EFFECTS OF CONSERVATIVE GRAZING ON A DESERT GRASSLAND RANGE AS SHOWN BY VEGETATIONAL ANALYSIS

by

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INTRODUCTION

On many of the desert grassland ranges in southern Arizona there is an objectionable replacement of the more valuable forage species by unpalatable weeds and shrubs. Under the pressure of continued heavy stocking by range livestock, the highly-palatable perennial grasses have decreased in vigor, reproductive capacity, and abundance. This decline in density of the better forage species has led to an increase in the less palatable grasses and worthless shrubs.

Ranges on which the degree of stocking has been excessive bear the imprint of grazing in their low-density vegetation which consists in large measure of unpalatable plants. Reduction of grazing pressure through conservative grazing allows a greater volume growth of species palatable to livestock, resulting in changes in species composition and density on ranges formerly heavily stocked. Progressive plant succession will continue under the influence of the lightened grazing pressure until a dynamic equilibrium is reached between the vegetation and its environment.

To determine the differences in species composition

and density between an overgrazed range and a reclaimed range in the semi-desert grassland type, an intensive sampling study was undertaken on the Page-Trowbridge Experimental Ranch.

THE STUDY AREA

Location

The Page-Trowbridge Experimental Ranch and adjoining overgrazed range (Plate I) near Oracle in southern Pinal County were selected for a detailed vegetational analysis. The reclaimed portion of the Page-Trowbridge Experimental Ranch used in the investigation is the half-section formerly owned by Mr. J.T. Page, and is often referred to as the Page Ranch. The Page Ranch comprises the south half of Section 27, T. 9 S., R. 14 E. of the Gila and Salt River Base Line in Arizona. The contrasting overgrazed half-section of the Page-Trowbridge Experimental Ranch adjoining the south boundary of the conserved area was not sampled in the present study; instead, the overused range adjoining the eastern boundary of the Page Ranch was selected (Plate II).

Vegetation

The study area, lying at an elevation of 3700 feet, is located in the upper portion of the Lower Sonoran Zone. As classified by Nichol (18, pp. 198-201 and map)*, the

*Numbers in parentheses refer to Bibliography.

general vegetation of this area is "desert grass." The main dominants are members of the grama tribe, including black, slender, and Rothrock grama. Narrow strips of mesquite follow the drainage systems, often spreading out onto the adjoining mesas. Scattered over the range are soapweed, cholla, and prickly pear.

At present, Upson et al. (26, p. 5) consider the principal plant cover in this area to be burroweed; the "balance mesquite, snakeweed, cactus, and minor species. Some grass." Mesquite, associated with the burroweed, probably yields more forage than the small amount of grass present on the overused range. Perennial grasses are generally in poor condition due to the effects of erosion and heavy use.

Climatic Factors

The climate of the Page-Trowbridge Experimental Ranch and surrounding area is characterized by two distinct rainy seasons, with hot summers and mild winters, as shown by the hythergraph in Figure 1. Climatic data are from the Oracle Station, located seven miles east of the Experimental Ranch. The elevation of Oracle is 4300 feet, whereas the elevation of the study area is 3700 feet.

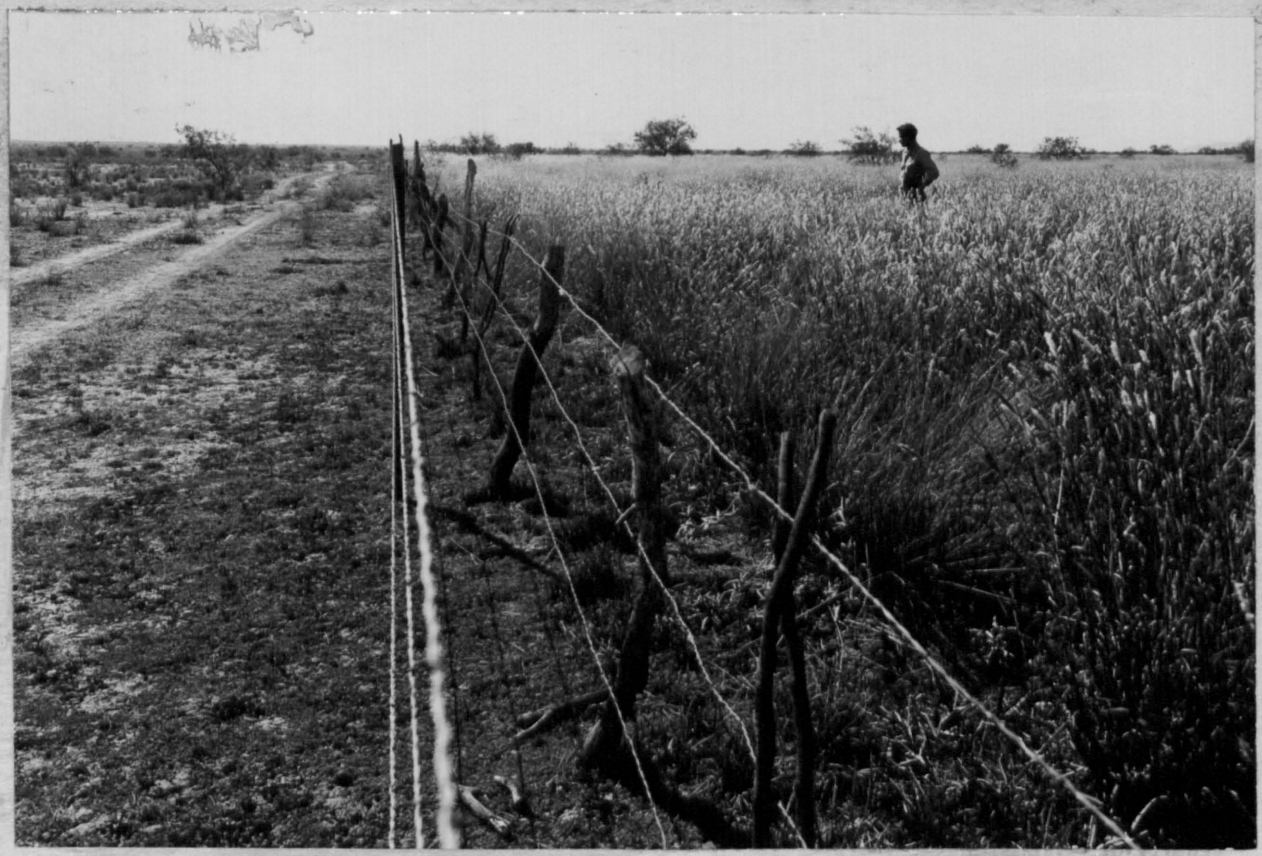
The annual precipitation (8, p. 763) based on a 35-year average for Oracle is 19.71 inches. The bulk of the

Plate I

-Soil Conservation Service

Aerial view of the study area taken from the northwest. The darker area is the conserved area, this aspect being due to the heavier stand of perennial grasses.

Plate II



-Soil Conservation Service

Fence line contrast on the study area. The conserved range (Page Ranch) is on the right, the overgrazed range on the left. The vegetation shown in the photograph on the conserved range is primarily cane beardgrass and mesquite; whereas on the overused area it is chiefly burroweed, annuals, and mesquite.

summer rain falls from July to September, and the winter rainy period is from December to March. The period from April to June and the months of October and November are usually very dry.

Rainfall records have been maintained since 1940 on the Page Ranch by the Soil Conservation Service. Comparison of the rainfall for Oracle and for the corresponding period on the Page Ranch is summarized in Table 1.

The average January temperature for Oracle is 46 degrees, and the July average is 80 degrees, with January minimums often below freezing and July maximums above 100 degrees. Smith (19, p. 362) states "The greater daily temperature ranges in the State vary from 45 to 65 degrees, although the average daily range is near 30 degrees." The frostless season is seven and one-half months, extending from the last of March to mid-November.

No specific data are available for the study area concerning evaporation, wind velocity, and humidity. The evaporation rate, as a rule, for the desert grassland type is high, especially during the summer months. At the University of Arizona at Tucson the precipitation-evaporation ratio is 1 to 7.7. Smith (19 p. 412) states that this ratio "may be assumed to be representative of large portions of southern and central Arizona where similar conditions prevail."

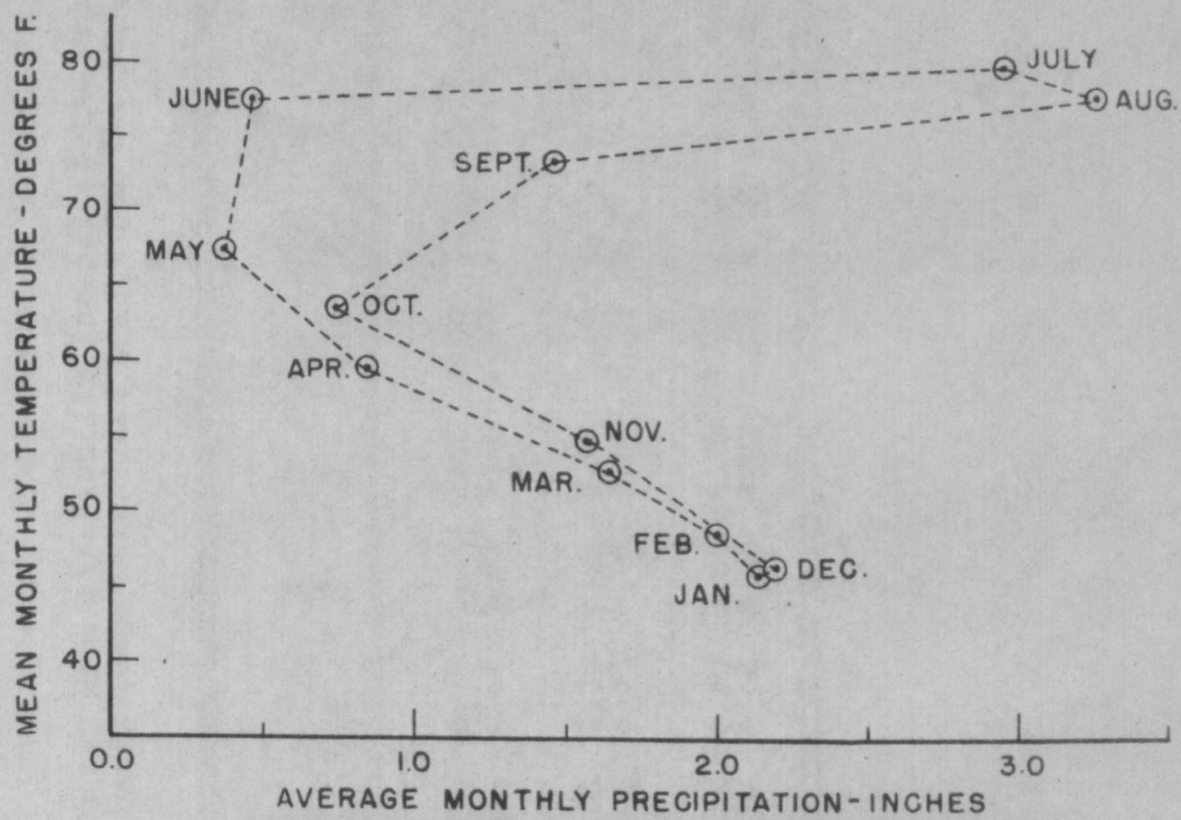


Fig. 1 - Hythergraph for Oracle, showing average monthly temperatures and precipitation.

Table 1. Monthly and Yearly Precipitation (in inches) at the Page-Trowbridge Experimental Ranch (Page Ranch) and Oracle for the period 1940-42.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1940													
P-T			0.05	0.67	0.35	1.39	1.58	0.68	2.81	0.71	3.66	5.20	17.10*
Oracle			0.12	1.41	0.48	1.99	1.28	2.38	2.02	0.99	4.13	5.68	20.48*
1941													
P-T	1.37	3.91	2.91	2.04	0.39	0.34	0.83	4.16	1.71	0.71	1.38	2.69	22.44
Oracle	2.25	3.38	3.47	2.02	0.75	0.06	1.60	3.79	3.39	0.72	2.60	3.04	27.87
1942													
P-T	1.02	1.60	0.81	1.50	0.00	0.00	0.74	1.69	1.48	0.63	0.00	1.76	11.23
Oracle	0.83	2.76	0.78	1.96	0.00	0.00	3.21	3.02	2.10	1.03	0.00	2.03	17.72

*Total for ten-month period

In general, prevailing winds are from the north, northwest, south, or southwest. For the area as a whole, the maximum wind velocity is not high and the annual velocity is low. Desert whirlwinds or "dust devils" are frequent, but are not of a destructive nature.

Low absolute humidity and high temperature make extremely low relative humidities common. From January the relative humidity drops regularly to May and June, the driest months in the year. The summer rains of July and August raise the average humidity, but not to as high a peak as the December-January humidity. The fall period is characterized by low humidity due to lack of rain. In November, cooler weather brings an increase in humidity, which reaches a maximum in the year for December.

Physiographic and Edaphic Factors

The study area is located on the lower reaches of the northwest side of the Santa Catalina Mountains. The general slope is westerly, and is not in excess of 10%.

Soils on the Page-Trowbridge Experimental Ranch and adjoining area are transported soils of an alluvial fan near the north base of the Santa Catalina Mountains. The soils are derived from granitic and other quartz-bearing rocks. Generally the surface horizons are leached of lime, and are characterized by a zone of lime accumulation at a

depth of 30 to 36 inches. The soils belong to the Reddish-Brown Group (21 p. 1092), and are developed under a warm temperate climate with hot summers and mild winters.

In an unpublished report, the Soil Conservation Service (5) lists the soil series on the Page Ranch as follows:

1. The Continental Series, derived mainly from granitic material, is the most extensive soil on the Page Ranch.

2. The Page Series, a recent alluvial soil derived from granitic material. It is a transported soil, being found in the narrow drainageways in the central portion of the ranch, lying below the Continental soils.

3. The Oracle Series, a slightly-developed soil of granitic origin, lying between the Continental and Page soils. It is found chiefly in the southeast portion of the Ranch.

4. The Trowbridge Series, a transported soil of granitic origin, is highly calcareous throughout the profile. It occurs in the central and extreme southwest portion.

On these soil series, no one species of grass is a definite indicator of a specific series. Due to its location in drainageways, the Page series supports the highest density of grasses. The dominant species on this series are the perennial three-awns, side oats grama, and Rothrock grama. The Oracle and Continental series are characterized by perennial three-awns, side oats grama, and silver beardgrass. Fluff grass, black grama, and the perennial

three-awns comprise the chief grass species on the Trowbridge series.

The problem of soil erosion is more serious on the overused area than on the conserved portion. On the Page Ranch gullies are shallow and the vegetation is reclaiming all past cutting. Evidences of recent cutting or the establishment of new erosion channels are lacking. On the overgrazed area, many deep gullies have been cut due to lack of cover for retention of runoff from adjacent areas. In the northern portion, gullying is serious and some of the gullies serve as barriers to cattle movement due to their steep, vertical banks. The number of new erosion channels is high; in one area near a major drainage, 5 gullies one foot wide and one to three feet deep were under or near the sample unit. Large deposits of sand and silt have been formed where the gullies enter the eastern boundary of the Page Ranch. This deposition is due to the slowing down of the run-off.

Biotic Factors

Following the settlement of southern Pinal County about 1870, large numbers of cattle and sheep were brought in and a grazing system of double use established. Available information indicates that grazing in the late eighties was probably heavy, but forage use did not become

destructive until the middle nineties. Sheep have been removed in recent years, but unregulated use by cattle has continued. At present, deterioration of the palatable forage plants has become serious enough to be well marked over most of the area.

One of the earliest conservation practices initiated by Mr. Page on the conserved area under study was a reduction in the number of stock. He grazed from 3 to 7 head year long, but eventually these were sold due to lack of available water. At present, the conserved area is not utilized by stock.

The range adjoining the conserved area has been continuously stocked in excess of grazing capacity based on conservative stocking rates. On Page's half-section the estimated grazing capacity is 10 head, or 20 per section yearlong, whereas on the overused area actual stocking rate is six animal units per section yearlong. For the desert grassland type as a whole, McArdle et al. (13, pp. 92-94) estimate the capacity of the virgin range to be 19 head of cattle per section yearlong, and on the present overgrazed range to be eight animal units per section yearlong.

The most conspicuous rodents in the area include the wood rat, banner-tailed kangaroo rat, and the ground squirrel. Also present, but not in great abundance, are

the antelope and blacktail rabbit and the cottontail. Vorhies (27) considers these small animals to act as "animal weeds" and to be "in part at least an effect of overgrazing rather than a cause." Due to Mr. Page's flooding of rat dens as a means of control (see Plate III), there are very few active dens on his ranch. However, on the overgrazed area the number of dens per acre is high, especially in the southern portion of the study area.

History of the Experimental Area

As evident from published records and reports of older residents, the area which includes the Page-Trowbridge Experimental Ranch has been grazed since the 1870's by cattle and sheep without regard for range conservation. On this depleted range area in 1923, Mr. J.T. Page purchased a half-section of land with the intention of dry farming. Failing at crop agriculture, Mr. Page endeavored to restore the range to its former condition. He built dikes and small dams and dug miles of trenches to conserve the rain and run-off water. He controlled noxious pests, weeds by grubbing and animals by flooding. As a result of his range and soil conservation efforts, the grass cover has been restored and the soil has been greatly improved in its productiveness.

In the fall of 1940, to preserve the work of Mr. Page, his land was purchased by Mr. W.B. Trowbridge and presented to the University of Arizona. Later, Mr. Trowbridge purchased the adjacent overgrazed half-section to the south and presented this additional area to the University. At present the University of Arizona,and the Soil Conservation Service, and the Southwestern Forest and Range Experiment Station are conducting experiments on soil and moisture conservation on the two half-sections.

Several popular articles have been written in the past few years, telling of Mr. Page's efforts to "bring the desert into flower."

Musgrave (17) speaks of Mr. Page as the "Miracle Maker of the Rangeland," telling how vision, plus hard work with a shovel, has stopped gullying at the fence line and brought about a stand of perennial grasses.

Vorhies (27) mentions Page's effort to conserve the moisture by flooding the rat dens. The rats were forced to leave and the stored seeds sprouted with addition of moisture.

Beutner (1) reported that at present the Page Ranch could "easily support 20 head of cattle, while a pasture of similar size in the desert-like area outside the fence would provide sustenance for only a few head."

In a technical report McIlvanie (15, pp. 29-31) concluded that the

> "overgrazed (outside) range has a more homogeneous vegetation composed of less species than the conserved (inside) range. There were 23 species outside and 33 inside.--- In composition by numbers of individuals, the inside area has 41.47% Rockrock grama and perennial three-awn, outside 71.70% is annual alfilaria and annual grama."

In a greenhouse study McIlvanie (16) found that successful establishment by seeding of two species of grass (Eragrostis Lehmanniana and Panicum antidotale) was obtained on soil from the overgrazed area west of the Page Ranch, but that no seeds germinated on the protected soil. Algae and moss covered the protected soil and prevented contact of the seeds with the mineral portion. Pot tests with four different kinds of plants "showed the protected soil to be twice as fertile as the overgrazed in terms of dry weight produced."

Sullivan (23), studying the influence of alfalfa, alfilaria, and native grass on properties of the Continental Series of soils on the Page-Trowbridge Experimental Ranch, found that surface mulching by organic matter increased the rate of infiltration, decreased run-off, and reduced erosion. The increased infiltration into the mulched soil favored establishment of twice as many grasses as were established on the undisturbed, untreated soil.

Beutner and Anderson (2), studying the effect of surface mulches, demonstrated that the vegetative cover of perennial grasses established on the Page Ranch has covered the soil between the plants with litter. This litter is effective in promoting absorption of water, so that almost all of the rainfall soaks into the soil. With this retention of moisture, the gullies have healed and a stabilized soil has resulted. On the adjacent depleted range, characterized by a remnant of the palatable grasses and a high density of shrubs, run-off is high and gully erosion is active. Beutner and Anderson conclude:

> "The importance of surface mulches in conserving water and soil cannot be overemphasized. Their maintenance should, wherever possible, be part of the range-management plan. They offer the most effective soil and water conservation measures and are more economical than many other artificial methods."

COLLECTION AND ANALYSIS OF THE DATA

The line interception method of Canfield (3) (4) was used in sampling the vegetation on the conserved and over-used ranges. Data on both areas were collected during the spring of 1941. To obviate the chance of concentrating all samples in one part of the area, each half-section was subdivided into eight 40-acre blocks. Twenty sample units were arbitrarily selected as the number of observations necessary within each individual block. The individual sampling unit was a line 50 feet in length.

Random distribution of sampling units within a block was obtained by the following procedure. A field map was prepared subdividing the area into 40-acre blocks, the south and west boundaries serving as coordinates. Randomly-selected numbers, taken in pairs from Fisher and Yates (6) table of random numbers, were plotted on the coordinates to locate the position of each sample unit. Each sample unit was located in the field by pacing from the western or eastern boundary of the block to the position indicated by its coordinate values. The 50-foot sample lines were then laid out in a north-south direction, using the predetermined point as the southern terminus.

The following measurements were made on each 50-foot line:

1. Living perennial grasses were measured at ground level.
2. Perennial herbs other than grasses were likewise measured at ground level. Stem-diameter measurements were taken for single-stemmed plants, and measurements of basal leaves intercepted were made on plants of a rosette-growth-form.
3. Living shrubs were measured on the crown spread as intercepted by the vertical projection of the line. This manner of measurement places shrubs in a different class of vegetation from grasses and weeds; hence, density is not directly comparable with that of herbaceous plants.
4. The number of spring annuals other than alfilaria occurring under the line were counted. Alfilaria was measured on the basis of ground covered.

English units were used, and measurements were made to the nearest 0.1 foot.

Following the completion of sampling each block, the field data were compiled, and the mean and standard errors of the total grass cover were determined, to test the adequacy for the block sample. Accuracy of sampling intensity for each block was tested by calculation of standard errors by Bessel's formula (20, p. 54).

Sampling accuracy was based on the standard error of the total grass cover, and the sample was considered sufficiently accurate if the mean exceeded its standard error by 3 or more times. The accuracy of sampling the shrub cover was tested in a similar manner. Observation of

the total means with their standard errors in Tables 2 and 3 reveals that 20 lines, each 50 feet long, are a valid sample of 40 acres of the mixed-grass type under consideration.

In a similar manner, standard errors for the dominant species were calculated. If a dominant species did not occur on at least ten lines per block, calculation of the standard error was omitted for that species.

Mean feet intercepted by species and by total grass-forb and browse cover were calculated for the conserved and overused areas. Density, as expressed in Tables 2 and 3, is the computed percentage of the ground surface actually occupied by herbaceous plants and the percent ground covered by the crown spread of shrubs as intercepted on the sample line. This series of values is similar to density estimates, and may be used for the same purposes.

RESULTS

Perennial Herbs

Data on the mean feet of grasses and forbs intercepted at ground level on 40-acre blocks, density of percent of ground occupied, and percentage composition on conserved and overused ranges are shown in Table 2.

Conserved area: The vegetation of the conserved range consists of a mixed grass-shrub type, and the herbaceous dominants include the perennial three-awns (Aristida divaricata, A. longiseta, and A. purpurea)* and Rothrock grama (Bouteloua rothrockii). As shown by Table 2, these species embrace nearly 60% of the total grass and forb cover. Perennial three-awns comprise 44.5%, and Rothrock grama 16.7% of the herbaceous vegetation.

Several other grasses are of importance on the conserved range. Ranking next to the dominants in percentage composition is cane beardgrass (Andropogon barbinodis). The densest stands of this grass are in the southeast portion of the Page Ranch. Also conspicuous in the southeast portion is side-oats grama (Bouteloua curtipendula), which

*Common and scientific names are based on the Range Plant Handbook prepared by the U.S. Forest Service (1937), and Flowering Plants and Ferns of Arizona by T.H. Kearney and R.H. Peebles (1942).

Table 2. Mean feet of grasses and forbs intercepted at ground level on 40-acre blocks, density and percentage composition on conserved and overused ranges. Measurements determined by line interception method on 50-foot sample units.

Block numbers	Perennial three-awns	Rothrock grama	Cane beardgrass	Misc. grama	Misc. grasses	Forbs	Total
			Conserved Range				
1	0.71 ± .16	0.13 ± .03	0.07	0.07	0.00	0.10	1.08 ± .21
2	0.37 ± .06	0.30 ± .06	0.04	0.00	0.02	0.06	0.79 ± .08
3	0.22 ± .08	0.23 ± .04	0.12	0.14	0.03	0.22	0.96 ± .21
4	0.19 ± .04	0.18 ± .03	0.06	0.31	0.01	0.01	0.76 ± .26
5	0.20 ± .05	0.14 ± .02	0.07	0.01	0.00	0.05	0.47 ± .07
6	0.48 ± .08	0.06 ± .01	0.14	0.03	0.00	0.04	0.75 ± .12
7	0.65 ± .13	0.10 ± .05	0.03	0.11	0.06	0.30	1.25 ± .29
8	0.44 ± .15	0.03	0.18	0.06	0.12	0.33	1.16 ± .41
Mean (ft)	0.40 ± .17	0.15 ± .03	0.09	0.09	0.03	0.14	0.90 ± .09
Density (%)	0.80	0.30	0.18	0.18	0.06	0.28	1.80
Composition(%)	44.5	16.7	10.0	10.0	3.3	15.5	100.0
			Overused Range				
9	0.00	0.02	0.00	0.00	0.08	0.02	0.12
10	0.00	0.01	0.00	0.00	0.00	0.02	0.04
11	0.00	0.01	0.00	0.00	0.01	0.02	0.04
12	0.00	0.01	0.00	0.00	0.02	0.01	0.04
13	0.00	0.01	0.00	0.00	0.01	0.02	0.04
14	0.00	0.04	0.06	0.00	0.00	0.04	0.14
15	0.01	0.07	0.00	0.00	0.01	0.01	0.11
16	0.01	0.08	0.00	0.00	0.01	0.03	0.13
Mean (ft)	0.00	0.03	0.01	0.00	0.01	0.02	0.07
Density (%)	0.00	0.06	0.02	0.00	0.02	0.04	0.14
Composition (%)	Trace	42.8	14.3		14.3	28.6	100.0

occurs in small patches over the remaining area. The other important grama grass is black grama (B. eriopoda), the densest stands of which are in the northwest and south-central portion of the Ranch. Some of these stands are nearly pure and comprise several square feet in area. Other gramas occurring as traces include slender grama (B. filiformis) and hairy grama (B. hirsuta). Miscellaneous grasses include Johnson grass (Sorghum halepense) and Panicum spp. in the eastern portion of the range, with fluffgrass (Triodia pulchella) and curly mesquite (Hilaria belangeri) in the northern portion. A few small patches of sand dropseed (Sporobolus cryptandrus), bush muhly (Muhlenbergia porteri), and Arizona cottongrass (Trichachne californica) were observed, but did not occur within the sample units.

Perennial herbs, because of their relative unimportance from the grazing standpoint, are grouped together. On the conserved area, perennial forbs comprise 15.5% of the total herbaceous cover. The more abundant perennial herbs include wild daisy (Erigeron concinnus), Gaura coccinea, and ragweed (Franseria tenuifolia). In the northwest portion, desert holly (Perezia nana) is abundant.

Overused area: The density of perennial grass species is low on the overused area. The principal dominant in the

herbaceous cover is Rothrock grama, with a composition of 42.8%. The scarcity of grasses on the overused area becomes apparent when it is observed from Table 2 that the ground covered by this dominant is 0.06%.

Other grasses on the overused range occur in very limited amounts, as shown by Table 2. Scattered over the area are fluffgrass and cane beardgrass, and in the southeast portion perennial three-awns are present. Traces of side-oats grama were observed, but none occurred on the sample units.

On the overused range perennial herbs comprise 28.6% of the herbaceous cover. Senna (Cassia bauhinioides) is the most abundant weed on this area. Wild daisy, Gaura, and ragweed occur as traces.

Shrubs

Data on the mean crown spread in feet of shrubs intercepted on 40-acre blocks, density or percent of ground occupied, and percentage composition of conserved and overused ranges are shown in Table 3.

Conserved area: The most abundant shrub on the conserved range is burroweed (Aplopappus tenuisectus), which comprises 52.0% of the total shrub cover. The distribution of burroweed has been affected by the activity of Mr. Page in the eradication and control of woody shrubs. Burroweed

Table 3. Mean crown spread (feet) of shrubs intercepted on 40-acre blocks, density, and percentage composition on conserved and overused ranges. Measurements determined by line interception method on 50-foot sample units

Block numbers	Wright buckwheatbrush	Burroweed	Snakeweed	Cactus	Mesquite	Misc. browse	Total
			Conserved Range				
1	0.54	0.79	0.00	0.01	0.07	0.00	1.41 ± .51
2	0.67	0.94 ± .22	0.00	0.29	0.35	0.00	2.25 ± .52
3	0.37	1.63 ± .27	0.00	0.03	0.00	0.00	2.03 ± .31
4	0.62	2.05 ± .39	0.00	0.12	0.05	0.00	2.99 ± .48
5	0.37	1.84 ± .40	0.00	0.07	0.86	0.15	3.14 ±1.05
6	0.00	0.61	0.00	0.00	0.66	0.00	1.27 ± .67
7	0.00	0.00	0.00	0.00	0.39	1.27	1.66
8	0.00	0.06	0.00	0.05	0.28	0.06	0.45
Mean (ft.)	0.32	0.99 ± .28	0.00	0.07	0.33	0.19	1.90 ± .31
Density (%)	0.64	1.98	0.00	0.14	0.66	0.38	3.80
Composition (%)	17.0	52.0		3.6	17.4	10.0	100.0
			Overused Range				
9	0.00	3.97 ± .58	0.35	0.25	0.61	0.18	5.36 ± .74
10	0.00	3.03 ± .45	0.70±.21	0.04	0.46	0.27	4.50 ± .71
11	0.02	2.32 ± .36	0.64±.18	0.06	0.08	0.34	3.45 ± .50
12	0.00	2.15 ± .38	1.00±.34	0.04	0.51	0.00	3.70 ± .71
13	0.01	1.58 ± .39	0.31±.13	0.03	0.47	0.24	2.63 ± .64
14	0.00	1.95 ± .37	0.30±.11	0.15	0.27	0.00	2.67 ± .39
15	0.00	4.99 ± .46	0.07	0.29	0.62	0.10	6.07 ± .68
16	0.00	5.50 ± .69	0.00	0.11	0.02	0.00	5.64 ± .69
Mean (ft.)		3.19 ± .52	0.42±.12	0.12	0.38	0.14	4.25 ± .47
Density (%)		6.38	0.84	0.24	0.76	0.28	8.50
Composition (%)	Trace	75.0	9.9	2.8	9.0	3.3	100.0

occurs in greatest abundance on the conserved area on the two westerly blocks (4 and 5), whereas only traces are present in the southeast corner (blocks 7 and 8). As Mr. Page seldom grubbed in the west portion, burroweed in this area has been but little disturbed.

To test for a significance of difference between the means of the various blocks, the method outlined by Girard and Gevorkiantz (7, p. 116) was employed. Blocks that showed no significance of difference between themselves were grouped. The following results were obtained:

1. A trace in the southeast corner (blocks 7 and 8).
2. A light stand in the middle and northeast portion (blocks 1, 2, and 6).
3. A medium stand along the west end (blocks 3, 4, and 5).

As shown in Table 3, several other shrubs are of importance on the conserved area. Ranking next to burroweed in percentage of total shrub cover is mesquite (Prosopis juliflora var. velutina). It is uniformly distributed on the Ranch and occurs in greatest abundance in the washes. The density of mesquite is increasing, for several young trees were noted during the course of the survey. The average age of the trees does not exceed 20 years, according to Mr. Page,* who stated that there were few

*Verbal communication.

trees on the area in his first years of ownership. In fact, Mr. Page attempted to increase the stand of mesquite by planting seed, but the results were a failure. Nearly equal to mesquite in density is Wright buckwheatbrush (Eriogonum wrightii), which reaches greatest abundance on the north portion of the Ranch. As Mr. Page grubbed this plant, only traces of the shrub are found near his home.

Other shrubs are found on the conserved area in less abundance. These include soapweed (Yucca elata) in the southeast and northwest portions; prickly pears and chollas (Opuntia spp.) and a few bisnagas (Echinocactus wislizeni) along the north and west boundaries; and a small stand of broom baccharis (Baccharis sarothroides) west of Page's residence. Other shrubs scattered over the area include catclaw (Acacia greggii), wait-a-minute bush (Mimosa biuncifera), desert thorn (Lycium sp.), desert hackberry (Celtis pallida) and Desmanthus cooleyi.

Overused area: As on the conserved area, the most abundant shrub on the overused area is burroweed, comprising 75.0% of the total shrub cover. The most abundant growth of burroweed was noted along the eastern boundary, particularly in the southeast corner (blocks 15 and 16). The smallest number of burroweed plants was adjacent to the eastern boundary of the conserved area (blocks 12 and 13)

and along the south boundary (block 14).

Test of significance of difference between blocks yielded the following results:

1. A medium stand over most of the area west of the road shown in Plate I (blocks 10 to 14 inclusive.)
2. A heavy stand in the northeast corner (block 9).
3. A dense stand in the southeast corner (blocks 15 and 16).

The abundance of burroweed along the eastern boundary of the overused area is probably due to soil conditions. Before destructive grazing brought about its results, this portion was a swale with deep soil, serving as a natural water-spreading area. Depletion of the cover resulted in a site favoring the establishment of a dense stand of burroweed.

As shown in Table 3, several other shrubs are abundant on the overused area. Snakeweed (Gutierrezia spp.) is abundant over most of the range, except in the southeast portion where only traces were sampled. As in the conserved area, mesquite is uniformly distributed and is confined principally to the washes.

Other shrubs present include soapweed in the southeast portion with prickly pears, chollas, and bisnagas uniformly scattered over the overused area. Minor shrubs of the overgrazed range are similar to those on the conserved area.

Comparison of Perennial Vegetation on the Conserved and Overused Areas

Marked improvement in the herbaceous vegetation has occurred on the conserved area as contrasted to the overused range (Figure 2). The improvement has been in both the amount of vegetation and the kind and quality of the plants making up the cover. The results of improved management as compared with unregulated grazing are summarized as follows:

1. The density of grasses and forbs is 1.80% on the conserved area and 0.14% on the overgrazed area. Shrub density, in terms of total crown spread, is 3.80% on the conserved area and 8.50% on the overused area.

2. On the conserved area, perennial three-awns are dominant in the herbaceous vegetation, whereas on the overused area they occur as traces.

3. Based on composition, Rothrock grama and forbs are more abundant on the overused area than on the conserved range; but, on the basis of mean density, these two components cover a higher percentage density on the conserved area.

4. Presence of better forage species, such as black grama, and a lack of poor species, i.e., fluffgrass, on the conserved area as contrasted to a lack of good forage plants and presence of poor species on the overgrazed area.

5. An average lower density of burroweed on the conserved area as compared with that of the overused area. The difference in density of burroweed is significant statistically on the two areas based on the averages of all blocks. However, there is no significant difference in density of burroweed if the "medium stand" of the conserved area (blocks 3 to 5) is compared with the stand west

of the road on the overgrazed area (blocks 10 to 14 inclusive).

6. Density of mesquite, in terms of percent ground occupied, is greater on the overused range than on the conserved range. However, this difference in mean densities is not statistically significant.

7. Wright buckwheatbrush is found in greatest abundance on the conserved range, whereas only traces of this palatable shrub are on the overused range.

8. Snakeweed is abundant on the overused area, whereas on the conserved range none were measured and only two or three plants were observed near the sample lines.

Thus, in terms of the combined densities of grasses, forbs, and browse, the overused area has a greater density than the conserved range. This higher density of the overused range, however, is more apparent than real, due to the inequalities in measurement of shrub and grass components.

Annual Vegetation

Table 4 shows the analysis of annual vegetation on the conserved and overused areas, and lists for alfilaria (Erodium cicutarium) the average ground spread and density by individual blocks. Total number per block and average number of annuals other than alfilaria are also shown.

As sampling was conducted during the spring months, the most abundant annual on the two areas was alfilaria. Average density of this species on the protected area was 19.8%, and on the overused area 18.8%. Due to the

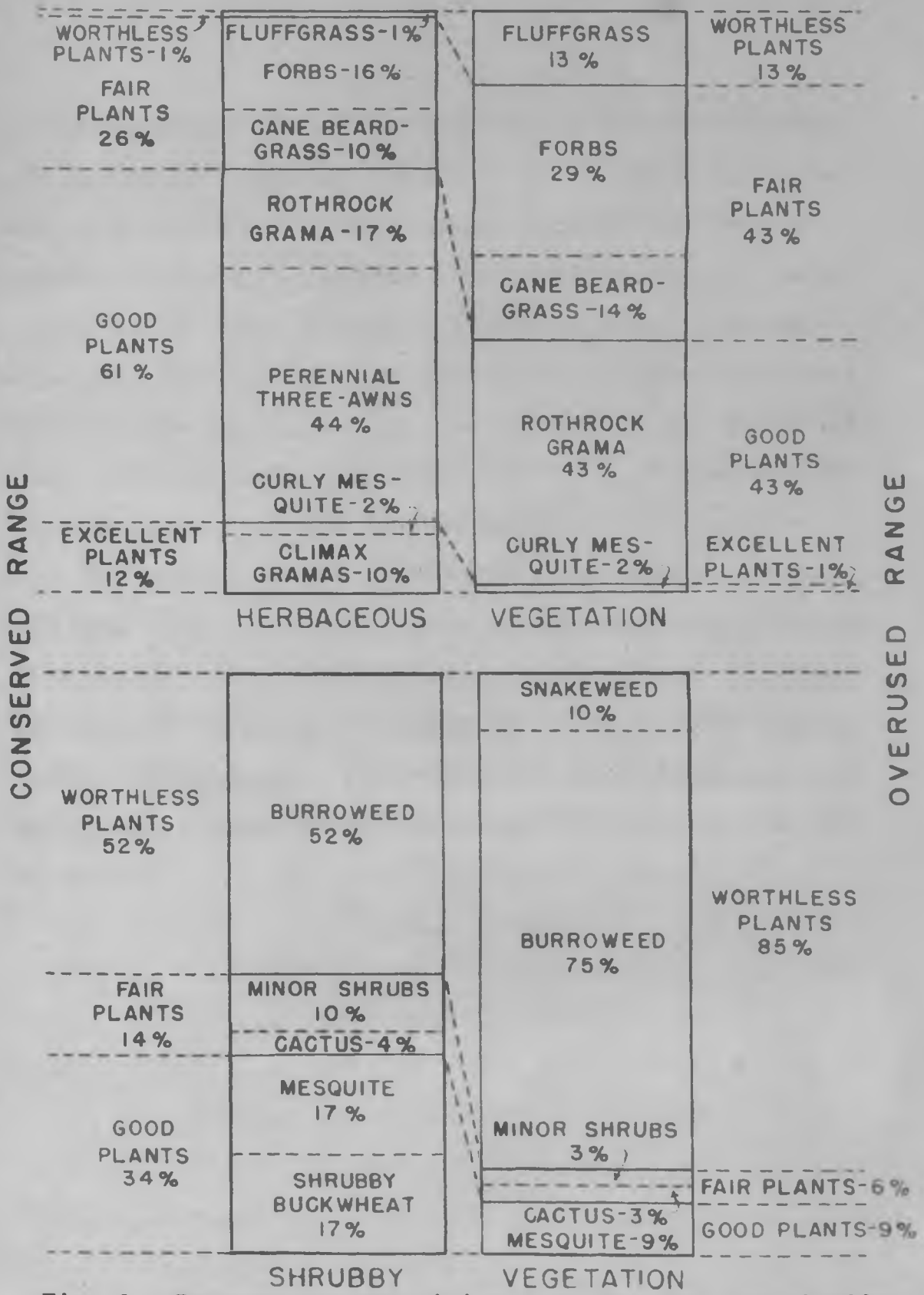


Fig. 2 - Percentage composition of herbaceous and shrubby vegetation on the conserved and overused ranges of the study area.

extremely favorable moisture conditions existing during the period of sampling, the yield of alfilaria was high; and in places the brilliant green color of this annual caused the range to resemble a cultivated pasture. As a result of the added run-off moisture received from the adjacent area, the greatest percentage of ground occupied by alfilaria was in the southeast corner of the conserved area. The southwest portion of the overused area had the highest density of this spring annual.

The average number of annuals other than alfilaria was 19.6 plants per sample unit on the conserved area, and 21.2 plants on the overused area. Indian wheat (Plantago sp.), vetch (Vicia sp.), Baeria sp., owl's clover (Orthocarpus purpurascens), and California poppy (Eschscholtzia californica) were the principal species found at the time of sampling.

Table 4. Mean feet and density on 40-acre blocks for alfilaria on conserved and overused ranges, and total number of other annuals counted on the 20 lines per block. Alfilaria measurements determined on 50-foot sample units by the line interception method.

Block Numbers	Alfilaria		Total number of other annuals
	Mean feet	Density	
	Conserved Range		
1	8.9	17.8	433
2	6.4	12.8	435
3	7.1	14.2	432
4	7.3	14.6	487
5	6.2	12.4	449
6	13.3	29.6	403
7	15.9	31.8	386
8	14.4	28.7	122
Average: per block	9.9	19.8	393
per line			19.6
	Overused Range		
9	10.2	20.4	505
10	9.6	19.3	478
11	11.0	21.9	337
12	3.7	7.4	567
13	11.4	22.9	355
14	18.0	36.0	275
15	4.3	8.7	506
16	6.6	13.1	380
Average: per block	9.4	18.8	425
per line			21.2

DISCUSSION

Historical Background of Vegetation Changes

History of the range area, gained from interviews with old residents and consultation of early publications concerning range management, is valuable as an aid to the interpretation of present trends. The history gives indications as to whether the present vegetation is stabilized or changing, evidence of past damage, and other facts useful in analyzing ecological developments.

McArdle et al. (13, p. 93) state that the semi-desert grass of southern Arizona is "one of the most severely depleted range types of the entire west." Formerly, in southern Pinal County, there was a rich stand of grama grass and the country, as one early stockman put it, "looked like a vast wheat field." As late as 1879 the area was described as knee-deep in waving grama and other grasses. Probably the decline of the range was intensified by the drought of 1890 and 1891, accompanying the overstocked condition of the range at that time. During this period practically no rain fell, and the cattle from the overstocked San Pedro Valley drifted in to consume the already sparse feed. By 1901 Griffiths (9) reports misuse

of the range country, with destruction being nearly complete. Speaking of the area around Oracle, a rancher (9, pp. 13-14) on the San Pedro said in 1900:

> "Of the rich grama grasses that originally covered the country so little now remains that no account can be taken of them.
>
> .....
>
> "Twelve years ago 40,000 cattle grew fat along a certain portion of the San Pedro Valley where now 3,000 head can not find sufficient forage for proper growth and development. If, instead of 40,000 head 10,000 had been kept on this range, it would in all probability be furnishing good pasture for this same number today. Very few of these cattle were sold or removed from the range. They were simply left there until the pasture was destroyed and the stock then perished by starvation."

As a result of drought and heavy use by livestock, the more palatable gramas and other grasses gave way to shrubby vegetation interspersed with annuals. At present the most abundant shrub in the former desert grassland type near Oracle is burroweed, which together with mesquite, cactus, and snakeweed forms the principal plant cover. Burroweed was probably not important on the range lands prior to 1900, for no reference to it, either by common or scientific name, has been located in the literature prior to this date. Griffiths (11) considered that burroweed, spreading from adjacent river valleys, started to invade upland grassland ranges about 1900. Mesquite is another shrub that has spread from major water courses

up secondary ravines and out onto the foothills and mesas. This spread has probably taken place in the last 30 years, for indications are that there was formerly no mesquite on the range except in the larger water courses.

Until 40 years ago annual weeds were unimportant on the range. With the thinning of the perennial grass cover, annual grasses and forbs have become established. Fortunately, the two most common weeds occurring in the springy rainy period are good forage and provide considerable feed for livestock. The most abundant annual is alfilaria, which Thornber (24, p. 33) reports had become established around 1880. In 1873 a herd of sheep was driven from California to Canada del Oro, a few miles south of Oracle. A few years later after the sheep had been removed, alfilaria was observed to be abundant in this canyon. From this location the seeds have been spread by other flocks of sheep, so "that the entire country about Oracle has come to be a veritable alfilaria patch and one of the best sheep ranges in the Territory (State)." Further, in 1910 Thornber (25 p. 264) stated that the ranges about Oracle rank among

> "the best in southern Arizona for winter and spring grazing, the winter annual species, chief of which is alfilaria, producing, ordinarily, an excellent growth which remains until late in the spring."

The other spring annual of importance is Indian wheat, a valuable weed that is established early in the

season. Griffiths (9, p. 15) reports that about 1900 this annual was abundant after the winter rains, forming a large part of feed on the range. Other annuals mentioned were needle grama (Bouteloua aristidoides) and Tragus berteronianus. In a later publication Griffiths (10, Plate VI) includes a photograph in which the conspicuous annuals are alfilaria and Indian wheat, and the principal perennial plants are prickly pear (Opuntia englemanii), yucca, and mesquite.

It is evident from the available historical information concerning the virgin range and present conditions as shown by this study that the conspicuous change in vegetation surrounding the study area has been from a grass type to a desert shrub type. The primary characteristic of the overused range is the dominance of the perennial forbs, unpalatable shrubs, and annual plants. These have largely replaced the nutritious perennial grasses, which occur mainly as scattered remnants in favorable locations.

Plant Succession

Continued excessive stocking results in a disturbance of the climax plant cover and leads to retrogressive succession, or succession that is directed away from the climax. Under stress of heavy grazing by livestock, the

most-preferred climax plants lose vigor, and gradually die and disappear as a result of reduced photosynthesis and lack of reproduction. With this decrease in numbers of climax plants there is also a decrease in competition, which results in an increase of the plants less preferred or more resistant to grazing. McGinnies, Parker, and Glendenning (14, p. 194) indicate that retrogressive succession in the desert grassland type is from black grama (dry sites) or mixed grama (moist sites) to a community composed largely of snakeweed, burroweed, mesquite, and Rothrock grama. If overgrazing is continued, annual weeds invade the area and eventually the ground approaches a barren state.

In the desert grassland type of southern Pinal County, overgrazing has brought about a retrogressive succession that follows these general trends. The study area offers a contrast between an area that has been continuously overgrazed with one that was formerly heavily stocked but for the past 20 years has been under conservative management. Continuous overgrazing on the area adjacent the Page Ranch has resulted in retrogressive succession, as indicated by the presence of annuals and high shrub densities. On the conserved area, development toward the grassland climax is still progressing, but probably the

former climax cover as it originally existed will never be attained.

Vegetation regression induced by grazing: On the overused range, the high shrub and low grass densities indicate a retrogressive succession. On this area two conspicuous changes in composition from the virgin conditions have taken place:

1. Disappearance of the climax plants. Black grama, slender grama, and the perennial three-awns have largely disappeared from the more accessible areas. Remnants of these species are found under the protection of cacti or thorny shrubs.

2. Invasion of new species. Following the breakdown of the climax cover, new species invaded the area. These species may or may not have been present in the primary succession, but they were not constituents of the climax cover. Probably the first invaders were annuals (alfilaria, Indian wheat, etc.) followed by establishment of shrubby unpalatable species such as burroweed and snakeweed.

Prolonged overgrazing has changed the former grass type into a desert shrub type. The dominant vegetation on the overused area is snakeweed and burroweed, indicating a breakdown of the climax cover and a reversal in successional trends. Jardine and Forsling (12, p. 32) state that snakeweed is an excellent indicator of later range deterioration, invading ranges where the better forage grasses have been decimated by overuse. Stoddard and Smith (22, p. 155) consider the ecological status of

burroweed to be indicative of an early regression stage.

The principal species of herbaceous vegetation include Rothrock grama, fluffgrass, and perennial weeds. These species are native to the area, and were present before the advent of livestock. With the exception of Rothrock grama, these herbaceous plants are nearly worthless for grazing, and they have become relatively more abundant and conspicuous by the removal of better forage species.

Another floristic change resulting from continued heavy use is an increase in the abundance of annual weeds. On the overgrazed range the principal winter annual is alfilaria, a palatable species resistant to grazing. Although the actual densities of alfilaria were similar on the overgrazed and conserved ranges, the relative proportion of ground occupied by alfilaria and other annuals was greater on the overgrazed range than on the conserved area, due to the lesser grass densities of the former.

On the overgrazed range a high density of alfilaria is generally accompanied by a low grass density. As the grass density increases, the density of alfilaria decreases as shown in Figure 3. Thus, as overgrazing tends to decrease the perennial herbaceous vegetation, it results in a corresponding increase in alfilaria density.

To summarize, the following conditions are evidence of vegetative regression induced by heavy grazing:

1. Replacement of the better forage plants by inferior shrubby invaders. On the study area this is shown on the overgrazed portion by the dominance of burroweed and snakeweed, with the climax grass species lacking or scattered.

2. Presence of worthless plants, such as fluffgrass and perennial weeds.

3. Abundance of annuals, including alfilaria, Indian wheat, etc.

Secondary succession following retrogression: On the conserved range the higher densities of the grass species and the presence of other more-palatable species indicate that retrogressive succession has been arrested and development toward climax conditions has been initiated. Evidence of secondary succession following the introduction of conservative grazing on deteriorated range is indicated by:

1. Reestablishment of climax species, first on favorable sites and gradually becoming dominant over the area.

2. Increase in density of other valuable herbaceous vegetation, accompanied by a decrease in worthless plants.

The present vegetation on the conserved range may be considered to be in a sub-climax stage. Nearly 60% of the herbaceous dominants consists of perennial three-awns and Rothrock grama. Climax species, such as black grama, are becoming established on the more favorable sites and spreading into the surrounding area. The range has not reached climax conditions, as shown by the presence of

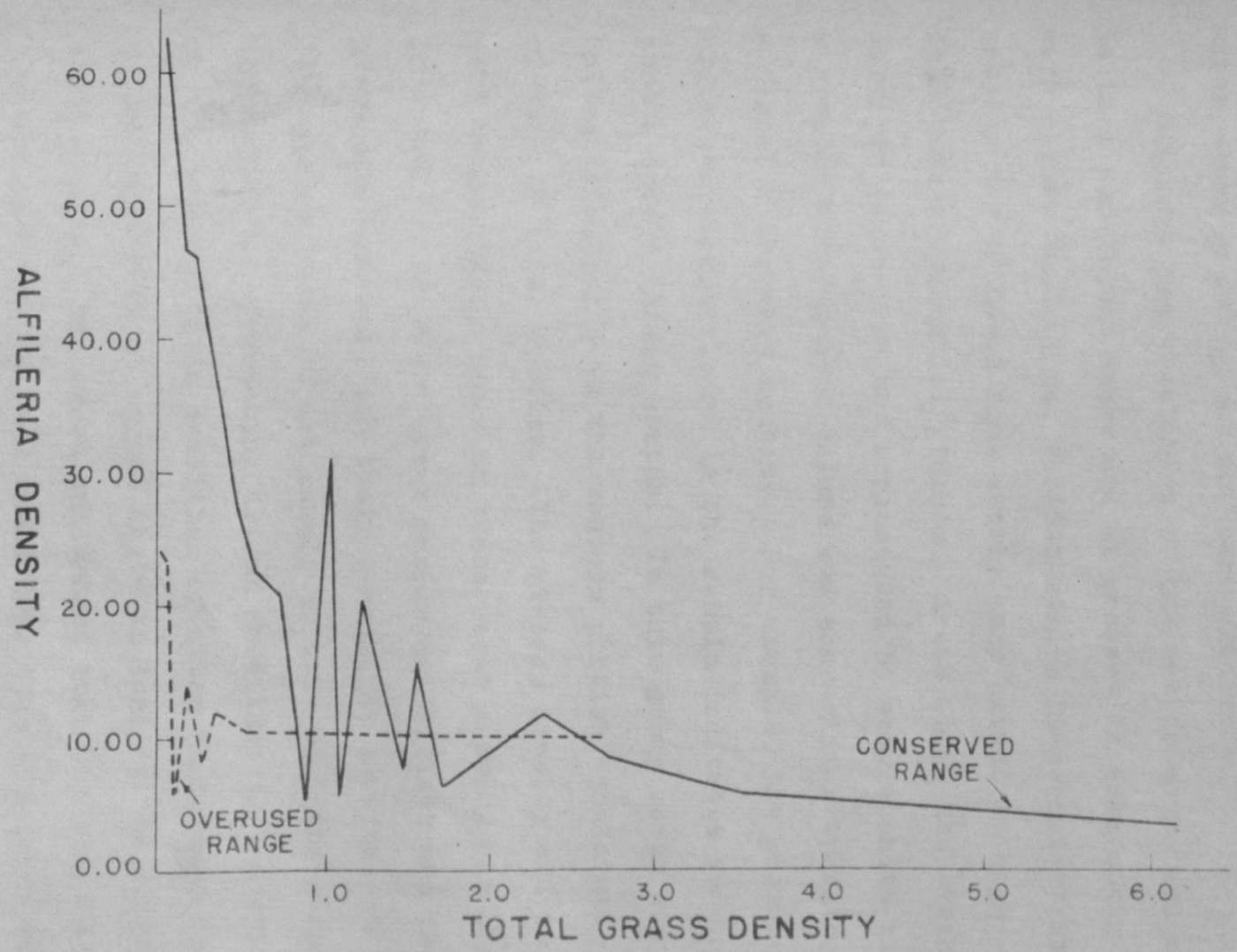


Fig. 3 - Alfilaria and total grass density on the conserved and overused ranges of the study area.

large numbers of annuals and the abundance of burroweed on areas where grubbing has not been extensive.

Although the vegetation of the entire conserved area is in a sub-climax stage and at present is developing toward climax conditions, various stages in secondary succession may be found from nearly bare ground to high densities of perennial grasses. Areas above the average level in succession are represented by sample units with a greater abundance of climax and near-climax species and a higher herbaceous density. For example, the presence of black and slender grama in the sample indicates an approach toward climax status. In this study seven sample units, principally in the western portion, contained one or both of these species. The average density and per cent composition, based on these seven samples, is listed in Table 5. On these seven sample units black and slender grama are dominant, and their density is 16 times that of the average based on all sample units. That the average vegetation is approaching climax condition is indicated by the similarity in densities of other herbaceous vegetation on the seven sample units to that on the total sample units. Burroweed and Wright buckwheatbrush are the dominant shrubs, and their densities are likewise similar under the two conditions. There is a decrease in

Table 5. Density (feet) and composition (%) of grasses and shrubs on sample units containing climax and near-climax species on the conserved range.

Sample units containing	Frequency	GRASSES							SHRUBS			
		Perennial three-awns	Rothrock grama	Cane beardgrass	Slender and black grama	Side oats grama	Minor species	Total grasses	Burroweed	Wright buckwheat brush	Minor species	Total shrubs
Slender and black grama	7	0.82 ft. 32.5%	0.34 ft. 13.4%	0.10 ft. 4.0%	1.08 ft. 43.0%	0.14 ft. 3.5%	0.04 ft. 1.6%	2.52 ft. 100.0%	1.98 ft. 80.0%	0.46 ft. 18.4%	0.04 ft. 1.6%	2.48 ft. 100.0%
Perennial three-awns*	17	3.12 ft. 79.4%	0.30 ft. 7.5%	0.32 ft. 8.1%	0.06 ft. 1.5%	0.10 ft. 2.0%	0.06 ft. 1.5%	3.96 ft. 100.0%	0.74 ft. 58.6%	0.20 ft. 15.9%	0.32 ft. 25.5%	1.26 ft. 100.0%
Cane beardgrass	39	0.88 ft. 37.2%	0.18 ft. 7.6%	0.74 ft. 31.2%	0.04 ft. 1.7%	0.38 ft. 16.1%	0.14 ft. 6.2%	2.36 ft. 100.0%	0.92 ft. 64.0%	0.25 ft. 17.3%	0.27 ft. 18.7%	1.44 ft. 100.0%
Wright buckwheatbrush	40	0.58 ft. 44.0%	0.50 ft. 38.0%	0.12 ft. 9.0%	0.08 ft. 6.0%	0.02 ft. 1.5%	0.02 ft. 1.5%	1.32 ft. 100.0%	3.26 ft. 53.0%	2.56 ft. 40.0%	0.46 ft. 7.0%	6.28 ft. 100.0%
Total lines	160	0.80 ft. 52.6%	0.30 ft. 19.9%	0.18 ft. 11.9%	0.04 ft. 2.7%	0.14 ft. 9.3%	0.06 ft. 3.6%	1.52 ft. 100.0%	1.98 ft. 52.0%	0.64 ft. 17.0%	1.18 ft. 31.0%	3.80 ft. 100.0%

*On lines exceeding a density of 2.0 feet of perennial three-awns.

minor species, however, giving a lower total shrub density for units where black grama is present as compared to the average total.

Since the perennial three-awns are co-dominant with the black and slender grama, sample units with a high percentage of the perennial three-awns may be considered as approaching climax status. On 17 sample units the density of these grasses exceeded two feet per 50-foot sample units. From the average percent composition of these 17 sample units shown in Table 5, it is evident that the perennial three-awns, where abundant, occupy the ground to the exclusion of nearly all other vegetation. An average density of 3.12 feet not only results in a lower average density of the other herbaceous species, but also reduces the shrub density below that of average conditions.

In the climax cover, cane beardgrass would not be conspicuous except in swales and water-retaining areas. Sample units in which this grass is present show the perennial three-awns to have the highest density of the herbaceous vegetation and a corresponding low shrub density.

Average composition of the 40 sample units containing shrubby buckwheat is shown in Table 5. Under this condition perennial three-awns are again the dominant species,

but average density of this grass is less than that for all units. The high density of burroweed on areas containing Wright buckwheatbrush indicates the species to be representative of a lower stage in succession than that indicated by the present average conditions.

The absence of snakeweed on the conserved range indicates that retrogressive succession has been arrested. Snakeweed is a short-lived perennial shrub, and under conservative grazing is one of the first species to disappear. Only scattered plants are found, which confirms other evidence that vegetational development is toward the climax.

Burroweed, on the other hand, due to its ability to withstand adverse conditions, is not as sensitive an indicator of successional changes. Burroweed is aggressive and its method of seed dispersal is effective. Hence on properly-managed ranges it tends to maintain its density for long periods. This is demonstrated in the western portion of the conserved area where the principal range conservation practice has been the reduction in livestock numbers. As previously shown, the density on this portion of the range is similar to that of the overgrazed area. In the eastern portion of the conserved area, control of noxious weeds, water-spreading, and other conservation practices have been more extensive. As a result, the

grass density is high and the corresponding shrub density is low. Therefore, a reduction in the stocking rate and an increase in competition offered by the herbaceous vegetation will ultimately reduce the density of burroweed; but, up to the present time, this natural method of control has not been effective and artificial means are necessary.

As on the overgrazed range, a high density of alfilaria is generally accompanied by low grass densities (Figure 3). The increased grass density induced by conservative grazing results in a decrease in abundance of alfilaria and other annuals.

Further evidence of the stages in secondary succession on the conserved area may be derived from the relationship between total grass density and individual species density as shown in Figure 4. If, as heretofore assumed, secondary succession results in an increase in perennial grass density, localized areas of low total density may represent lower stages in succession than areas of high vegetative density. Changes in relative species densities and composition of sample units with an increase in total grass density as shown in the figure may be considered broadly indicative of general changes taking place on the area as a whole.

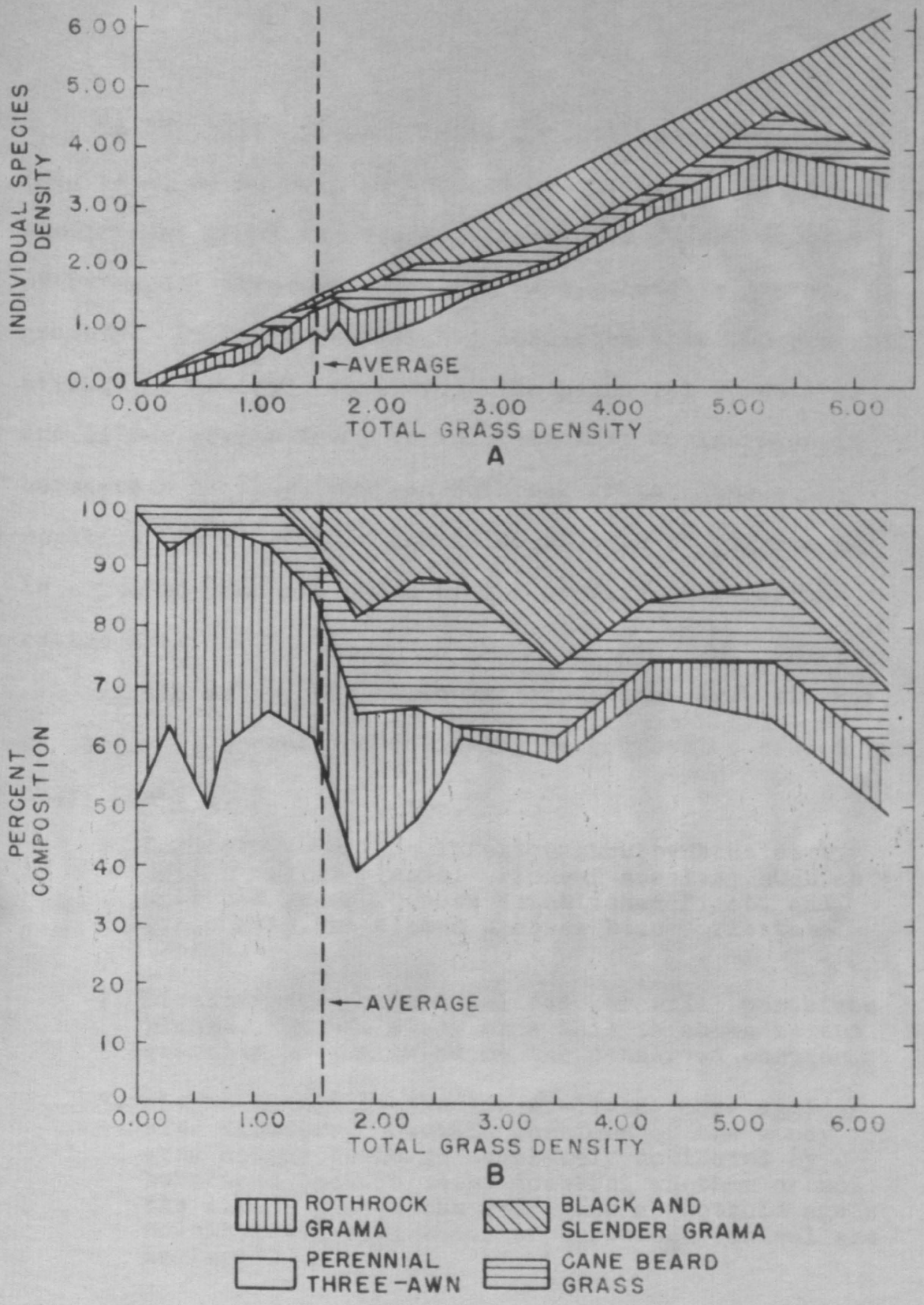


Fig. 4 - Total densities of grass and individual species on the conserved area, (A) based on individual species densities, (B) based on % composition.

On the basis of individual species densities, (Figure 4, A) as well as percent composition (Figure 4, B), the present trend is toward a herbaceous cover composed of perennial three-awns and the more palatable grama grasses. On areas with higher densities than the present average conditions, density of the perennial three-awns and climax gramas tends to increase with an increase in herbaceous density, whereas Rothrock grama shows a negative trend. Higher densities of cane beardgrass may be expected than are shown by the average data for the entire area.

To summarize, the following conditions are evidence of secondary succession following retrogression caused by heavy grazing:

1. Replacement of the inferior shrubby species by better forage plants. Pioneer species, such as Rothrock grama, become established first, and eventually the climax species become reestablished.

2. Disappearance of short-lived perennial worthless plants. On the study area this is shown by the scarcity of snakeweed on the conserved portion.

3. Slight change in the longer-lived, more aggressive invaders. Certain portions of the study area appear to be so completely dominated by burroweed that it seems doubtful whether or not the climax plants can ever gain a foothold again, unless artificial means of burroweed control are employed.

4. Presence of annuals, as shown by alfilaria, an increase in herbaceous vegetation results in a decrease in the annual density.

Succession on localized areas within the conserved range: In the southeast portion of the conserved area, where Mr. Page was active in his control and range-improvement work, zones of succession around old rat and ant nests may be observed. Plate III shows these zones around an old rat nest flooded by Mr. Page. He dug two small ditches on the upslope side of the nest to catch and divert the run-off into the den. This excess water caused the den to become abandoned, and the added moisture resulted in the seeds of the perennial three-awns and other grasses germinating and becoming established on the disturbed soil. From this favorable location the grasses are able to invade the surrounding area supporting an annual cover, and improve the site so that climax grasses may become established.

On the borders of large areas composed of annuals and Rothrock grama, zones of succession are likewise noted. Invading the area occupied by the annuals and Rothrock grama are the perennial three-awns, which in turn give way to cane beardgrass and the various climax gramas.

Plate III

-Soil Conservation Service

Succession on localized areas within the conserved range. In the foreground is an abandoned rat den supporting a stand of perennial three-awns. In the upper left-hand corner a zone of succession is noted. The perennial three-awns are invading the annual Rothrock grama cover, and in the background are cane beardgrass and the grama grasses.

Succession and its relation to palatability: Palatability aids in analysis of secondary successional trends and also may be used to measure the relative extent to which the various plants have been grazed in the past. Consideration of the percentage composition of the principal species and their palatabilities listed in Table 6 reveals that the vegetation on the conserved area has a greater forage value than on the overused area. Under continued overgrazing, plants of little palatability such as fluffgrass, burroweed, and snakeweed have increased greatly in recent years; whereas the more palatable species such as the gramas, bush muhly, and Wright buckwheatbrush are reduced in number and volume of forage produced. The low palatabilities of the principal species on the overused area are evidence of range deterioration caused by sustained heavy grazing.

Table 6. Composition and palatability of principal species on the conserved and overused ranges of the study area.

	Composition		
	Conserved Range	Overused Range	Palatability*
Herbaceous vegetation:			
Perennial three-awns	44.5%	Trace	20%
Rothrock grama	16.7	37.5	60
Misc. gramas	10.0	00.0	75
Fluffgrass	Trace	25.0	0
Shrubby vegetation:			
Wright buckwheatbrush	17.0	0.2	40
Burroweed	52.0	74.9	0
Snakeweed	00.0	9.8	0

*Palatabilities based on "Scientific and Approved Common Plant Names, Symbols, and Palatabilities for Important Arizona and New Mexico Range Plants." Interagency Range Survey Committee, mimeo.

SUMMARY

To analyze the effects of conservative grazing on a deteriorated desert grassland range in southern Arizona, a sampling study was made of the vegetation on the Page-Trowbridge Experimental Ranch and adjoining area, located near Oracle, Arizona. The portion of the Page-Trowbridge Ranch which has been under conservative use for the past twenty years was compared with the severely-grazed area adjoining the eastern boundary of the Ranch.

The line interception method was used to sample the vegetation on the conserved and overused areas. Each area was subdivided into eight 40-acre blocks and each block was sampled by 20 randomly-selected lines, 50 feet in length.

Vegetation on the conserved range consists of a mixed grass-shrub type and on the overused area of a desert shrub type. Total herbaceous density is 1.80% on the conserved area and 0.14% on the overused area; shrub density is 3.80% and 8.50% respectively on the two areas. The herbaceous dominants on the conserved area include perennial three-awns and Rothrock grama, which together comprise nearly 60% of the herbaceous composition. Grass density is low on the overused area. The dominant grass

is Rothrock grama, which represents 42.8% of the herbaceous cover. Shrubby dominants on the conserved range include burroweed (52.0% composition), mesquite (17.4% composition), and Wright buckwheatbrush (17.0% composition). On the overused area the shrubby dominants are burroweed (75.0% composition), snakeweed (9.9% composition), and mesquite (9.0% composition). On the two areas alfilaria was the only annual vegetation measured, its density being similar on the conserved and overused areas.

Historical evidence demonstrated that grasses, chiefly the grama grasses, were the former climax cover of the area surrounding Oracle. Deterioration of the range resulted from continued heavy use, and led to a replacement of the perennial grasses by shrubby vegetation interspersed with annuals.

The study area offers a successional contrast between a range that has been continuously overstocked with one that was formerly overgrazed, but for the past twenty years has been under conservative management. On the overgrazed area the conditions indicating regression induced by grazing are the dominance of burroweed and snakeweed, the presence of short-lived plants, and the absence or relict occurrence of climax species. On the conserved area, progressive succession is evidenced by a re-establishment of the climax species, an increased

density of other valuable herbaceous vegetation, and a decrease in worthless plants. Successional trends point to the development of a climax grass cover consisting of perennial gramas, perennial three-awns, and cane beardgrass.

Further evidence of range deterioration is shown by the palatabilities of the dominant species on the two areas. Due to conservative management for the past twenty years, the forage value on the conserved range has increased with the increase in palatable, climax species. The present low palatabilities of the principal species on the overused range are further evidence of range deterioration caused by sustained heavy grazing.

As shown by this study, the principal effect of conservative grazing on the semi-desert grassland of southern Arizona is an improvement in grazing capacity. By interpreting the past management as being successful on the conserved range, it is evident that reduced stocking and range conservation are needed to increase the productive capacity of the overgrazed area.

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