Meeting Drought on Southern Arizona Rangelands

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THE effects of drought are now less disastrous on southern Arizona rangelands than in the early days of the livestock industry. Supplemental feeding, irrigated pastures and improved transportation facilities have practically eliminated starvation losses. However, some of these management practices are not geared to proper grazing of native rangelands. A better understanding of the relation of drought to grazing is still needed in order to avoid permanent range injury and to maintain the highest level of livestock production in the face of a highly variable forage supply (Fig. 1).

Thirty years of records of forage variations and animal production for the Santa Rita Experimental Range[2] and numerous rainfall records for other localities are presented in this paper as a guide to the frequency, duration, severity and effects of droughts which can be expected in southern Arizona. Management practices which result in the highest level of production consistent with maintenance of the forage resource are also suggested.

This analysis defines drought, relates it to livestock reductions and describes some practices which can be used to reduce the disastrous effects of drought on southwestern ranges. New concepts of the nature of drought are presented.

Previous Work

Desert grasslands, exemplified by the Santa Rita Experimental Range, were early recognized as being subject to devastating droughts. The early statement of Thornber (1910) is still appropriate:

> Periods of moderately heavy precipitation are of short duration and quite infrequent, while prolonged droughts are rather to be looked for; these commonly alternate with one another in sharp succession, as do also periods of relatively wet years with corresponding ones of dry years.

Under comparable climatic conditions in southern New Mexico, the consequences of drought were also early noted. Wooton (1908, 1915) related differences in yearly precipitation to variations in forage production. Jardine and Forsling (1922) reported that drought was one of the chief setbacks to the cattle industry in the Southwest. Nelson (1934) pioneered an intensive study of black grama, finding that on both grazed and ungrazed areas this species fluctuated greatly in density and height growth in response to variations in rainfall. Lister and Schumacher (1937) studied the height growth and density responses of three forage grasses of southern Arizona to an additional inch of rainfall in any month. They found that threeawn was admirably adapted for growth in a variable rainfall pattern; and that Rothrock and black gramas responded most favorably to a dry winter-wet summer distribution of rainfall.

Lantow and Flory (1940) presented an excellent evaluation of the effects of fluctuating forage production upon proper range management based upon results of earlier workers and their own observations. Vegetation was reported to fluctuate more than rainfall. This was believed to be caused by the delayed growth response of perennial grass crowns and the complicating effects of overutilization during periods of low rainfall. The necessity of keeping animal numbers at a conservative stocking level to prevent overuse of range plants during drought was emphasized. Animal adjustments were observed to usually be made too late to avoid animal weight losses and to prevent serious injury to the range. Animal adjustments based upon annual range inspections and fall sale of livestock were recommended. Additional practices recommended for facilitating animal adjustments were early sales of top-condition animals to conserve feed for the breeding herd and disposal by close culling of old-off type and otherwise inferior breeding cows.

Area of Application

Desert grasslands form a transition with the Sonoran Desert of Shreve (1951) on the west and south, the oak-woodland of Darrow (1944) and the pinyon-juniper of Nichol (1943) on the north and the black grama subdivision of the mesquite-grassland of Shantz and Zon (1924) on the east. Southeastern Arizona and the southwestern corner of New Mexico between elevations of 2,000 and 5,000 feet are included in this grassland type. Grassland is not continuous, but is

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[2] *Most of the data upon which this paper is based were recorded by Matt J. Culley, who was in charge of the Santa Rita Experimental Range from 1921 to 1950. The Santa Rita Experimental Range, located about 35 miles south of Tucson, Arizona, is a field unit of the Rocky Mountain Forest and Range Experiment Station. Research on this area is conducted in cooperation with the University of Arizona and three independent stockmen.*

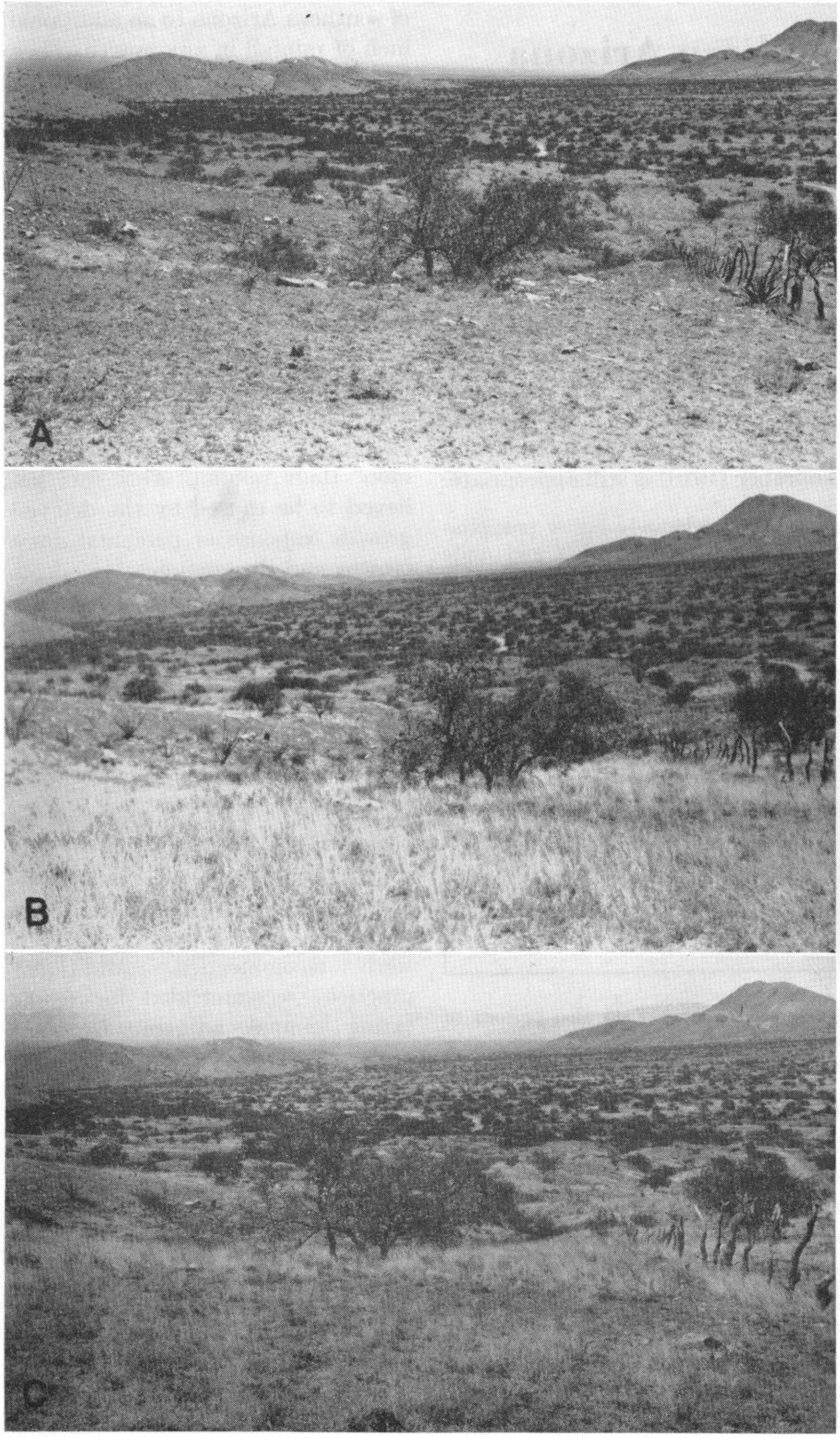

FIGURE 1. Great differences in herbage consumption result from a variable forage supply as shown by these views taken from a selected photo point on the Santa Rita Experimental Range at the end of the grazing season in early July. (*A*) 1948. During 1947 only 35 pounds of forage per acre were produced. By the end of the grazing season it was completely consumed in spite of substantial livestock reductions. (*B*) 1951. Drought continued during 1948, but two years of favorable rainfall thereafter resulted in considerable recovery in density and height growth. Utilization was light to promote recovery. (*C*) 1952. Herbage production, utilization, and stocking were about average.

broken by numerous drainage systems and isolated mountain ranges. Vegetation characteristic of the Sonoran desert exists along the major waterways. The major desert mountains are covered by oak-woodland on the lower slopes and by ponderosa pine (*Pinus ponderosa*) and various firs (*Abies* spp.) at the higher elevations.

The vegetational characteristics of desert grasslands vary with elevation. Three slightly arbitrary elevational units are sometimes recognized (Canfield 1948). The foothill unit includes elevations between 4,000 and 5,000 feet, where rainfall averages from 17 to 22 inches. Cacti and half-shrubs are rare at this elevation and perennial grass density is relatively high. Shrubs are usually confined to the drainages. Many species of perennial grasses occur; the most important in order of abundance are: Arizona cottongrass (*Trichachne californica*), slender grama (*Bouteloua filiformis*), threeawns, (*Aristida* spp.), black grama (*B. eriopoda*), tanglehead (*Heteropogon contortus*) and hairy grama (*B. hirsuta*).

The mesa unit occurs at elevations ranging from 3,000 to 4,000 feet, where average annual rainfall varies from 12 to 17 inches. Shrubs, cacti and half-shrubs are usually abundant and perennial-grass density is lower than in the foothill unit. On ranges in good condition, perennial grasses in order of abundance are: Arizona cottongrass, black grama, threeawns, bush muhly (*Muhlenbergia porteri*), Rothrock grama (*B. rothrockii*), tanglehead and several minor species.

Below 3,000-feet elevation, a transition occurs with creosotebush and other plants of the Sonoran desert community. Average annual precipitation is less than 12 inches. The aspect is one of shrubs. The ground cover is composed mainly of annual species. Perennial grass is scarce. The order of relative abundance of perennial grasses is: threeawns, bush muhly, Rothrock grama, sand dropseed (*Sporobolus cryptandrus*) and fluffgrass (*Tridens pulchellus*).

Experimental Records

A foothill pasture of about 900 acres on the Santa Rita Experimental Range was used to compare the effect of rainfall variations upon perennial-grass yield and animal production. This pasture has been maintained in productive condition during the last 30 years, as evidenced by the lack of deterioration in perennial-grass density or composition. Black grama comprises 70 to 85 percent of the perennial-grass composition on both grazed and ungrazed exclosures. Moreover, mesquite invasion has not been serious enough to necessitate livestock adjustments to compensate for the perennial grass replaced. Hence, variations in forage production are almost entirely associated with annual rainfall differences and are not the result of changes in range condition resulting from improper grazing or invasion of mesquite.

Forage production has been measured since 1939 by clipping and weighing representative samples. Previous to this time it was estimated in terms of percentage of longtime-average production. For uniformity, these percentages were converted to pounds per acre. Rainfall was determined by two standard rain gages located within and adjacent to the pasture. June–September rainfall was used for all comparisons inasmuch as 90 percent of perennial grass growth results from precipitation received during this period (Culley 1943).

Drought Severity Defined

Desert grasslands are characterized by a highly variable summer rainfall. Thirty years is probably a minimum for defining variability in relation to average conditions.

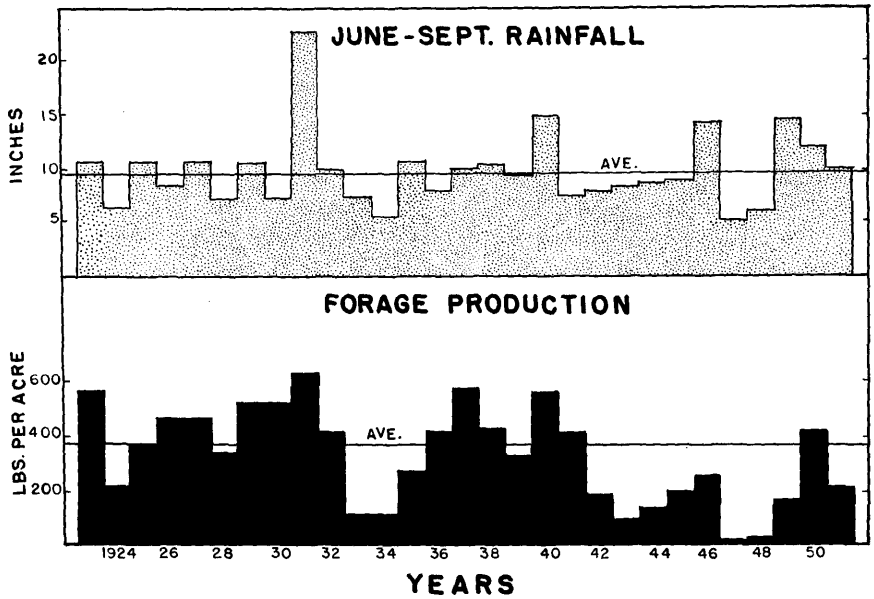

FIGURE 2. Variation in forage production in relation to June–September rainfall for a foothill pasture on the Santa Rita Experimental Range.

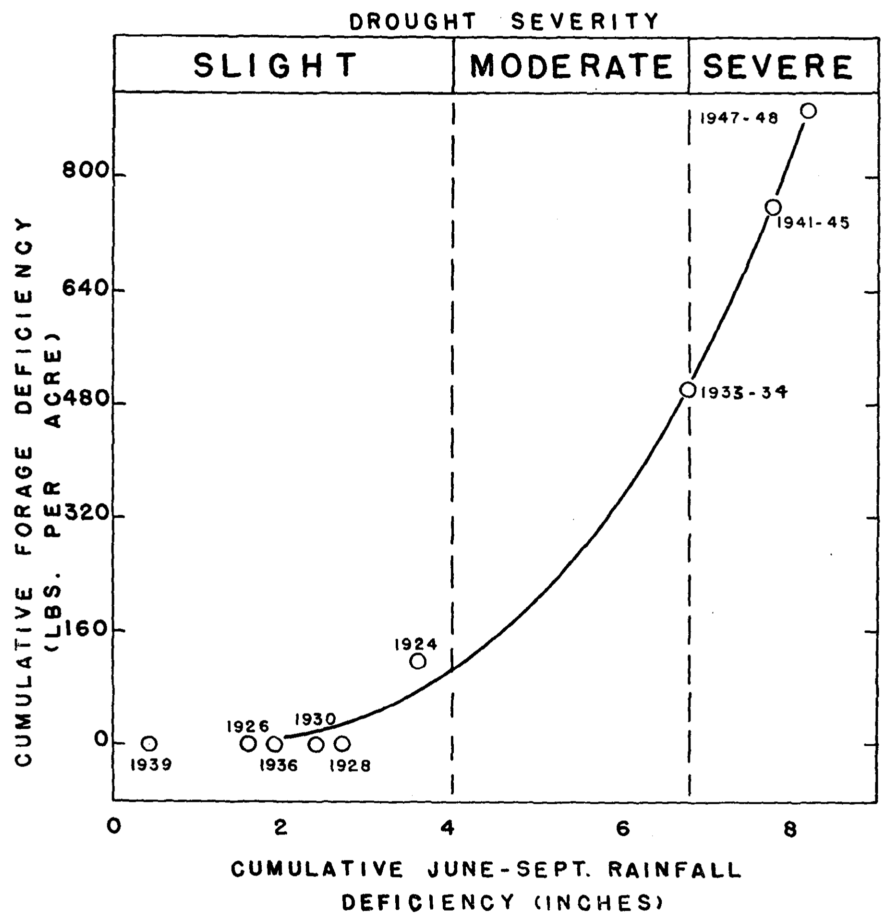

FIGURE 3. Effect of cumulative rainfall deficiency upon loss in forage production and the delineation of drought categories.

Table 1. Comparison of drought severity, forage production and stocking rates for an experimental pasture on the Santa Rita Experimental Range

Period	Droughts		Growing Conditions	Forage Production	Stocking	
	Number	Severity	Percent of average	Percent of average	Percent of average	Cows per section
1922–31	4	Slight	130	140	145	34.0
1932–41	1	Moderate	120	110	95	22.3
	2	Slight				
1942–51	2	Severe	50	50	60	14.3

Rainfall may be high one year and low the next, although there is a tendency for high and low years to occur in groups. These groups of successive years of above- or below-average rainfall are usually from 2 to 5 years in duration and appear to follow no regular pattern. Annual forage production responds noticeably to variations in annual rainfall.

Forage production does not always show a direct response to variations in annual summer precipitation because of timeliness and distribution of individual showers. For example, in 1926, 1930, 1936 and 1941, forage production in the experimental pastures remained above average when precipitation fell below average (Fig. 2). Also, after prolonged dry periods, forage production does not increase immediately with improved rainfall. This is shown by the below average rainfall of 1933–34, which was reflected in a lowered forage production from 1933 through 1935; and low rainfall during 1947 and 1948, which was responsible for decreased forage yield for the years 1947 to 1949.

The effect of successive years of rainfall deficiency upon forage production is well illustrated by the period 1941–45. Rainfall was only slightly below average during these years, but the long succession of dry years greatly lowered forage production. In 1942–43, forage production decreased, in spite of slight increases in rainfall. Thereafter, continued slight increases in rainfall were reflected in increased forage production. However, after 5 consecutive years of low rainfall, vegetation was so weakened that high rainfall during 1946 did not produce a proportionate increase in forage.

The effect of amount and distribution of below-average rainfall upon decreased forage production suggested a definition and evaluation of drought severity. Any year or period of successive years which fell below average summer rainfall was considered to be a drought. The relation between actual forage loss and drought in terms of rainfall was then obtained. Total forage departures from average were plotted against a summation of successive departures of rainfall from average for the same period. The result was a curvilinear relation between loss in forage production and drought periods (Fig. 3). Total forage loss occurred at an increasing rate as rainfall departures from average accumulated. A small annual deficiency in rainfall over a long series of years had an effect similar to a large annual deficiency over a shorter period. Severity of drought is thus a combination of the amount of rainfall deficiency for any year and the number of years in succession which rainfall remains below average.

Drought severity was divided into categories of slight, moderate and severe, based upon reductions in livestock numbers which were necessary because of forage scarcity. Since the drought of 1924 was the most severe of those which did not require livestock reductions on this conservatively-stocked range, it was selected as the upper limit of slight drought (Fig. 3). Moderate reductions in animal numbers were required because of drought in 1933 and 1934, so this period was taken as the upper limit of moderate drought. The years 1941–45 and 1947–48 were placed in the severe-drought category because of drastic reductions in animal numbers which were required.

Effect on Stocking Rates

Stocking rates in the experimental pasture reflect forage production differences resulting from drought severity. Stocking was repeatedly adjusted so as to provide adequate forage for a high plane of nutrition, and to maintain sufficient herbage on the site for plant and soil maintenance. As a result, there is a close relation among severity of drought periods, forage production and stocking rates, when three 10-year periods are expressed in terms of percent of average conditions (Table 1). During the 10-year period characterized by slight droughts, growing conditions, forage and stocking rates were considerably above average; and during the period of worst drought conditions, they were substantially below average.

A conservative stocking level was maintained in the experimental pasture at all times. During the 30-year period, actual stocking was maintained about 20 percent below that which would have been possible based upon average forage production. This conservative stocking rate kept sacrifice areas around waterholes at a minimum where the greatest distance to water was 1 mile. Also, this practice reserved some forage for years of slight drought. Thus, during the period 1922–31, when only slight droughts were experienced, stocking was 45 percent above average and no stocking reductions were necessary.

During periods of moderate and severe drought, stocking rate was reduced below average. For the 10-year period in which one moderate and two slight droughts occurred, stocking was 95 percent of average. When two severe droughts occurred in the span of 10 years, stocking rates had to be lowered to 60 percent of average to supply sufficient forage without overutilizing the pasture.

Effect on Animal Production

The major factors which affect calf crop and weights on the Santa Rita Experimental Range are nutrition, handling and type of animals. The effect of quantitative nutrition was practically eliminated by periodic adjustments in stocking rates to supply sufficient forage at all times. Supplemental feeding was not employed. Methods of handling livestock, such as closer inspection of grazing animals, more care in the handling of bulls and breeding cows and close culling of shy or non-breeding cows have improved over the years (Culley 1946). Also, there has been an improvement in conformation of bulls and selection for better breeding cows among the grazing herd.

Calf crop and calf weights in the experimental pasture reflect strongly the general improvement in animals and handling methods. The upward trend in calf crop and weights resulting from better management and superior type of animal is particularly noticeable when the period 1922–29 is compared with later periods (Fig. 4).

Loss in calf crop is partially associated with drought periods of low forage production. Scarcity of forage in 1933–35 appears to have contributed to the decrease in calf crop during that period. For the period 1942–45, calf crops were decreased in 1943 and continued generally low in spite of animal reductions.

When stocking is conservative and adequate forage is available, drought appears to have little effect upon calf weights. With minor exceptions, livestock reductions were sufficient for proper nutrition and maintenance of calf weights during all drought periods. This suggests that reductions in calf crop during a drought may be related to inadequate quality rather than quantity of forage. Supplemental feeding, although not used in this study, has been helpful elsewhere for improving quality of nutrition during a drought.

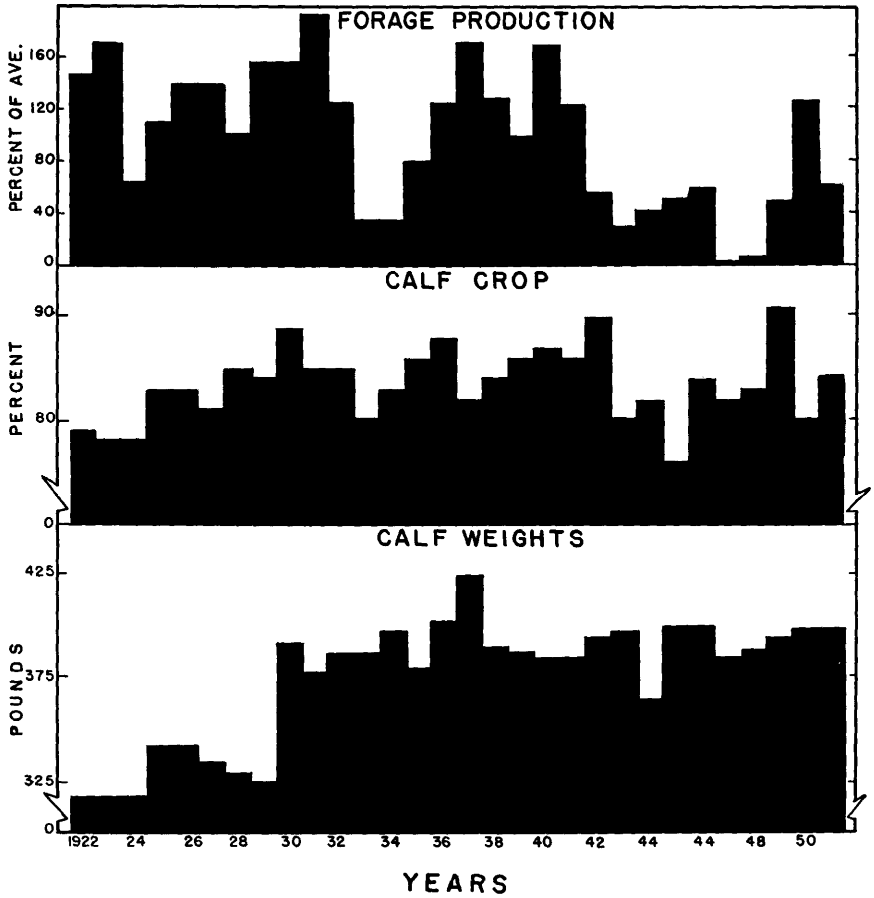

FIGURE 4. Relation of calf crops and weights to forage production by years for a foothill pasture on the Santa Rita Experimental Range.

Management Practices for Reducing Drought Effects

Animal Management

Provision for pastures of a size to accommodate 50 to 100 cows assists in avoiding drought effects. Distribution of animals is more uniform, supervision is easier and local areas of drought or above average forage can be utilized more efficiently (Culley 1949). Good control and distribution of water also aid in keeping animals well distributed within a pasture, holding areas of overgrazing to a minimum and keeping livestock in a better condition.

Reductions during moderate droughts can be accomplished with minimum loss in productivity by carrying weaner calves through to long yearlings. Disposal of these animals during droughts leads to substantial reductions in grazing pressure, and maintains the integrity of the breeding herd which may be the result of years of effort in selection and grade improvement.

Proper Utilization

Proper utilization is the key to maintenance of desert grasslands

Table 2. Average and extremes for frequence of occurrence, severity, and duration of moderate and severe droughts for desert-grassland ranges

Classification	Percent of years occurring		Number of years duration		Percent average stocking rate for proper use	
	Median	Extremes	Median	Extremes	Median	Extremes
Moderate	14	0–36	2	1–5	50	30–95
Severe	21	0–54	3	1–9	30	0–80
Total	35	20–54	2	1–9	40	0–95

during periods of recurrent drought. For most perennial grasses in this type, utilization should average 35 to 55 percent removal of the total herbage weight (Parker and Glendening, 1942). The remaining herbage is needed for plant and soil maintenance. This degree of utilization has maintained perennial grasses in a desirable state of density, composition and vigor over a period of 30 years. Utilization should not exceed proper, even when a drought is long and severe. Only when stocking rate is geared to proper utilization can recurrent periods of drought be weathered without range deterioration.

Redistribution of animals or rotation of use of pastures helps greatly to combat drought. Severity of drought varies greatly within short distances. For example, on various parts of 50,000 acres on the Santa Rita Experimental Range in 1938, forage production varied between 20 and 110 percent of the longtime average. The southeast and northwest portions of the Experimental Range showed above-average forage production, whereas the northeast portion was experiencing a severe drought. The remainder of the range exhibited conditions of slight drought. Individual pasture evaluation and stocking adjustments can thus aid materially in obtaining proper utilization during a drought.

Planning for Drought

To maintain a stable income during recurrent periods of drought, it is necessary to know the frequency with which droughts occur, their severity and their duration. To obtain an estimate of these drought characteristics for desert grasslands, weather records for 39 stations of more than 20 years length in southern Arizona and southwestern New Mexico were evaluated.

Categories of drought severity as outlined in Figure 3 were converted to percentages of average rainfall in order to apply the drought-severity concept to other areas in the desert grassland. When summated departures of below-average rainfall for the experimental area are expressed as a percent of average rainfall, drought categories are defined as follows:

slight drought,—summated departures of below-average rainfall lie between 0 and 40 percent of average rainfall.

moderate drought,—summated departures are between 41 and 70 percent of average rainfall.

severe drought,—summated departures exceed 70 percent of average rainfall.

Data for the 39 weather stations within the desert-grassland province show that droughts severe enough for livestock reductions occur at most stations 35 percent of the time (Table 2). Individual stations showed extremes of drought conditions varying from 20 to 54 percent of the time. Within this total percentage, moderate droughts occurred 14 (0–36) percent of the time, and severe droughts 21 (0–54) percent of the time. Duration of drought was also subject to wide variability for individual stations. For all droughts which require livestock reductions the most frequent duration was 2 (1–9) years; for severe conditions, 3 (1–9), years; and for moderate conditions 2 (1–5) years.

As an overall estimate for desert-grassland ranges, stocking should be 40 percent below the longtime average 35 percent of the time to achieve proper utilization during droughts. For a moderate drought, stocking should be about 50 percent of the longtime average stocking rate, and during severe droughts should be reduced to 30 percent of average. These figures express the average expectations only and should be used as guides, since for an individual locality much greater stocking reductions may be needed. The safest basis for proper stocking is annual adjustments in numbers so as to utilize no more than 35 to 55 percent of total perennial grass herbage produced in any year.

Drought presents two major problems to the livestock industry on desert-grassland ranges where sustained use without deterioration of rangelands is the major objective. The first problem is how to make animal adjustments rapidly enough to maintain proper annual use of a highly-variable forage supply. The other is concerned with maintenance of a stable annual income where the basis for income—the forage crop—is highly variable.

There are several alternatives for making animal adjustments. The most conservative would be one aimed at maintaining the integrity of an exclusive cow-calf operation. Such a system would necessitate reducing numbers of breeding animals to use about 40 percent of the average longtime forage production. Such a system would insure adequate forage with the exception of an occasional severe drought, but would make inefficient use of forage about 60 percent of the years. The most liberal system would depend upon purchase of yearlings or older animals annually in July for marketing sometime between November and May.

Several compromise livestock operations are possible. One would be that of maintaining breeding animals at 40 percent of the herd, and using the remaining forage by holding over yearlings or buying other growing animals. A slight modification of this procedure has proved practical on the Jornada Experimental Range (Ares, 1952). Another possible system is that of supplying forage from an outside source. If this practice is followed precautionary measures to avoid range damage should be observed. Supplemental feeding of concentrates on rangelands should be used only to supply a nutrient deficiency such as protein or minerals. It should not be used to carry over animals on the range, when stocking reductions are necessary to prevent overutilization of range plants. If feed is obtained from irrigated pastures or other sources, it should be made available in feed lots or special holding areas to avoid damage of valuable range lands. The most desirable method for taking advantage of annual fluctuations in forage must be worked out for each operation, if optimum returns from desert grasslands are to be realized without range deterioration.

A stabilized income on desert-grassland ranges should be based upon adequate financial reserves. Reserves may take any of several forms including savings, easily-liquidated investments, insurance or other negotiable securities. Such reserves are basic to a stable income because livestock enterprises can be expected to operate at 40 percent of average stocking for periods up to 9 years. Standards of living should not be attached to periods of high stocking rates and income. Even though livestock reductions during time of drought can be compensated during periods of above-average rainfall, a stable income is dependent upon financial reserves.

Summary

Drought is a recurring problem on desert-grassland ranges. It always lowers forage production, and sometimes necessitates livestock reductions to prevent overutilization of the forage resource. This analysis defines drought, relates it to livestock reductions and describes some practices which can be used to reduce the disastrous effects of drought. Data extend over 30 years of records for a foothill pasture on the Santa Rita Experimental Range—an area representative of desert grasslands of southern Arizona.

Drought is defined as below-average rainfall. Drought periods or summated departures of successive years of below-average summer rainfall are closely related to forage losses. Periods of drought severity are designated as slight, moderate and severe, depending upon forage scarcity. The last two require livestock reductions to prevent overutilization of the forage crop, whereas slight droughts can be avoided by conservative stocking.

Livestock reductions to provide adequate forage result in maintenance of calf weights even during a severe drought. Slight reductions in calf crops during drought periods are presumed to be caused by nutritive deficiencies of the forage.

Proper utilization is the key to maintenance of desert grasslands and should average 35 to 55 percent of the annual herbage produced by perennial grasses. As an average estimate for desert-grassland ranges, stocking should be 40 percent below the longtime average about 35 percent of the time when droughts reach moderate and severe intensity. Drought reductions necessitate rapid adjustments in animal numbers to maintain proper utilization. Moreover, financial reserves should be maintained to insure a stable income on desert-grassland ranges, even though livestock increases during drought-free periods can be expected to compensate for income reductions during drought periods.

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THE CHEMICAL CHARACTERISTICS OF NATURAL LICKS USED BY BIG GAME ANIMALS IN WESTERN MONTANA

(Abstract of thesis presented in partial fulfillment of the requirements for the degree of Master of Science in the School of Forestry, Montana State University, June, 1953.)

Game managers and sportsmen have been speculating for many years as to why big game ruminants make use of natural licks. With the advent of extensive big game salting programs in many states, the solution to this problem assumed new importance. The answer would apparently indicate which salt or salts should be used to secure maximum effectiveness of the salting programs. For these reasons, as well as to add to the knowledge of big game habits, a study of natural licks in western Montana was inaugurated in October, 1950 at Montana State University.

Artificial licks consisting of mineral cafeterias or soil impregnation tests were established on various game ranges on the assumption that the animals would indicate a preference for a certain salt or salts. The mineral cafeterias consisted of a series of jars containing various chemical compounds mixed with soil from areas not used as licks by the animals. The soil impregnation tests consisted of areas of soil treated with solutions of various chemical compounds. The following elements were used in various forms in the artificial lick tests: copper, cobalt, calcium, sodium, phosphorus, potassium, chlorine, iron, sulphur, magnesium, and iodine.

Chemical analyses of various properties and elements were made on one set of six samples from each of 18 natural lick areas. Three of these six samples were taken from actively used portions of each lick and three from the first foot of a normal soil profile near the lick area.

The results of the artificial licks strongly indicated that compounds containing the sodium ion were preferred by the big game in all study areas.

pH determinations revealed that all actively used lick samples were alkaline in nature and possessed a higher pH value than the corresponding unused soil samples. Electrical conductivity determinations disclosed that the actively used lick samples contained larger amounts of water soluble salts than did the unused soil samples. Both of these determinations indicated that a larger amount of the cations were present in the actively used lick samples. Additional chemical analyses revealed this to be the case.

Quantitative chemical determinations of various elements revealed that calcium, magnesium, sodium, and potassium were found in fairly large amounts in all lick areas, while chlorine, sulphur and iron were present in smaller amounts. Phosphorus was detected in minute quantities in all but one lick area. When the results of these determinations are interpreted in light of the findings of the mineral preference tests, the evidence strongly indicates that big game ruminants in western Montana are utilizing natural licks to obtain sodium.

The results of all phases of this study have indicated that sodium chloride should be effective as an attracting agent in the big game salting programs.

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