *(Aristida longiseta)*	Protected	0.65	0.34	0.02	42.8	11.3	1.3	85.3	36.2	3.0
	Grazed	T	0.07	0.00	T	6.2	0.0	3.7	12.5	0.0
Rothrock grama *(Bouteloua rothrockii)*	Protected	0.30	0.35	T	19.7	11.7	T	75.6	53.7	2.0
	Grazed	0.06	0.52	0.00	50.0	46.4	0.0	39.4	51.2	0.0
Sand dropseed *(Sporobolus cryptandrus)*	Protected	0.00	0.08	0.02	0.0	2.7	1.3	0.0	13.7	4.0
	Grazed	0.00	0.05	0.00	0.0	4.5	0.0	0.0	6.2	0.0
Sideoats grama *(Bouteloua curtipendula)*	Protected	0.12	0.53	T	7.9	17.7	T	10.6	27.5	1.0
	Grazed	0.00	0.01	0.00	0.0	0.9	0.0	0.0	1.2	0.0
Others	Protected	0.12	0.06	1.04	7.9	2.0	67.5			
	Grazed	0.04	0.04	T	33.3	3.6	T			
Total	Protected	1.52	3.00	1.54	100.0	100.0	100.0			
	Grazed	0.12	1.12	0.01	100.0	100.0	100.0			

T indicates a trace.

effects of fire on individual trees and shrubs varied with species (Table 3). Effects on cover, composition and frequency were similar.

Buckwheat. Effects of fire on Buckwheat were negligible or favorable since by 1980 the crown cover of Buckwheat was slightly higher on the burned area.

Burroweed. This shrub was equally abundant on the unburned and burned areas in 1980. This represents a rapid recovery since it is highly susceptible to killing by fire (Cable, 1967). Undoubtedly the above normal winter moisture, reduction in grass competition due to the fire, and fertility from the ashes favored recovery.

Mesquite. The 1973 fires had a marked effect on Mesquite since, in 1980, Mesquite crown cover on the burned area was still about half that on the unburned area. This was also evident by the numerous young and old dead tree skeletons still standing in 1980. The fires must have been very hot since prior studies indicate low total kills by fire on Mesquites with stems over 5 cm in diameter (Cable, 1965, 1967).

Snakeweed. The crown cover of this shrub was only slightly less on the burned area than on the unburned area in 1980. As with Burroweed this represents rapid recovery since it is highly susceptible to killing by fire.

Other Trees and Shrubs. The principal other species in this category were cacti. Fire had a very significant effect on cacti since, in 1980, the cacti were still only 17% as abundant on the burned area as on the unburned. This probably represents

Table 3. Crown cover, composition and frequency of trees and shrubs on the protected unburned and burned areas in the Page Ranch study area in 1980.

	Crown Cover %		Species Composition %		Plant Frequency %	
Species	Unburned	Burned	Unburned	Burned	Unburned	Burned
Buckwheat	5.1	6.4	23.7	37.5	43	63
Burroweed	5.3	5.0	24.5	29.2	66	83
Mesquite	7.5	3.9	34.9	22.6	61	30
Snakeweed	1.3	1.0	6.1	5.9	43	35
Others	2.4	0.8	10.8	4.8		
Cacti (Opuntia)	2.3	0.4	10.5	2.6	40	9
Miscellaneous	0.1	0.4	0.3	2.2	3	11
Total	21.6	17.1	100.0	100.0		

Table 4. Basal cover, composition and frequency of perennial grasses on the protected unburned and burned areas in the Page Ranch study area in 1980.

	Basal Cover %		Species Composition %		Plant Frequency %	
Species	Unburned	Burned	Unburned	Burned	Unburned	Burned
Arizona cottontop	0.17	0.02	12.5	1.2	16.0	3.0
Cane beardgrass	0.06	T	4.0	T	1.0	1.0
Lehmann lovegrass	T	0.32	T	19.2	1.0	10.0
Poverty threeawns	0.03	0.27	2.4	16.2	4.0	16.0
Red threeawn	0.00	0.04	0.0	2.4	0.0	5.0
Rothrock grama	0.00	0.01	0.0	0.6	0.0	3.0
Sand dropseed	0.02	0.01	1.8	0.6	5.0	3.0
Sideoats grama	0.02	0.00	1.5	0.0	3.0	0.0
Others	1.06	1.00	77.8	59.8		
Bush muhly (*Muhlenbergia porteri*)	0.16	0.08	11.8	4.8	6.0	3.0
Purple threeawn (*Aristida purpurea*)	0.28	0.18	20.5	10.7	23.0	18.0
Squirreltail (*Sitanion hystrix*)	0.51	0.09	37.4	5.4	33.0	8.0
Vine-mesquite (*Panicum obtusum*)	T	0.56	T	33.5	1.0	3.0
Miscellaneous	0.11	0.09	8.1	5.4	4.0	6.0
Total	1.36	1.67	100.0	100.0		

T indicates a trace.

the degree of kill by fire since it is moderately susceptible to burning and recovery is rather slow (Cable, 1967).

EFFECTS ON INDIVIDUAL PERENNIAL GRASSES. Fire had some very interesting and varied effects on perennial grasses (Table 4). Effects on cover, composition and frequency were similar.

Arizona Cottontop. In the 1980 survey there was only about 10% as much Arizona Cottontop on the burned area as on the unburned. This indicates that this perennial-stemmed warm-season grass is highly susceptible to fire and that recovery is slow under below normal summer moisture conditions.

Cane Beardgrass. This grass was not very abundant on the protected area prior to the burning and most plants present were killed by the fires. As with Arizona Cottontop this indicates that this tall midgrass is highly susceptible to fire and that recovery is slow under below normal summer rainfall conditions. Also, since most plants were killed, the shortage of seed plants and scarcity of grazing animals to bring in seed further delayed recovery.

Lehmann Lovegrass. This introduced grass, which is highly susceptible to fire and one that reseeds rapidly (Cable, 1965, 1971), had not reached the unburned part of the protected area so comparison with the burned part was not possible. However, the large amount on the burned area in 1980 indicates that it had recovered rapidly from the fire even with subnormal summer precipitation.

Poverty Threeawns. In 1980, basal cover of these species was 10 times as great on the burned area as on the unburned. This indicates that fire favors their establishment. This response may be due to the ability of these warm-season grasses with cool-season growth tendencies to take advantage of above normal winter moisture, seed scarification by fire, reduced plant competition, fertilization from the fire ash, or a combination of the above.

Red Threeawn, Rothrock Grama, Sand Dropseed and Sideoats Grama. The levels of these species were too low on both burned and unburned areas to make evaluations.

Other Perennial Grasses. The basal cover of Bush Muhly, Purple Threeawn and Squirreltail was lower on the burned area while basal cover of Vine-Mesquite was greater. The lower cover of Bush Muhly probably resulted because of the high susceptibility of its shrubby stems to damage by fire. The lower levels of Purple Threeawn and Squirreltail on the burned area probably indicate recovery due to their ability to make early spring growth on favorable winter and spring moisture. Vine-mesquite is a sodgrass that grows mostly in swales where extra moisture is available so its distribution is limited. This is verified by frequency. Therefore the difference in Vine-mesquite on the two areas may be due to a sampling anomaly (because of its limited distribution) and/or site differences (such as higher soil moisture) which would reduce fire damage and increase recovery.

Conclusions

This study showed that mesquite is drought resistant and can rapidly invade desert grassland ranges regardless of protection from grazing but that competition from perennial grasses and fire can slow the invasion of Mesquite. For effective natural control it appears that a dense grass stand and very hot fires (more frequent than every 7 years) would be needed to effectively control Mesquite. These are conditions not likely to be found in drier desert grassland ranges such as the one studied. In the shrub category, Buckwheat, a desirable plant which was increased by protection, reduced by close grazing and resistant to drought and burning, can be maintained by proper grazing management. Also, the undesirable shrubs Burroweed and Snakeweed, which increased under close grazing and were reduced by grass competition, can be partially controlled by good grass management. In addition, both are susceptible to fire which can be used to aid in their control. Fire can also be used to control cacti but where fire is not desirable chemical or biological treatments may be needed.

In general the more palatable native perennial midgrasses, such as Arizona Cottontop, Cane Beardgrass and Sideoats Grama, were favored by protection from grazing during the early part of the study but the below normal summer rainfall between 1969 and 1980 killed most of these plants regardless of protection. Also, the short-lived Rothrock Grama which had increased on both grazed and protected ranges by 1969, was killed on both ranges by summer droughts.

In addition, Arizona Cottontop, Bush Muhly, Purple Threeawn and Squirreltail were reduced by fire. In contrast, Leh-

mann Lovegrass and the Poverty Threeawns were the most resistant of the perennial grasses to summer drought and both survived fire, Lehmann Lovegrass by revegetation and Poverty Threeawns by withstanding burning and/or by revegetation. Vine-mesquite, which grows in swales, also survived drought and burning, probably because of better soil moisture conditions. Therefore, these latter three species were the most stable of the perennial grasses for this area.

Perennial forbs, although little affected by summer drought or fire, were inversely affected by grass competition and therefore under good grass management they would make up a minor constituent of the forage complex on this site.

In summary, wide fluctuations in grass cover and marked increases in tree and shrub cover occur on the desert grassland even under complete protection from livestock grazing. Therefore, for range improvement to occur on this site, good grazing management combined with an effective means of Mesquite control plus natural or artificial revegetation of drought and fire resistant native or introduced grasses will be needed to protect this area against erosion and make it possible to use it for wildlife and livestock production. Based on this study Lehmann Lovegrass and/or related crosses such as Cochise Lovegrass *(Eragrostis lehmanniana* x *trichophora)* are leading candidates for this low elevation desert grassland site. For higher elevations where drought cycles are not so critical, mixed native species appear more desirable. In any case some form of continuing Mesquite control will be necessary to maintain productivity.

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Editorial

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Sorghum germplasm has been like putty in the hands of the plant breeder. We have reduced the internode length to make dwarf varieties easily harvested with a combine. We have "sorgos" with sweet stalks that yield syrup. We have grain types (Kaffir, Milo, etc.) used in making feeds for poultry and cattle. We have forage types like Sudangrass used for pasture, hay and silage. There are "broomcorn" types which have been selected to yield the stiff but tough straw for our traditional household broom.

There are many other grasses of great importance. The large number of field grasses nourish our beef animals and milk cattle. Small-grained crop grasses are lumped together under the name "millet." The average American is most familiar with them as the chief components of the birdseed sold in pet stores. They also are grown for forage and for mixing into stock feed.

The overall importance of grasses to the world's economy is staggering. Aside from the species discussed above there are heavy-weights such as Sugar Cane *(Saccharum officinarum)* and Rice *(Oryza sativa)*. Rice alone is said to feed half of the world's population! We have given the special name "cereal" to the grasses which have been adapted by man to yield enlarged easily harvested grains, adapting the name from the Greek goddess Ceres, the giver of man's staff of life. Although we have made some strides in adapting existing cereals to irrigated agriculture in arid lands, we have spent precious little time doing the reverse—looking for adapted arid land grasses to make into new cultivars. This latter approach has much to offer and may prove to be the breakthrough field of the future! It should theoretically be more advantageous to create a cereal or forage from a grass already adapted to arid lands than to use large amounts of fresh water for irrigating non-arid cereals in arid lands. Over 420 kinds of grasses grow wild in Arizona alone and more in other arid regions. We need to thoroughly screen these for potential use in bettering the lives of desert dwellers.