Trends in Carrying Capacity and Vegetation on an Arid Southwestern Range

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Cattle ranchers of the Southwest are confronted with an ever-changing forage resource. This means that they must make continual adjustments in their ranch operations. It is not easy to sell all or part of a herd that has been developed through years of selective breeding and care. However, pressure to do so often faces the southwestern rancher. In addition, there are insidious changes in the range vegetation that are not apparent except where they have been carefully documented by objective, long-term records. Some of these fluctuations and changes that have taken place on one range area are described herein.

Pertinent records have been kept at the Jornada Experimental Range in south-central New Mexico about 60 miles north of the international boundary. They include livestock numbers, cover, production of forage and nonforage plants, precipitation, wind velocity, evaporation, and maximum and minimum temperatures.

Range lands similar to the Jornada occupy 26 million acres, mainly in southern New Mexico and western Texas. These comprise the range areas known as the black grama *(Bouteloua eriopoda Torr.)* and tobosa *(Hilaria mutica* (Buckl.) Benth.) grasslands and associated shrub ranges. Typical examples of the main range types are shown in figure 1.

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The grassland areas furnish most of the forage for livestock and are of first importance to the livestock operation. In the past they occasionally have been cut for hay (Griffiths et al., 1915 and Ares, 1939). Areas dominated by shrubs furnish comparatively little grazing. Moreover, many of the shrubs, worthless as forage, invade and crowd out the more valuable grasses, thus resulting in an ever-diminishing area of grassland (Parker and Martin, 1952). Most noteworthy of these shrubby invaders is mesquite *(Prosopis juliflora* (Swartz) DC.). Mesquite sandhills (Fig. 1c) represent the final stages of mesquite invasion on black grama areas (Jardine and Forsling, 1922) and is referred to by Campbell (1929) as a moving dune complex.

Precipitation

Of the facets of climate important to the growth and maintenance of the range vegetation, precipitation is perhaps most strikingly responsible for changes in the plant cover. Although the amount of precipitation is vital to plant growth, its timing or distribution may also be a controlling factor. Characteristically, half of the annual precipitation on the Jornada Experimental Range falls within 3 months—July, August, and September. Immediately before and after, rainfall is distinctly lower and plant growth is restricted. Furthermore, during this short period more than 90 percent of the total forage is usually produced.

Annual precipitation on the Jornada Experimental Range since 1915 has averaged 9.02 inches. Sporadic records of precipitation from Army posts along the Rio Grande since before the Civil War and continuous records at New Mexico State University near Las Cruces, New Mexico since 1891 show that there has been no general increase or decrease in amount of annual precipitation during the past century. Instead, groups of years have been alternately dry and then comparatively moist (Figure 2). The duration of each alternating group has been about 20 years. Departures from the long-time average precipitation during each group of years has ranged from 8 to 18 percent and individual years have often been noticeably different from the group average. For example, the Jornada record began midway in a series of dry years, and from 1916 to 1926 precipitation averaged 8.02 inches or 11 percent below the long-term average. However, in 2 years—1919 and 1920—precipitation averaged 36 percent above average. Conversely, 2 consecutive years during the moist period, 1927 to 1943, averaged 28 percent below average. The most recent dry period began in 1944, and up to 1956 rainfall averaged 7.37 inches.

Effects of Rainfall on Vegetation

The effect of these roughly cyclic variations in precipitation are reflected by the plant cover; however, the vegetative response is governed by timing and distribution of the year-to-year precipitation as well as the amount received. Also, important is the degree of herbage removal by the grazing animal. Beginning in 1916, meter-square quadrats were charted on the Jornada Experimental Range to follow changes in vegetation. The quadrats on which black grama was the major grass were later classified as having received heavy, intermediate, conserva-

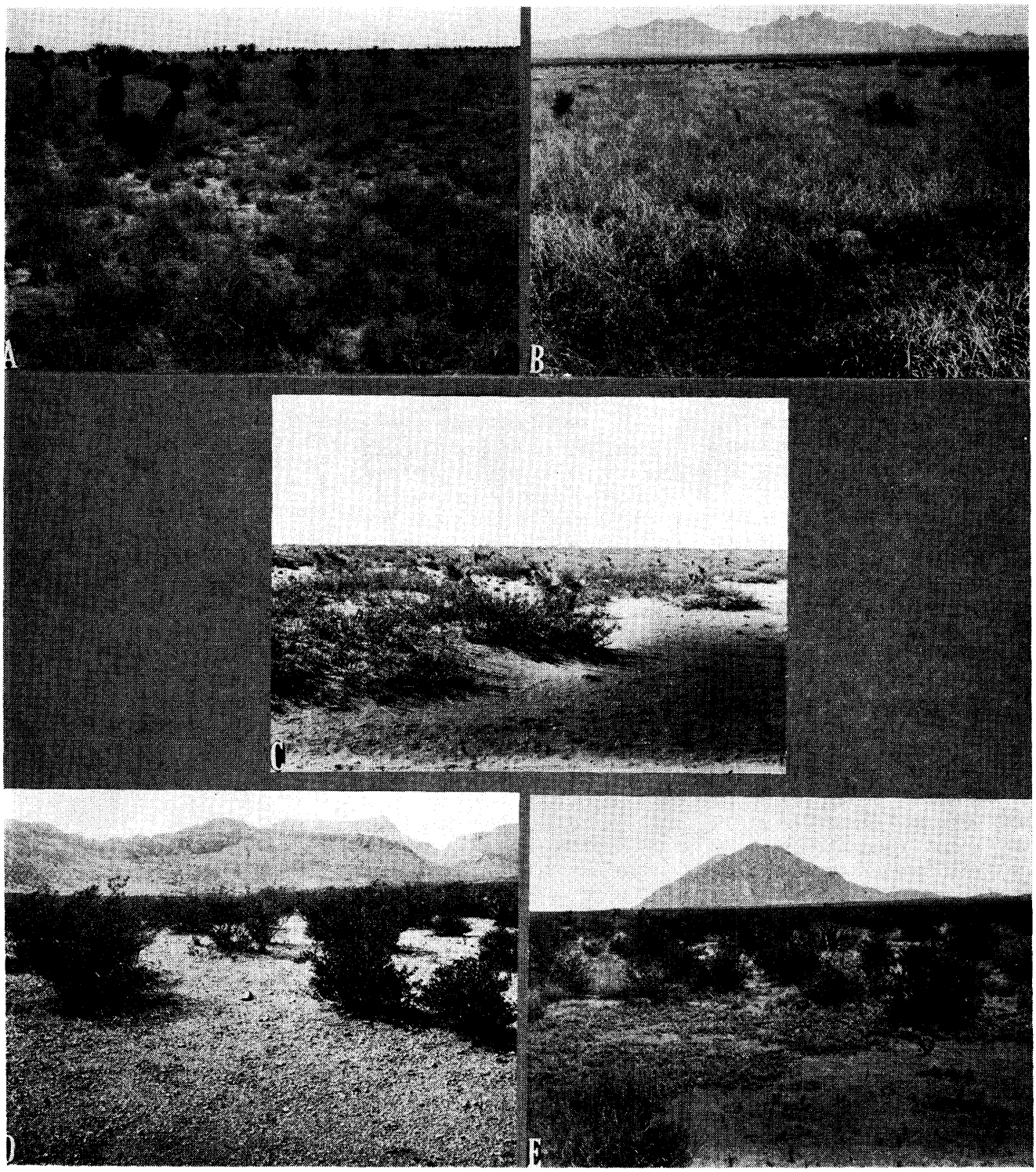

FIGURE 1. (A) Black grama range under favorable climatic conditions and conservative grazing. (B) Tobosa grass forms a dense cover on swale sites that receive some surface runoff water. (C) Mesquite sandhills range has very sparse herbaceous cover. (D) Creosotebush type with typical erosion pavement. (E) Tobosa and burrograss *(Scleropogon brevifolius)* are often intermingled with tarbush in this shrub type.

tive, and no grazing (Figure 3). These intensities correspond to: (1) more than 55 percent removal of the current year's herbage, (2) 40-55 percent removal, and (3) less than 40 percent removal, respectively.

Vegetation on quadrats protected from cattle grazing averaged 424 square centimeters in basal area, or about 4 percent of the quadrat surface area over the 38-year period. However, much more of the ground surface was protected from wind

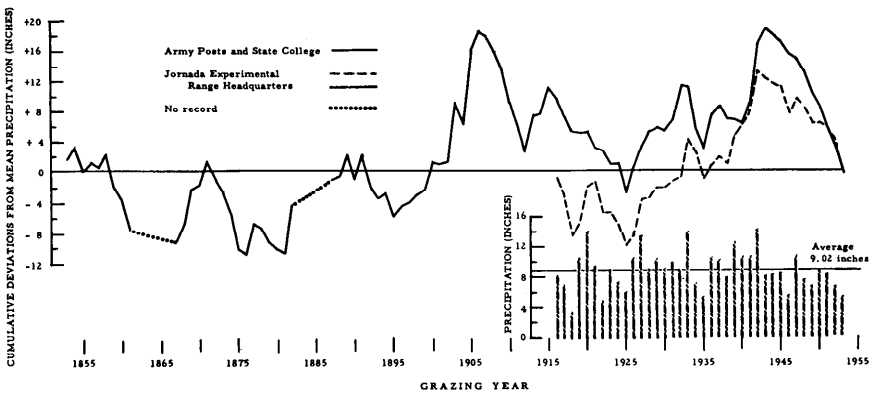

FIGURE 2. Cumulative deviations from mean annual precipitation in southern New Mexico and the Jornada Experimental Range.

and rain by the leaves and stems of the plants, often to the extent that the ground surface in places appeared almost completely covered.

During the generally dry years from 1916 to 1926, basal area on the protected quadrats declined greatly. The effect of more favorable rainfall beginning in 1926 was evident in 1927 and black grama generally increased until 1934, when it reached its maximum basal area. This was 31 times greater than its low point in 1924. Precipitation in 1934 and 1935 averaged only 6.49 inches, and by 1936 black grama basal area had suffered a loss of 75 percent. Precipitation up to 1943 was adequate in amount, but was ill-timed and not effective for maximum plant growth.

In contrast to this, rainfall from 1943 to 1945 averaged 0.68 inch below the mean; however, it was comparatively favorable for black grama and the basal area generally increased until 1946, when rainfall averaged only 5.68 inches. As the drought continued, black grama disappeared from all protected quadrats by 1956. It is likely that revegetation will be slow because of the sparsity of plants and the fact that regeneration by seed is poor in this region (Nelson 1934). Black grama recovery must largely depend upon spreading by stolons and tillering (Canfield, 1939).

Effects of Grazing on Vegetation

Black grama on grazed quadrats responded similarly to that within cattle exclosures, but the magnitude of the response was different. Within all intensities of grazing, the series of dry years 1916 to 1926 reduced the basal area of black grama to approximately the same point irrespective of grazing intensity or initial basal area. Minimums ranged from 83 to 127 square centimeters on the grazed quadrats, or approximately 1 percent of the surface area of the meter-square quadrats. This was slightly higher than the minimum basal area on the protected quadrats, which averaged only 30 square centimeters. In the latest drought period, black grama on the quadrats again declined to approximately the same point under all intensities of grazing. Also, as in the first drought period, more black grama remained on the grazed quadrats than on the ungrazed. By 1956, on the 30 grazed quadrats black grama was absent from 8 out of 12 of those heavily grazed, 5 out of 8 intermediately grazed, and 3 out of 10 conservatively grazed.

The recovery made during the moist period on the conservatively grazed quadrats was significant. By 1930 the basal area of black grama on these quadrats was 1,055 square centimeters, 8 times the low point reached during the preceding dry period. Under the other two intensities of grazing, basal area by 1930 reached 839 and 699 square centimeters on quadrats receiving intermediate and heavy use, respectively.

The tobosa type is the other main forage-producing grass type of the Jornada Experimental Range. Tobosa is the major species in this type. It is found on swale sites that receive some surface runoff and consequently, it is less affected by drought conditions than is black grama. Quadrat records of this species show that it may be maintained under grazing and that removes about 40 to 55 percent of the herbage. Tobosa averaged 1,804 square centimeters on quadrats having the longest and most complete charting record. Where grazing was heavier or excluded, basal area of this species was reduced.

When old growth of this species was not removed, the plants tended to stagnate. Where grazing became too heavy, the stand thinned and bare ground appeared between the plants. Moderate and frequent grazing, on the other hand, stimulated rhizome growth and produced large amounts of succulent forage.

Changes in Grazing Capacity

The number of animals on the experimental range fluctuated greatly from year to year and accompanied changes in the vegetation. Stocking of the range was based on an annual appraisal of forage production and past utilization. Although in some years utilization may have been heavy, in general it was conservative. For example, from 1939 to 1953 utilization of perennial grasses averaged about 40 percent of five experimental units and 33 percent on another. Because of variation in size, shape, stock watering facilities and forage, differences between pastures were recognized.

During the dry period, 1916-26,

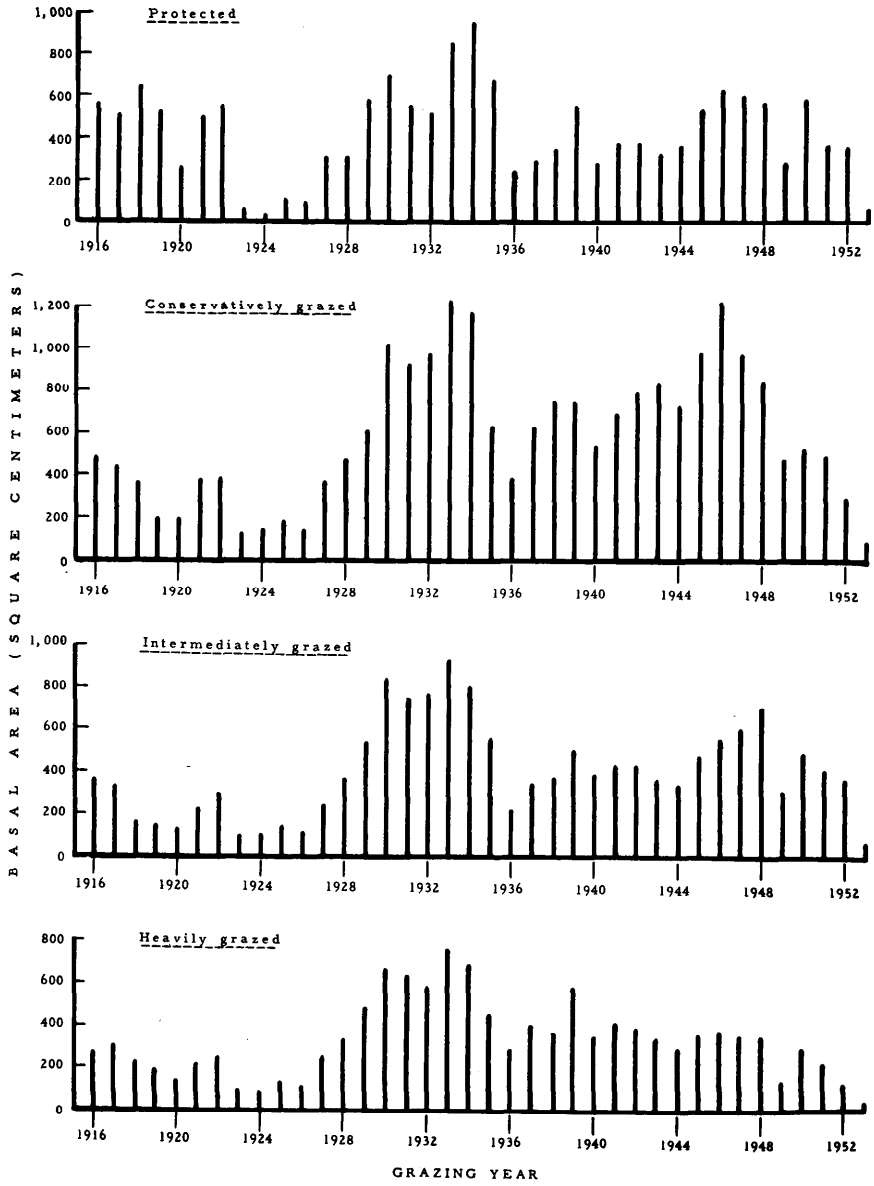

FIGURE 3. Average basal area of black grama on meter-square quadrats under 3 intensities of grazing and no grazing, 1916-53.

stocking averaged 2,340 animal units, but only 251 animal units remained at the end of the period in 1926. Between 1928 and 1943 the number of animal units averaged 1,037 and in the final period, 1944 to 1953, stocking averaged 639 animal units. In 1954 forage production dropped and only 137 animal units grazed on the experimental area.

Six pastures on the Jornada carried the bulk of the experimental herd. These differed in surface acreage and also as to the kind and amount of vegetation (Table 1). In pastures 5, 9, and 10, grasslands predominated and black grama was the most important type; whereas, in pastures 1, 2, and 6 shrub types were the major vegetation, but large areas of black grama, tobosa, and associated grasses furnished most of the forage.

The annual surface-acre requirement of an animal unit within each pasture is an expression of grazing capacity and is comparable between pastures regardless of size. It was obtained as follows:

$$\text{Acres per animal unit per year} = \frac{\text{Acres in pasture}}{\text{Animal units stocked} \times \frac{\text{proper use of grasses in percent}}{\text{actual use of grasses in percent}}}$$

Annual surface-acre requirements fluctuated widely as a result of variation in forage produced and livestock grazed. But whether the trend in surface-acre requirements was upward or downward is more important.

Trends were computed from the annual pasture records of surface-acre requirements over time (Figure 4). The trend in carrying capacity on the grassland pastures showed little change during the years. Pasture 5 was near headquarters and was often used as a holding trap and horse pasture. Initially the surface-acre requirement of this pasture was low, but some depletion of the forage resulted from drought and too-heavy yearlong grazing. The other two grass pastures commonly were grazed after forage growth was completed in the fall, and the surface-acre requirement has shown an important trend. The surface-acre requirement of pasture 9 averaged 24 acres per animal unit until 1934. During the next 3 years it averaged 33 acres. Grazing capacity since 1941 remained relatively constant until 1952 when, because of extremely low precipitation and little growth, most of the animals were removed. The surface-acre requirement of pasture 10 varied from an average of 77 acres per animal unit during the dry years 1916 to 1926, to 49 acres during the period of more favorable moisture 1927 to 1943, and finally 68 acres for the years 1944 to 1951.

For the period 1916 to 1951, the average surface-acre requirement of the 3 grass pastures was 59 surface acres per animal unit yearlong. This is equivalent to 11 animal units per section.

Brush pastures 1, 2, and 6 had an average surface-acre requirement equivalent to 5 animal units per section for the same

Table 1. Acreages and vegetation types of six pastures on the Jornada Experimental Range.

Pasture	Black grama		Tobosa		Mesquite		Creosotebush and tarbush		Total
	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres
Brush									
1	8,175	9.7	7,276	8.7	38,938	46.4	29,572	35.2	83,961
2	9,302	31.5	959	3.3	19,251	65.2	0	0	29,512
6	1,859	12.7	3,970	27.1	254	1.7	8,575	58.5	14,658
Grass									
5	1,461	82.1	132	7.4	187	10.5	0	0	1,780
9	3,028	95.5	0	0	144	4.5	0	0	3,172
10	5,992	83.6	1,113	15.5	25	.3	42	.6	7,172
Total	29,817		13,450		58,799		38,189		140,255

period. More important, however, the brush pastures declined in grazing capacity over the years. Pasture 2, for example, which in 1928 had 65 percent of its area dominated by mesquite, declined at an increasingly rapid rate. The change in grazing capacity in this pasture was slow during the early years, but it became much more rapid toward the end of the period. Invasion by mesquite and subsequent loss of the forage plants were largely responsible, since pasture 2 was generally conservatively grazed primarily in the winter-spring period, when the grasses were dormant.

The rate at which mesquite became established on the Jornada Experimental Range is shown by repeat measurements of the vegetation on a 1,500-foot permanent belt transect in pasture 2. The transect originated within mesquite sandhills and extended through the mesquite-grass transition into black grama grassland. Mesquite seeds disseminated by cattle and rodents increased the numbers of plants by 73 percent in the mesquite sandhills section of the transect and by 450 percent in the transition zone between 1936 and 1951. The increase of mesquite in the grassland segment of the transect was 100 percent in this 16-year period, and apparently mesquite will continue to invade the adjacent grassland unless control is undertaken. Accompanying the increase of mesquite, black grama decreased 23 percent, and dropseed *(Sporobolus* spp.) decreased more than 50 percent between 1936 and 1951. On a nearby area of former grassland that is now heavily infested by mesquite, production of grasses in one year was less than 10 pounds per acre in contrast to a similar area where the invasion was in the early stages and forage production was 228 pounds per acre (Norris, 1953). Other studies in southern Arizona have shown that up to 10½ times as much forage was produced on areas cleared of mesquite as on adjacent uncleared areas.

In pasture 1 thickening of the brush and the subsequent invasion of isolated grassland areas resulted in a steady loss of grazing capacity, as shown by an annual increase of nearly 5 surface-acres per animal unit per year. From an initial requirement of 71 surface-acres per year the average surface-acre requirement between 1947 and 1951 was 225 surface-acres, which represents a decrease of more than 6 animal units per section yearlong. Livestock grazing in pasture 1 has been usually yearlong, and has been a contributing factor in the invasion of mesquite and the accompanying decline in grazing capacity.

Following establishment in 1927, pasture 6 averaged 90 surface-acres per animal unit per year for 11 years. During the period 1946 to 1951 grazing capacity averaged 196 surface-acres per animal unit per year. Originally black grama was a major forage species in a part of this pasture now dominated by creosotebush *(Larrea tridentata* (DC.) Coville). Under predominately summer use, black grama suffered, and with invasion of tobosa and other swale types by tarbush *(Flourensia*

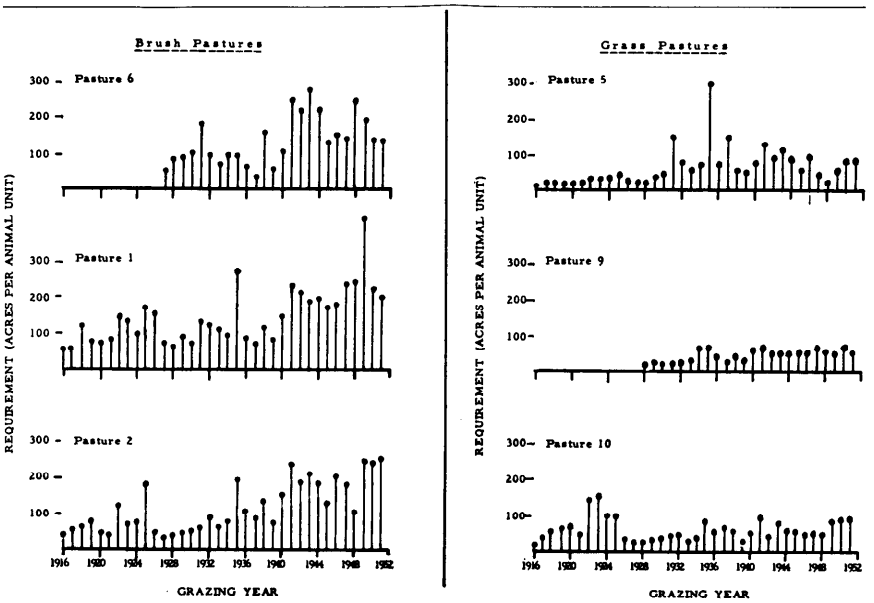

FIGURE 4. Surface-acre requirement per animal unit of six experimental pastures, 1916-53, Jornada Experimental Range.

cernua DC.) and creosotebush, grazing capacity declined. Some of the tarbush died in recent drought years, and the invasion of the grassland sites by this species was set back.

Summary and Conclusions

During years of low precipitation on black grama and tobosa grasslands and associated shrub ranges of the Southwest, herbaceous cover is reduced and in years of more favorable rainfall it recovers. During a series of dry years on the Jornada Experimental Range in south-central New Mexico basal area of black grama was reduced to approximately the same point irrespective of grazing intensity. Recovery of black grama was greatest where grazing usually removed less than 40 percent of the herbage. Tobosa maintained its greatest basal area under somewhat heavier grazing, which removed 40 to 55 percent of the annual herbage growth.

Sustained grazing capacity does not exist on these semidesert ranges. There are periods of high forage production and periods of low forage production (Lantow and Flory, 1940). Correspondingly, stocking may be high in some periods and in others there is virtually no capacity. During periods of deficient rainfall, forage production declined irrespective of the grazing use and the best management. Twice in 40 years on the Jornada Experimental Range it was necessary to remove nearly all the cattle during extreme drought periods, despite application of the best known techniques of range management.

Where shrubs such as mesquite are in the initial stages of invasion of the grassland areas an active and continuing program of brush control is mandatory. Otherwise, an ever-increasing decline in grazing capacity must be anticipated. Once the mesquite sandhills stage is reached, it is presently not economical to attempt control (Knox et al., 1951).

LITERATURE CITED

ARES, FRED N. 1939. Cutting tobosa grass for hay. Cattleman 25(9): 47-50, illus.

CAMPBELL, R. S. 1929. Vegetative succession in the *Prosopis* sand dunes of southern New Mexico. Ecol. 10: 392-398, illus.

CANFIELD, R. H. 1939. The effect of intensity and frequency of clipping on density and yield of black grama and tobosa grass. U. S. Dept. Agr. Tech. Bul. 681, 32 pp., illus.

GRIFFITHS, DAVID, BIDWELL, GEORGE L., AND GOODRICH, CHARLES E. 1915. Native pasture grasses of the United States. U. S. Dept. Agr. Bul. 201, 52 pp., illus.

JARDINE, JAMES T. AND FORSLING, C. L. 1922. Range and cattle management during drought. U. S. Dept. Agr. Bul. 1031. 83 pp., illus.

KNOX, J. H., WATKINS, W. E., KOGER, MARVIN, AND VALENTINE, K. A. 1951. Research on the college ranch. New Mexico Agr. Expt. Sta. Bul. 359. 32 pp., illus.

LANTOW, J. L. AND FLORY, E. L. 1940. Fluctuating forage production. Soil Conserv. 6: 137-144, illus.

NELSON, ENOCH W. 1934. The influence of precipitation and grazing upon black grama grass range. U. S. Dept. Agr. Tech. Bul. 409, 32 pp., illus.

NORRIS, J. J. 1953. Mesquite invasion. *In* Ranch Day, Jornada Experimental Range and College Ranch, Las Cruces, New Mexico. October 12, 1953.

PARKER, KENNETH W. AND MARTIN, S. CLARK. 1952. The mesquite problem on southern Arizona ranges. U. S. Dept. Agr. Cir. 908, 70 pp., illus.