Managing Grass-Shrub Cattle Ranges in the Southwest

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Managing Grass-Shrub Cattle Ranges in the Southwest

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INTRODUCTION

Grass-shrub rangelands occupy extensive acreages in southeastern Arizona and southwestern New Mexico between elevations of 3,000 and 5,000 feet. At lower elevations, the grass-shrub type merges with deserts dominated by creosotebush.[2] At higher elevations, the type forms a transition with chaparral, pinyon-juniper, or oak-woodland types (fig. 1). Perennial grasses are the mainstay of the forage supply but browse species and annual grasses are sometimes important.

Sustained high production of perennial grass forage depends upon stocking the proper number of animals, grazing at appropriate times, and providing for optimum distribution of livestock. The usual practice is to graze the ranges yearlong. Annual or periodic adjustments in number of grazing animals are necessary because of wide variations in forage production. Seasonal adjustments are also helpful. Grazing can often be planned to make summer use of abundant annuals at lower elevations, spring use of ranges where browse is abundant, and winter use of ranges where black grama is an important component.

Better utilization of grass-shrub ranges can be had by fencing subdivisions to accomodate 50 to 100 animal units, providing permanent and dependable watering places, and using salt or salt-meal mix judiciously. On many ranges forage production is low because undesirable shrubs have replaced good forage species. Here, shrub control, revegetation, or other measures are needed to restore forage production.

This publication describes the grass-shrub type at Santa Rita Experimental Range, about 30 miles south of Tucson, Ariz. Recommendations for management of the type and improvement in practices are based upon intensive work on the experimental range and observations elsewhere. Many of the recommendations are applicable, possibly with local modifications, over the entire grass-shrub range.

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[1] Central headquarters of station maintained at Fort Collins, Colo., in cooperation with Colorado State University; studies reported in this publication were conducted in cooperation with the University of Arizona, Tucson, Ariz.

[2] Common and scientific names of plants mentioned are listed on page 38.

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FIGURE 1.—Grass-shrub rangelands (*B*) lie between the oak-woodland and chaparral areas (*A*) above 5,000-foot elevation, and the creosotebush desert (*C*) below 3,000 feet.

THE EXPERIMENTAL RANGE

Santa Rita Experimental Range is an area of about 52,000 acres. It is on a gently sloping plain that drains northwest into Santa Cruz River. The general topography is interrupted by a few stony buttes and low foothills, and by numerous drainage channels.

Twenty experimental pastures constitute the experimental range. Grazing studies are conducted with privately owned cattle, but grazing management plans are under control of the Federal Government. Wells, surface tanks, and pipelines from mountain springs have been constructed as opportunity and finances permitted.

Climate

At the experimental range headquarters at an elevation of 5,000 feet, daily maximum temperatures sometimes exceed 100° F. during the summer. Mean minimum July temperature is 68° and the mean maximum in June is 91° (fig. 2). Frost-free periods extend from March to November. More than 275 days are relatively cloudless each year, with sunshine more than 80 percent of the time. Relative humidities are low, and wind movements are usually light and variable. Evaporation rate is about 75 inches a year from free-water surfaces.

Rainfall Distribution

Precipitation is almost entirely rain. About half of the annual rainfall comes during July, August, and September (fig. 2), and about 40 percent of it comes during the 6-month period October through March. April, May, and June are the driest months of the year. Typically, the rainfall pattern consists of a summer peak, a winter plateau, and a late spring drought. About once in 10 years rainfall is unusually high in the winter or spring.

Summer and winter precipitation differ in origin of moisture and type of storm. The torrential showers in the summer come from moisture-bearing air that originates over the Gulf of Mexico to the southeast. Winter storms—usually in the form of rain—are largely of the frontal type, originating in the north and west.

Rainfall Variations

Annual and seasonal rainfall vary greatly (fig. 3). Over a period of 50 years at Santa Rita Experimental Range headquarters, annual rainfall has varied from a maximum of 36.8 inches in 1930–31 to a minimum of 11.2 inches in 1903–04, and has averaged 19.5 inches.

Successive years of above-average or below-average rainfall are common. For example, in the 50-year record there are six periods in which two successive years of below-average moisture occurred before relief by a year of above-average rainfall; and in two other periods, three successive years of below-average rainfall occurred.

Annual rainfall varies greatly with elevation. For example, on the southern edge of the experimental range, with a 500-foot increase in elevation there is an average increase of 4 inches.

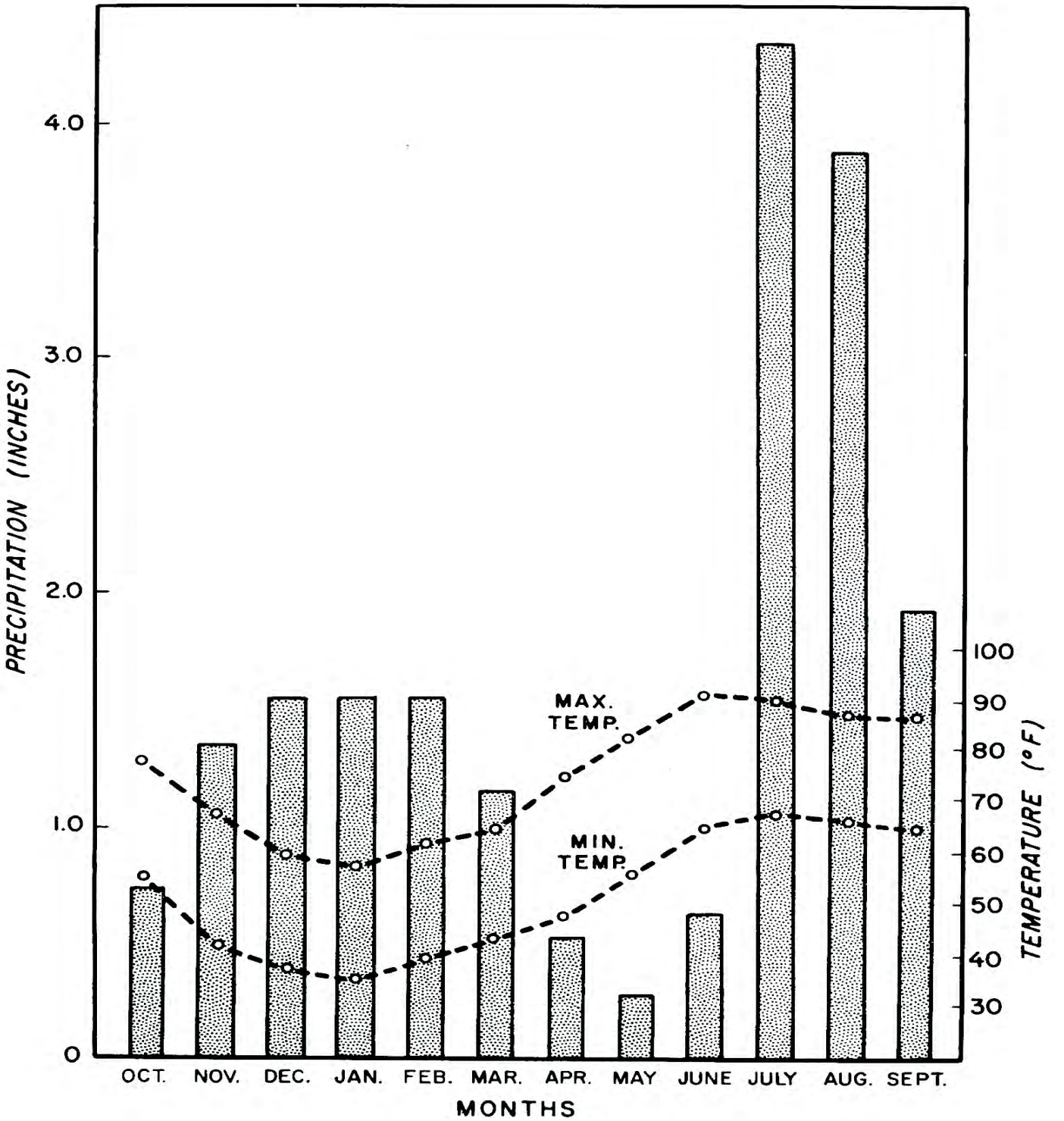

FIGURE 2.—Average monthly precipitation and average maximum and minimum monthly temperatures at Santa Rita Experimental Range, based on 50 years of record.

Summer rainfall is spotty. In a given year, differences of 1 inch have been noted within the distance of a mile, though the average rainfall at both locations is the same. One area may be drought stricken while an adjacent area may receive above-average rainfall. Also, individual storms may be extremely local; rains of 1 inch or more may fall on an area of less than a square mile.

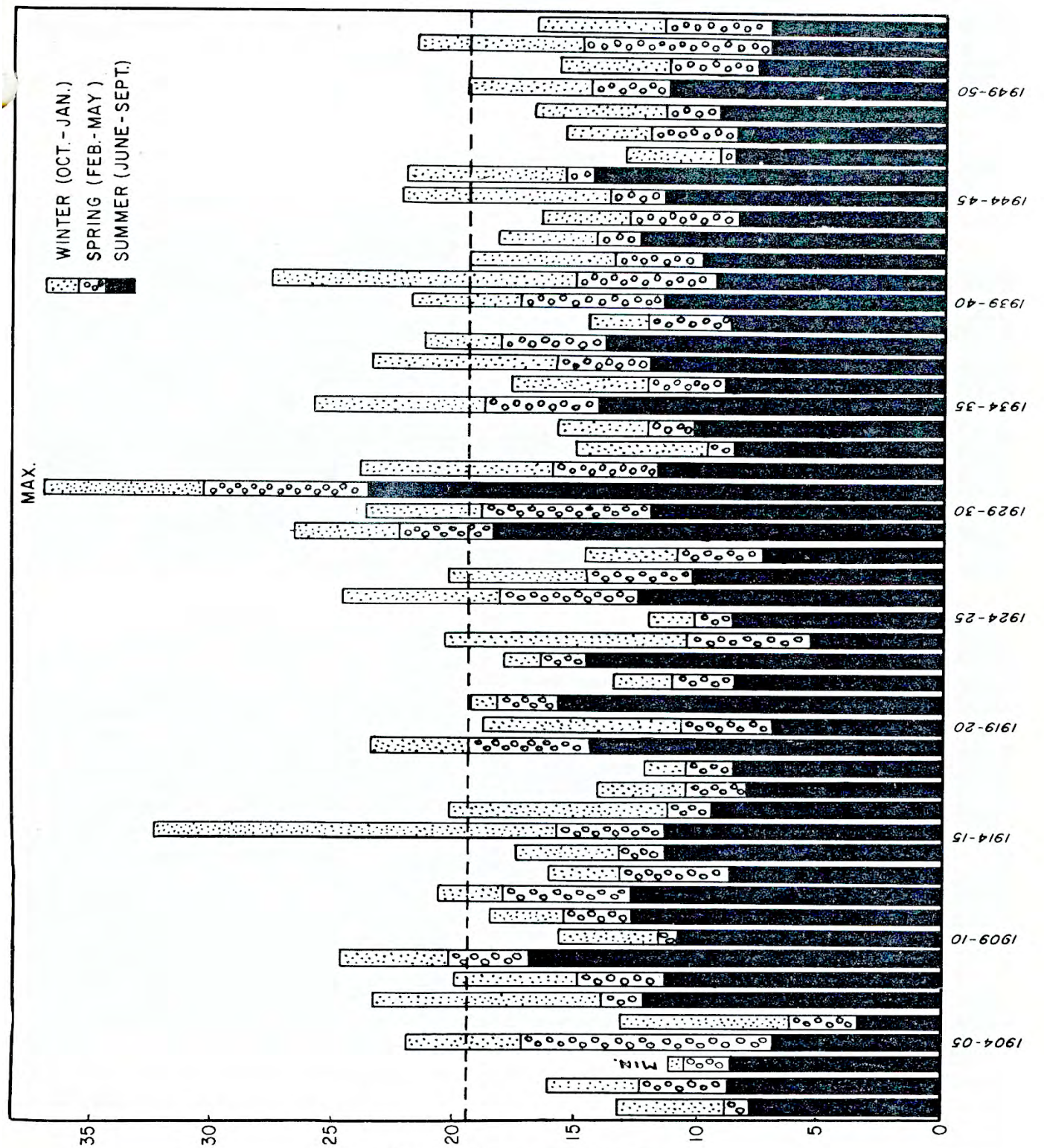

FIGURE 3.—Annual and seasonal precipitation at Santa Rita Experimental Range.

Vegetation

Because vegetation of the grass-shrub type varies with elevation, the vegetation on the experimental range will be discussed separately for lowest and driest elevations, upper and more moist elevations, and intermediate elevations. The range was considered to be in fair condition when surveyed in 1941. A list of the principal perennial grass and shrub species representative of each elevation and in order of abundance is given in table 1.

TABLE 1.—*Relative abundance of perennial grasses and shrubs for three elevations on Santa Rita Experimental Range for areas judged to be in fair condition* [1]

PERENNIAL GRASSES

High elevation (5,000–4,000 ft.; rainfall 19–16 in.)		Intermediate elevation (4,000–3,300 ft.; rainfall 15–13 in.)		Low elevation (3,300 ft. or less; rainfall 12 in. or less)	
	Percent		*Percent*		*Percent*
Sprucetop grama	38	Rothrock grama	7	Fluffgrass	2
Black grama	13	Black grama	5	Bush muhly	1
Arizona cottontop	7	Sideoats grama	3	Santa Rita threeawn	1
Slender grama	7	Curlymesquite	3	Rothrock grama	1
Sideoats grama	3	Bush muhly	2	Arizona cottontop	1
Threeawns, misc	3	Santa Rita threeawn	1	Sand dropseed	(2)
Hairy grama	2	Hairy grama	1	Threeawns, misc	(2)
Other perennial grasses	4	Arizona cottontop	1	Alkali sacaton	(2)
		Sprucetop grama	1	Tanglehead	(2)
		Plains bristlegrass	1	Black grama	(2)
		Sand dropseed	1	Other perennial grasses	(2)
		Threeawns, misc	1		
		Other perennial grasses	1		

SHRUBS

Velvet mesquite	9	Burroweed	35	Burroweed	46
Wright eriogonum	7	Velvet mesquite	20	Velvet mesquite	18
Falsemesquite	7	Cholla, cane & jumping	13	Cholla	15
		Shortleaf baccharis	2	Creosotebush	8
		Hackberry, spiny	2	Shortleaf baccharis	2
				Ephedra, longleaf	2
				Desert zinnia	2
				Saltbush, fourwing	1

[1] Approximate composition based upon areal cover by ocular estimate.
[2] Less than 0.5 percent.

At the highest elevations, perennial grasses make up three-fourths of the plant composition (fig. 4). Shrubs are sparse but some, such as falsemesquite and Wright eriogonum, are good browse. Important perennial grasses are the gramas—sprucetop, black, slender, sideoats, and hairy—Arizona cottontop, and threeawns. Miscellaneous grasses of lesser importance are Rothrock grama, plains lovegrass, green sprangletop, and curlymesquite.

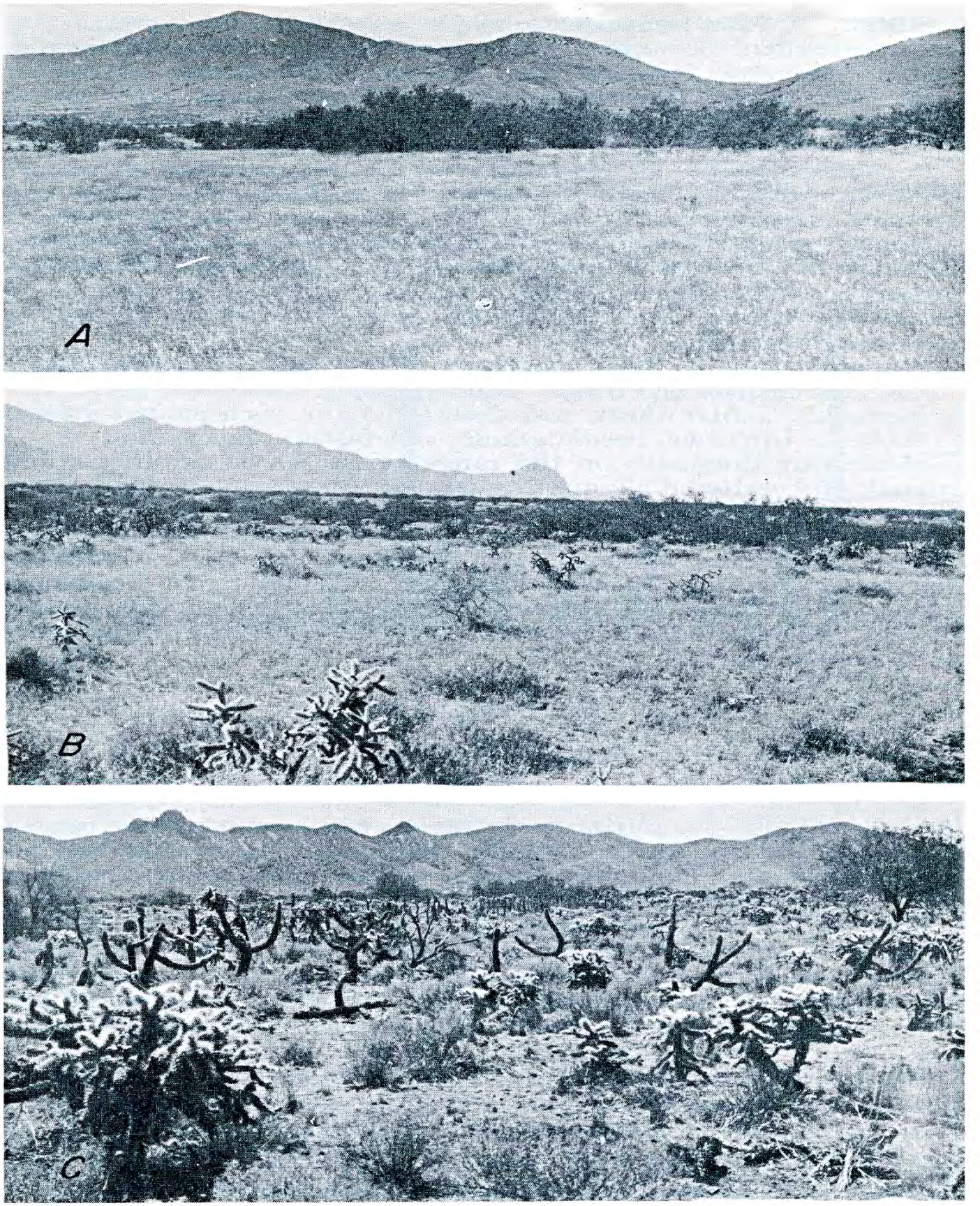

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FIGURE 4.—*A*, The highest elevations are characterized by perennial grass. Shrubs are confined largely to arroyos. *B*, At the intermediate elevations, shrubs are more abundant, and perennial grass density is lower. *C*, At the lowest elevations, shrubs and cacti predominate.

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Shrubby species comprise about 70 percent of the vegetation at the intermediate elevations. Low-value shrubs, such as burroweed, cholla, and velvet mesquite, are common. The natural habitat of these species is at the lower elevations. Woody plants have spread from there to many higher adjacent areas, making dense, vigorous stands of brush.

Perennial grasses are abundant at the intermediate elevations. Rothrock grama is most prevalent. It is fairly short-lived and fluctuates excessively with variations in rainfall. Among the more abundant grasses are black grama, sideoats grama, curlymesquite, and bush muhly. Other species found sparingly include Santa Rita threeawn, hairy grama, sprucetop grama, Arizona cottontop, and plains bristlegrass. Bush muhly and sand dropseed are prominent along the broad sandy washes.

Annual species, at times, constitute a large part of the vegetation at the intermediate elevations. Most common are annual herbs such as heronbill, Indianwheat, and deervetch; and such annual grasses as sixweeks threeawn, needle grama, and feather fingergrass.

Shrubs are dominant on the range at the lower elevations, and annuals and scattered clumps of perennial grass grow between them. The main woody species are burroweed, velvet mesquite, and cholla. Also present are such shrubs are creosotebush, desert zinnia, longleaf ephedra, fourwing saltbush, and shortleaf baccharis. Perennial grasses, mainly bush muhly, Rothrock grama, Arizona cottontop, and sand dropseed, are sparse. Fluffgrass is the most abundant species. Annual grasses outproduce perennial grasses during years of favorable rainfall.

The Forage Crop

Growth Periods

Rainfall during both summer and winter makes possible two growth periods—one during early spring when temperatures become favorable, and one during summer when rains begin after the late spring drought. Perennial grasses, browse, and annuals react in their own characteristic fashion to this climate.

Most perennial grasses begin growth with the start of summer rains and continue growing throughout July, August, and September. Some may also produce a little growth at intermittent intervals from February through June. However, more than 90 percent of perennial-grass growth is produced after summer rains begin (*9*)[3].

Height measurements of flower stalks of Rothrock grama, slender grama, and Arizona cottontop illustrate the growth response of perennial grasses to summer rainfall (fig. 5). During the year of measurement, the first rains came on June 28 after a 2-month dry period. Subsequent distribution of rainfall was excellent, and as a result growth was uninterrupted. Growth commenced about 2 weeks after the first rains, was most rapid during August, and was completed by September 22.

[3] Italic numbers in parentheses refer to Literature Cited, p. 39.

During the years 1929–33, length of growing season of perennial grasses measured at several sites varied from 56 to 84 days. The earliest date of growth was July 1, and the latest date was September 29. For the 5 years, average starting and ending dates were July 7 and September 14, for an average growing season of 69 days. On the average, growth commenced 11 days after the first effective rain and continued for 4 days after the last effective rain. An effective rain was defined as a total of at least 0.4 inch of rainfall on successive days.

Shrubby plants commence growth on winter-spring moisture. Growth usually begins in March and many species flower and fruit

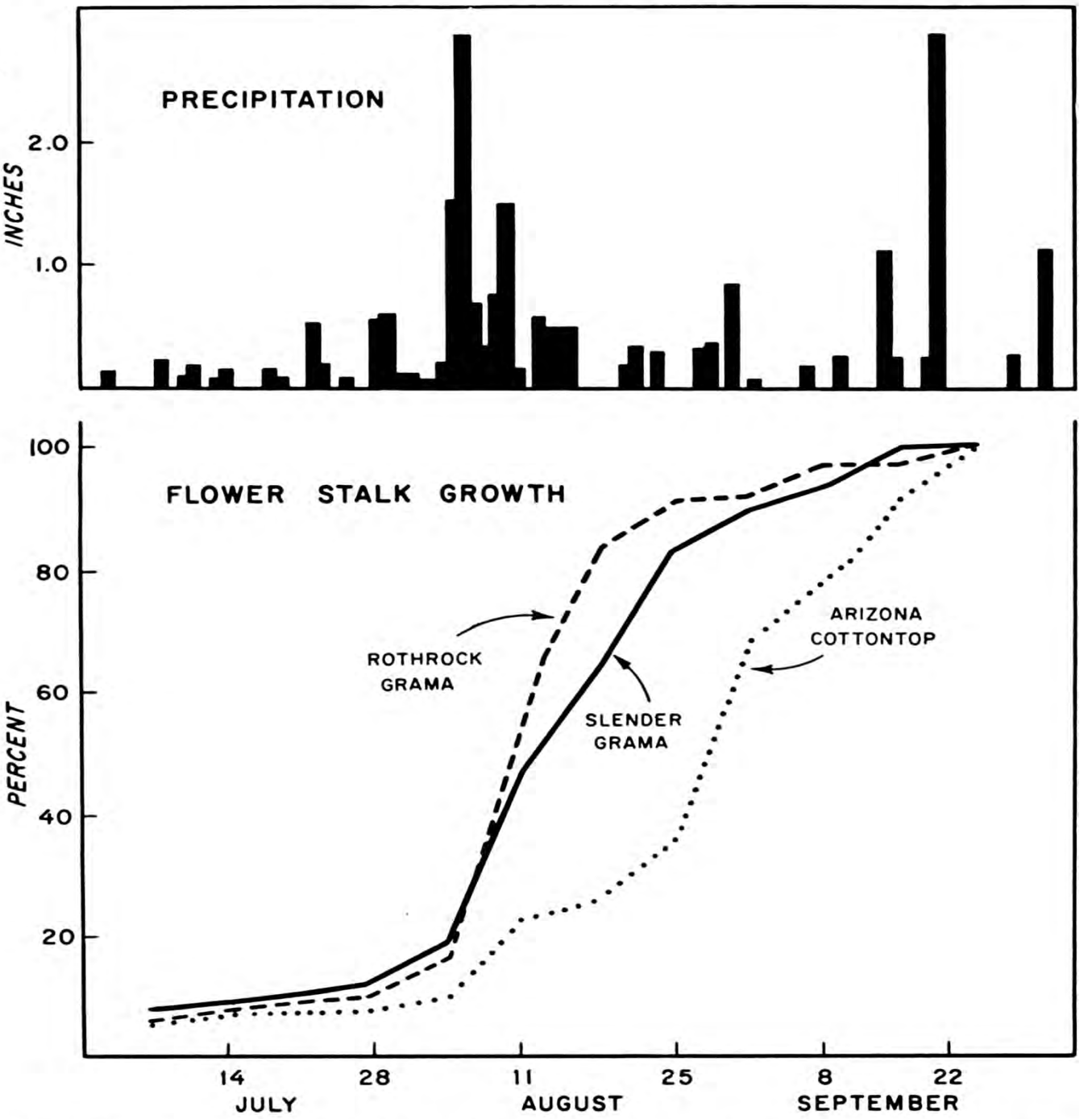

FIGURE 5.—Growth curves of flower stalks of slender grama, Rothrock grama, and Arizona cottontop in relation to rainfall distribution during one summer on Santa Rita Experimental Range.

in May. Some species flower and fruit a second time during the summer rainy season and complete the cycle in August or September. Leaves usually remain throughout the spring and summer growing season. However, some species, notably falsemesquite, may produce a second set of leaves during the summer rainy season if the May-June dry season is severe enough to cause defoliation.

Annual plants grow during two seasons. One group germinates at low temperatures and completes growth during the spring. Another group requires higher temperatures accompanied by summer rains. Examples of the low-temperature group are sixweeks fescue, heronbill, deervetch, and Indianwheat. Sixweeks threeawn, feather fingergrass, and needle grama are good examples of summer annuals.

Forage Production

Production of perennial grasses increases with elevation. The average production of perennial grasses on Santa Rita Experimental Range during the period 1939–49 was as follows:

Elevation (feet):	*Average annual rainfall (inches)*	*Perennial grass per acre (air-dry lbs.)*
5,000–4,000	16–19	440
4,000–3,300	13–15	260
3,300 or less	12 or less	110

On the average, the highest elevations produce about four times as much perennial grass herbage as the lowest. This difference occurs within a distance of less than 10 miles and within an elevation change of less than 2,000 feet.

Because of the cumulative effect of successive years of abnormal rainfall, production of perennial grasses varies more than rainfall. A year of low rainfall after several successive years of above-average rainfall does not affect production as greatly as if it followed several low rainfall years. Also, after a prolonged drought, increased rainfall does not produce an immediate response (*17*).

Production of annuals varies from year to year, depending on amount and distribution of rainfall. Production is abundant in years of favorable rainfall, but during dry periods seeds may not germinate. Large amounts of spring annuals are produced only during the infrequent wet winters. Production of summer annuals is more consistent but may differ greatly in some years.

The variation in annual grass production per acre is illustrated by the following tabulation:

Elevation (feet):	*1954 (pounds)*	*1955 (pounds)*	*1956 (pounds)*
5,000–4,000	130	360	80
4,000–3, 300	180	170	20
3,300 or less	450	220	10

This tabulation also shows the greatest variation at the low elevation, which receives the lowest average rainfall.

Forage Preferences

Cattle prefer green forage. As a result, grazing tends to be concentrated on areas where plants green-up early or remain green longer than usual.

Cattle often graze heavily on annuals that are in the growth stage. During favorable springs, heronbill, sixweeks fescue, and Indianwheat sometimes furnish considerable forage. However, production of annuals is most dependable during a summer period of 1 month to 6 weeks.

Perennial grasses are preferred by cattle and may be used yearlong as a source of forage (*4*). In the spring when rainfall is favorable, Santa Rita threeawn grows rapidly and is especially favored as forage. In the summer and early fall, many species of perennial grasses are grazed. As the plants mature, however, cattle become more selective. For example, black grama, curlymesquite, and bush muhly are preferred in the late fall and winter. Ranges with a high proportion of black grama are especially adapted to use during late winter and spring, because black grama retains its nutritive value better than most perennial grasses.

Many species of shrubs are palatable, including falsemesquite, Wright eriogonum, velvet mesquite, shortleaf baccharis, and range ratany. Shrubs are especially preferred from fall to late spring when other vegetation is usually dry. At lower elevations shrubs are grazed throughout the year; hence they may furnish the bulk of the forage.

RANGE CONDITION

Range condition is a term used to describe range health. Every range has a given potential for production as determined by climate and soil under longtime proper grazing use. The position of a range relative to its potential can be stated in terms of different condition classes. Thus, a range in excellent condition is producing at its potential consistent with longtime grazing use. Important factors affecting productivity of grass-shrub ranges are weather, mesquite or other woody plant invaders, grazing, rodents, and rabbits.

Effect of Weather

Drought periods, particularly if they continue for three or more consecutive years, can bring about a deterioration in plant composition, vegetational cover, and herbage production (fig. 6). Species most susceptible to drought include tanglehead, Rothrock grama, and slender grama. During protracted droughts, even such highly resistant species as black grama may be severely affected.

A year of above-average moisture may produce an abundance of annuals and short-lived perennials and increase the vigor of the long-lived perennials. If the favorable moisture continues for two or more successive years, new plants of the better, longer lived species will become established.

Speed of range recovery depends upon the seriousness of a drought. If it is a prolonged one, the plants should be given an

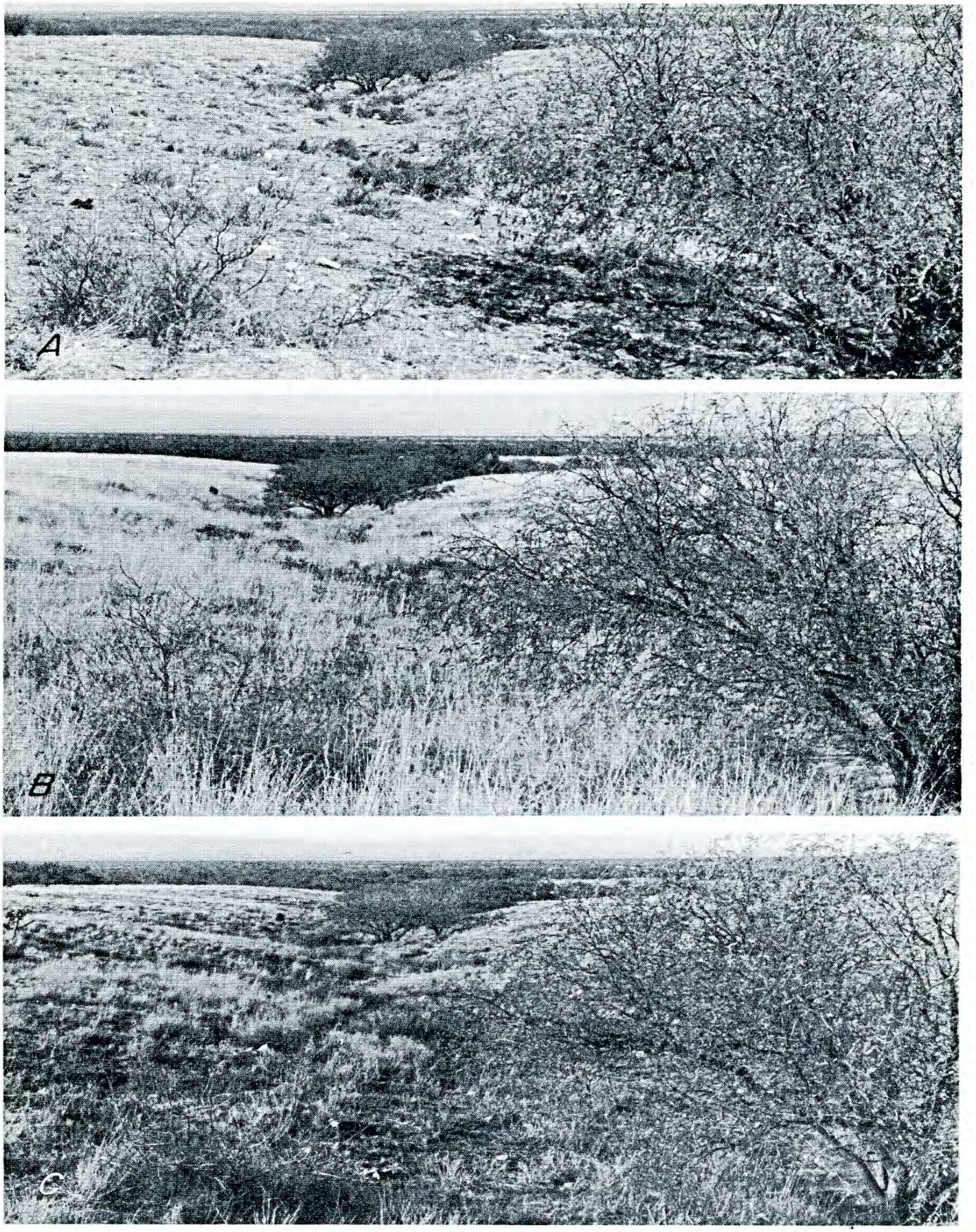

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FIGURE 6.—Great yearly variations occur in forage production on grass-shrub ranges of southern Arizona. *A*, In 1948, less than 10 pounds of perennial grass per acre were produced; *B*, in 1950, more than 300 pounds per acre; *C*, in 1952, only 100 pounds per acre.

opportunity to recover. Range condition will improve much more quickly if grazing use is kept light for a year or two.

Effect of Shrubs

The spread and thickening of undesirable shrubs have an important influence on range productivity. Mesquite, cacti, and burroweed are the most serious invaders, but the effect of mesquite is known best.

Mesquite has increased greatly in the past 50 years and has spread from its original habitat along drainage channels and arroyos to the uplands (fig. 7). Dissemination of seed by grazing cattle is largely responsible for the recent spread (*12*). Mesquite furnishes some forage, especially during the season of seed production, but

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FIGURE 7.—Mesquite spreads rapidly when seeds are abundant. At this site, mesquite has increased greatly in a period of 18 years.

not enough to compensate for the loss of perennial grass (fig. 8). Because mesquite lowers forage production, fewer animals must be grazed to avoid injury to perennial grasses.

A comparison of cattle stocking of two range units on Santa Rita Experimental Range over an 11-year period illustrates the effect of mesquite invasion upon cattle production. Mesquite made up 21 percent of the vegetation as measured by crown spread in 1937 on one unit, whereas mesquite made up only 8 percent of the composition in the other unit. In the more heavily infested unit, mesquite increased rapidly, and in 11 years the site was densely occupied by mesquite. In the lightly infested unit, the increase of mesquite was much slower. The more heavily infested range could support only 40 percent of the livestock it supported 11 years earlier. The slow spread of mesquite in the lightly infested range did not materially affect production, and stocking was maintained at a more nearly constant rate for the same period.

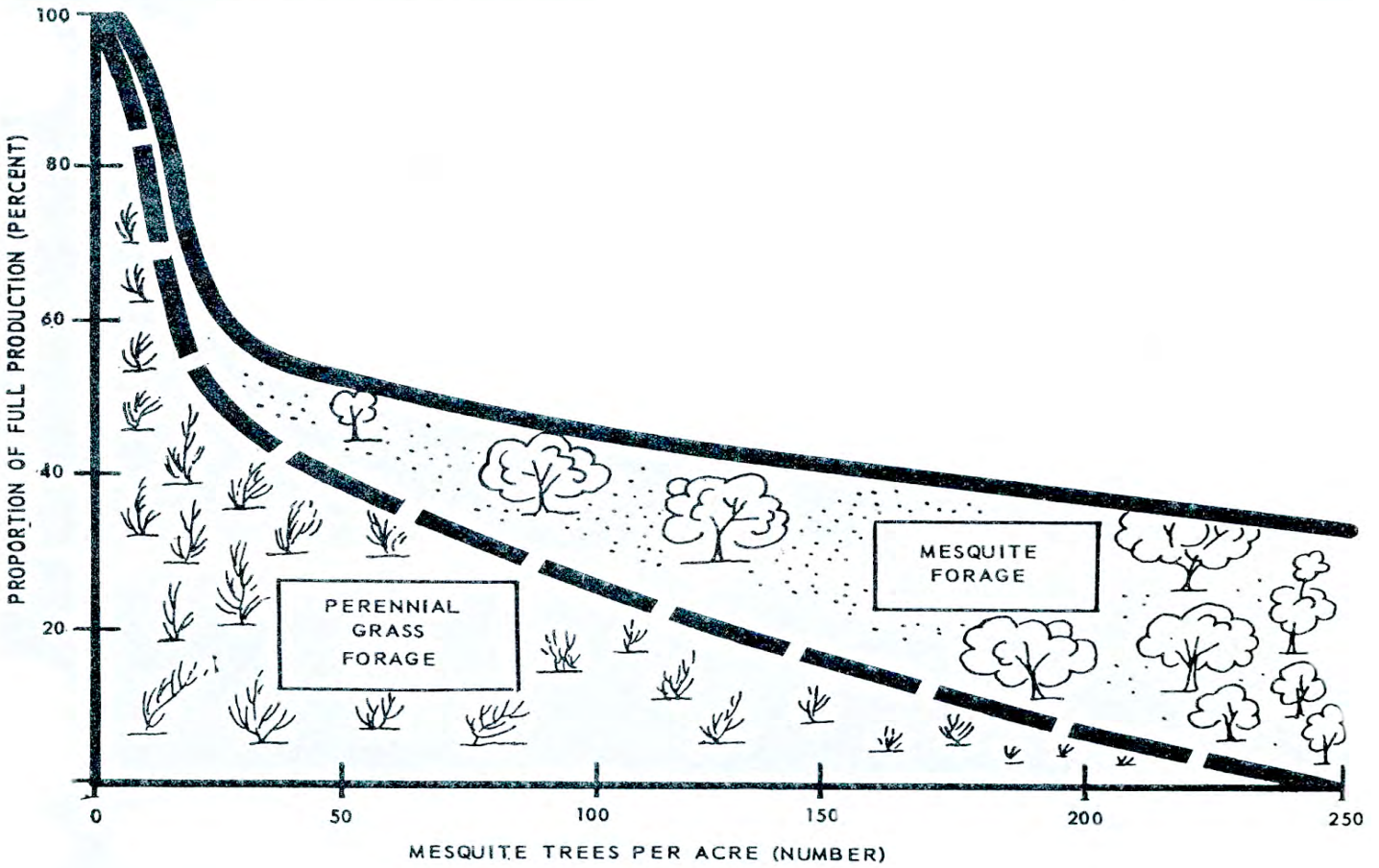

FIGURE 8.—Relation of mesquite abundance to forage production (*20*).

Effect of Grazing

Grazing influences vegetation chiefly as a result of herbage removal. In order to maintain healthy and vigorous forage plants, sufficient leafage must be left after grazing to provide for food manufacture and storage and to protect the plants during dormancy.

The need for maintaining sufficient leafage to sustain plant production is illustrated by a clipping study made on Santa Rita Experimental Range over a 9-year period. One treatment consisted

of clipping perennial grasses (hairy, sprucetop, and slender grama, and curlymesquite) to a height of 1 inch at weekly intervals during the growing season. This removed most of the leafage at a time when the plants were manufacturing food for growth and storage. Herbage production of these plants was compared with another group of plants clipped to the same height at the end of the growing season. Over the period of 9 years, plots clipped at weekly intervals produced an average of only 53 percent as much total herbage as plots clipped only at the end of the growing season. The decrease in herbage production was similar in all four species treated.

Plant species on grass-shrub ranges vary greatly in their palatability, and cattle tend to select and graze the preferred species closely. As these plants lose vigor and die where grazing is excessive, they are replaced by species that are less palatable or more resistant to grazing. Thus, selective grazing changes plant composition.

An example of how cattle grazing can change plant composition is shown by comparing vegetation inside 15 ungrazed enclosures with that in adjacent plots grazed continuously yearlong for approximately 25 years. Plant composition inside and outside the enclosures was similar when the enclosures were established. Grazing removed about half the total production of all perennial grasses each year; however, certain species were grazed much heavier than this. Species most abundant under continuous yearlong grazing were curlymesquite, Rothrock grama, and slender grama (table 2). Those favored by protection from grazing were Arizona cottontop, bush

TABLE 2.—*Composition of perennial grasses on areas protected from grazing for approximately 25 years and on adjacent areas grazed continuously*

Species	Grasses at high elevations		Grasses at intermediate elevations	
	Protected areas	Grazed areas	Protected areas	Grazed areas
	Percent	*Percent*	*Percent*	*Percent*
Arizona cottontop	31	6	26	2
Bush muhly	0	0	11	(1)
Curlymesquite	1	13	0	0
Grama:				
Black	7	5	26	15
Hairy	3	2	0	0
Rothrock	2	12	7	64
Sideoats	10	6	2	(1)
Slender	15	49	1	5
Threeawns	9	5	14	10
Tanglehead	5	1	3	3
Other grasses	17	1	10	1
Total	100	100	100	100

Basis: basal area.

[1] Less than 0.5 percent.

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muhly, black grama, sideoats grama, threeawns, and a variety of less abundant grasses, such as plains lovegrass and green sprangletop.

Another study (*6*) has demonstrated that the number of new plants produced by perennial grasses is influenced by grazing. Wolftail, Rothrock grama, sprucetop grama, slender grama, and curlymesquite produced more new seedlings where grazed than where protected. In contrast black grama, sideoats grama, hairy grama, and tanglehead produced more new plants where protected from grazing. The same study indicated that grazing reduced the average life span of wolftail, black grama, hairy grama, sideoats grama, tanglehead, mesa threeawn, and Arizona cottontop, and extended the life of Rothrock and slender gramas and curlymesquite.

The objective of grazing management is to maintain a continuous and abundant supply of good quality forage. Therefore, a range in good condition must have a fairly stable population of highly productive perennial grasses. Such preferred species as Arizona cottontop, bush muhly, black grama, hairy grama, and sideoats grama produce a more stable source of forage and are better able to withstand periodic droughts.

Effect of Rodents and Rabbits

Rodents and rabbits use vegetation that would otherwise be available for livestock and thereby lower overall grazing capacity of a range. For example, on Santa Rita Experimental Range in 1937, rodents and rabbits were estimated to consume about two-fifths of the total forage produced (*8*). Animal numbers for the entire experimental range, and estimated forage consumption, were as follows:

Species:	*Animals* (*no.*)	*Forage consumed per animal per year* (*lbs.*)	*Forage consumed per year* (*lbs./acre*)
Allen jackrabbit	10, 300	175. 20	35
California jackrabbit	620	120. 45	1
Arizona cottontail	3, 530	54. 75	4
Roundtail groundsquirrel	29, 780	8. 21	5
Bannertail kangaroo rat	87, 125	5. 53	9
Merriam kangaroo rat	42, 025	2. 41	2
Total			56

Rodents and rabbits can be more detrimental to range vegetation than cattle because they graze much closer and may even dig up root systems during dry periods (fig. 9). Also, certain species, particularly kangaroo rats, help establish unwanted shrubs by disseminating the seeds (*18*). Jackrabbits and some kangaroo rats are most abundant on ranges in poor condition and therefore have their greatest effect on these ranges.

Not all rodents are detrimental to rangelands. Many species are rare, or they graze plants that are not used by cattle.

When rodents and rabbits are present in such numbers that they seriously damage the range, control becomes desirable. Any control program should be planned and supervised by a competent biologist.

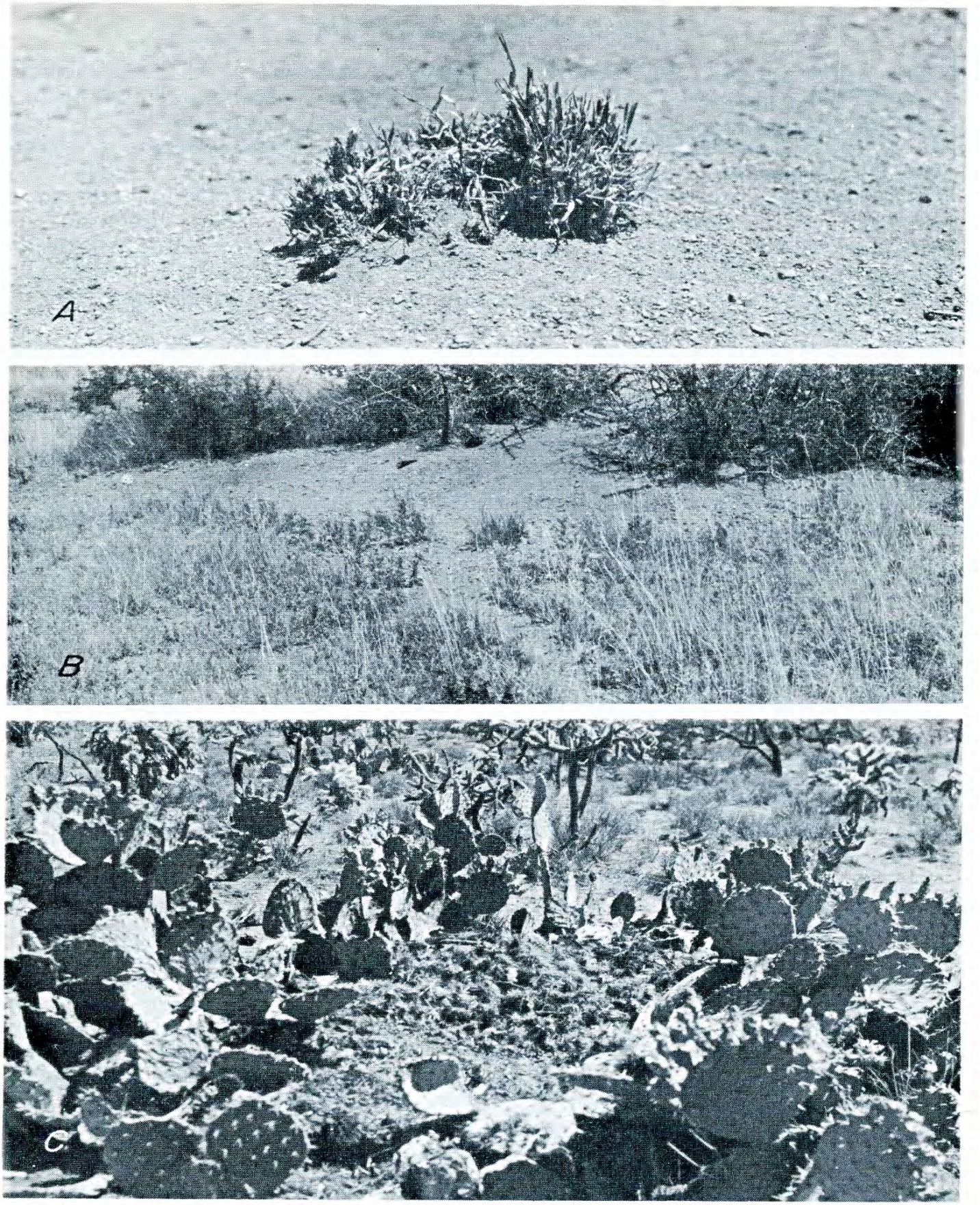

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FIGURE 9.—*A*, Rabbits are particularly destructive on grass-shrub ranges because they graze more closely than livestock. *B*, Bannertail kangaroo rats may completely destroy perennial grass within 20 to 50 feet of home burrows. *C*, The white-throated woodrat is numerous on deteriorated ranges, mainly because of the abundance of cactus and mesquite that provide food and homesites.

Judging Range Condition

An experienced observer can classify condition of grass-shrub range by visual inspection. For example, he can note such characteristics as plant species, accelerated soil erosion, ground cover (living and dead), and plant vigor. He compares these with the same characteristics on a range in top condition.

Photographs and fence-line contrasts are helpful in making comparisons, and extremes in range condition are often reflected in condition of the grazing animals (fig. 10). However, rainfall must always be considered because in years of good precipitation lush growth on a range in poor condition may give the appearance of a range in much better condition. On the other hand, in a period of low precipitation vegetation on ranges in good to excellent condition may be sparse.

Ordinarily, five range condition classes are recognized:

1. A range in *excellent condition* has a good mixture of palatable perennial grasses; plants are vigorous and reproducing well to provide a good cover of living and dead material.

2. In the *good condition* class, palatable grasses still predominate but there may be some invasion of undesirable woody plants; the cover is more open; and conditions for reproduction are less favorable.

3. When a range is in *fair condition*, the more palatable perennial grasses are exceeded by less palatable species; woody plants may be abundant and reducing forage production; litter is rare and the better perennial grasses are not reproducing.

4. In *poor condition*, palatable grasses are rare and even the poorer species are not reproducing; woody plants may form the dominant aspect; and the soil is poorly covered by living or dead material.

5. When a *very poor condition* is reached, the range is almost depleted. Perennial grasses are rare; woody plants may completely occupy the site; and the cover may be reduced to bare ground or a poor cover of annuals.

Soil erosion should also be considered in evaluating range condition. Soils are well stabilized on ranges in good or excellent condition. As vegetation is thinned, erosion may increase and will usually be apparent on ranges in poor or very poor condition.

Several techniques have been worked out for the quantitative determination of range condition. An elaboration of these techniques will be found in articles already published. These techniques include the climax approach (*11*); the forage production method (*13*); and the score-card method based on plant density, composition, and vigor (*14*).

Recognition of trend in range condition is important. A rancher should know whether his range is improving, because this has a bearing upon the stability and future of his enterprise. Trend in range condition can be determined best by measurements or observations on the same area at 3- to 5-year intervals. Allowance should be made for rainfall received in the meantime. An upward trend during a series of wet years or a downward trend in a series of dry years is not as meaningful as an upward trend during a series of dry or about average years.

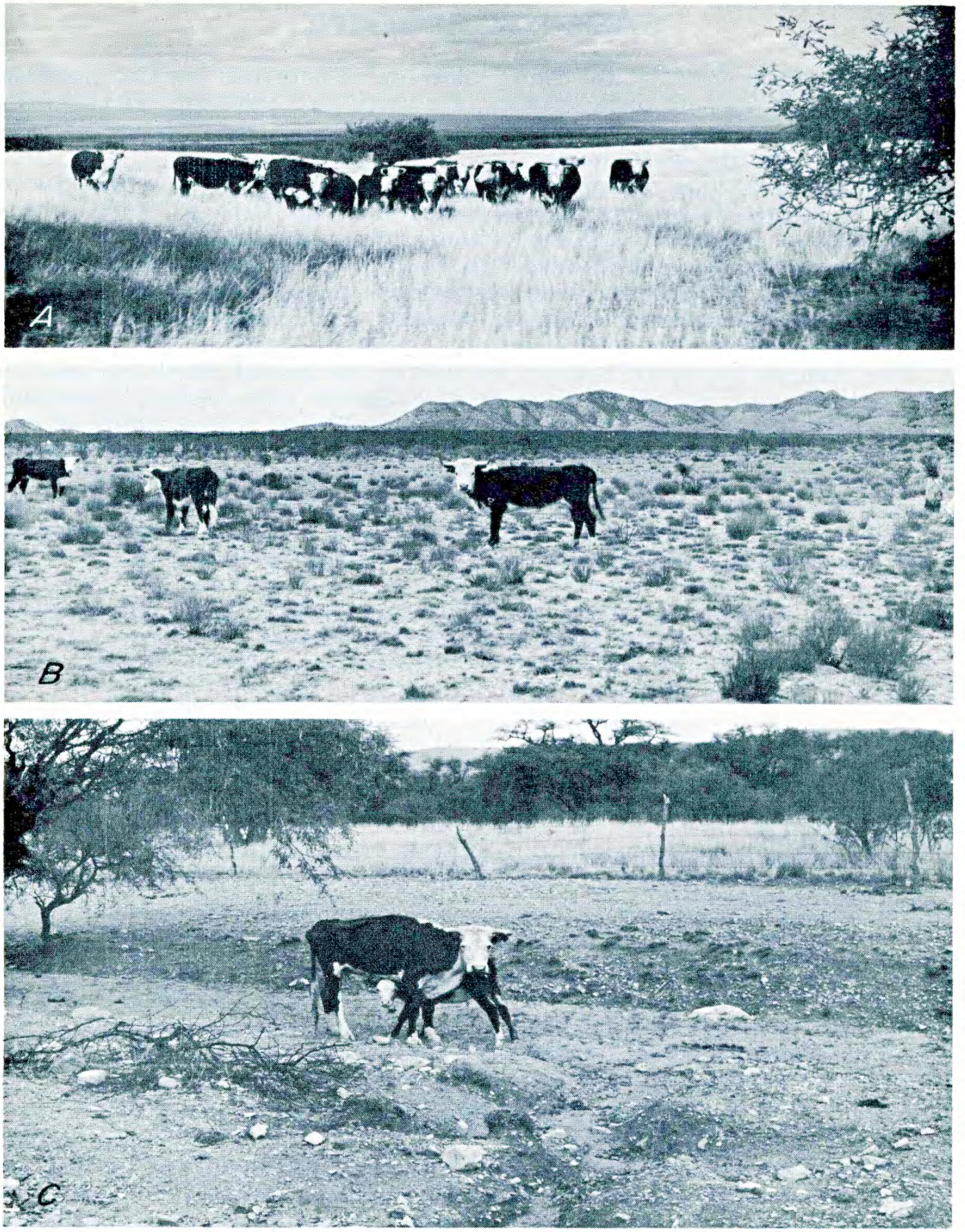

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FIGURE 10.—*A*, This range is in excellent to good condition; plants in excellent vigor and abundance, stable soil. *B*, Fair to poor condition; plant cover reduced, undesirable half-shrubs abundant, sheet erosion evident. *C*, Very poor condition; perennial grasses and topsoil almost gone, gully erosion beginning.

BASIS FOR STOCKING

Ranges vary greatly in their capacity to support cattle, because of differences in soil productivity, amounts and patterns of rainfall, topography, and other conditions. Accordingly, each range should be stocked on its own merits.

Average yearlong animal units per section for the grass-shrub type on Santa Rita Experimental Range from 1915 to 1949, inclusive, were as follows: high elevations, 15 to 18; intermediate elevations, 12 to 15; low elevations, 6 to 9. Table 3 presents estimates of stocking rates for these three elevations in relation to range condition, based on actual stocking records and differences in forage production.

The figures in table 3 may be useful as initial stocking guides for grass-shrub ranges similar to the Santa Rita range, provided that variations are recognized and nonusable or waste range is excluded from initial computations. On the Santa Rita, distribution of livestock by watering, salting, and range subdivisions was better than average for grass-shrub ranges so that virtually full stocking of the units was attained. On more moist areas, higher stocking may be possible, and on drier ranges stocking will be less.

TABLE 3.—*Estimated average yearlong stocking rate, by condition class, Santa Rita Experimental Range*

Elevation and stocking	Range condition		
	Very poor [1]	Poor and fair	Good and excellent
High elevations:			
Animals per square mile	<15	15–20	20–25
Acres per animal	>40	30–40	25–30
Intermediate elevations:			
Animals per square mile	<10	10–15	15–20
Acres per animal	>60	40–60	30–40
Low elevations:			
Animals per square mile	<6	6–8	8–10
Acres per animal	>100	80–100	60–80

[1] < signifies "less than"; > signifies "more than."

FORAGE UTILIZATION

Efficient use of a range depends on proper utilization of the forage crop. The initial stocking should be based on range condition and productivity of the site, and adjusted annually and periodically thereafter. Making proper use of the forage crop necessitates (1) grazing at an intensity that will allow for growth of the main forage species; (2) grazing when herbage is most nutritious; and (3) distributing the grazing animals for full use.

Proper Degree of Use

In a period of approximately 2 months, perennial grasses must manufacture enough food to complete growth, produce seed, and store nourishment for the remainder of the year and the following spring. Grazing leaves and stems too closely can severely interfere with food production, storage, and protection of dormant buds.

Proper use factors have been determined by observing the amount of herbage that can be removed without damaging individual plants. In defining proper use factor for a species, only average plants are considered. Even with proper utilization of a range, many plants remain ungrazed; some are lightly grazed; and others are closely grazed. The percentage of weight that may be removed refers to normally healthy plants. Unthrifty plants resulting from unfavorable site, drought, or previous severe use should be given lighter use; and conversely, on especially favorable sites plants might stand somewhat heavier use. Average proper use factors for important species of the grass-shrub range in satisfactory condition under yearlong grazing are as follows (*15*):

Species:	*Weight herbage removal (percent)*
Arizona cottontop	40
Bush muhly	35
Curlymesquite	40
Dropseeds	35
Grama:	
Black	45
Hairy	45
Rothrock	55
Sideoats	45
Slender	50
Sprucetop	40
Tanglehead	40
Threeawns	50
Wolftail	40

These values have proved satisfactory from the standpoint of range maintenance on the Santa Rita. They indicate that about 40-percent utilization of desirable species is generally satisfactory for grass-shrub ranges in the southwest.

Seasonal Grazing

Seasonal grazing is an important factor in proper use of the forage crop. There are several possibilities for making seasonal use of grass-shrub ranges, based upon the forage preference of cattle. Also some plants, particularly perennial grasses, benefit from seasonal as opposed to yearlong use. Thus, both the preferences of cattle and the responses of plants can be considered in developing plans for seasonal grazing use.

Using Forage Classes in Combination

Perennial grasses, annual grasses, and browse have somewhat different growth periods. As a result there is some variation in time of highest nutritional level among these classes of forage.

Preferences of cattle rather closely follow the times of highest nutritional level. Where the different classes of forage exist in combination, seasonal shifts in grazing offer possibilities for best use of the forage. One example is a range where elevational site differences produce annual grasses, perennial grasses, and browse on different areas that can be used in combination. The amount of use in combination will be limited by the relative amounts of the various classes of forage and the possibilities of controlling herd movements.

Late in the spring, browse ranges are the only ones that furnish any large amount of green forage. They can be used profitably at this time in combination with dry annual or perennial grasses that serve as bulk forage. When summer rains commence, green annuals are ideal forage, and cattle graze them with relish. Their nutritive content is high, and the plants can stand considerable grazing before it interferes with setting of seed. Lower ranges provide an excellent opportunity for concentrated grazing in the summer because of the annuals produced. If cattle are grazed yearlong on such ranges, they must graze for long periods on dry forage. As annuals begin to dry, cattle can be shifted to ranges where perennial grasses are abundant.

Most perennial grasses are palatable during the fall and maintain their food value fairly well. Black grama, particularly, maintains its nutritive value well into the winter. Also, as will be discussed later, summer deferment is especially beneficial to this species. Thus, the general objective of management should be to get maximum summer use of annuals, fall and winter use of perennial grasses, and spring use of browse.

Where velvet mesquite is present, particularly on intermediate and higher elevations, special management should be adopted. Cattle graze its leafage whenever it is available, but they especially seek out the nutritious bean pods produced in late spring and summer. Because viable beans are spread in cattle droppings, areas where mesquite predominates should be fenced off from good grassland and utilized separately wherever possible.

Summer Deferment Versus Yearlong Grazing

Summer deferment benefits the desirable perennial grasses. The following tabulation shows how the proportions of species changed under two treatments between 1937 and 1948 on a unit of Santa Rita Experimental Range:

Treatment and perennial grass species	*Composition*	
	1937 (percent)	*1948 (percent)*
Summer deferred:		
Desirable species:		
Arizona cottontop	0	6.1
Black grama	6.1	11.1
Bush muhly	0	1.0
Tanglehead	1.5	22.2
Santa Rita threeawn	29.3	27.3
Other	0	1.0
Total	36.9	68.7

Treatment and perennial grass species	*Composition*	
	1937 (percent)	*1948 (percent)*
Less desirable species:		
Rothrock grama	46.2	19.2
Threeawns, misc	16.9	12.1
Total	63.1	31.3
Total perennial grasses	100.0	100.0
Grazed yearlong:		
Desirable species:		
Arizona cottontop	3.1	15.5
Grama:		
Black	16.1	15.0
Sideoats	1.0	3.1
Sprucetop	3.5	1.0
Bush muhly	2.4	4.3
Tanglehead	.7	6.9
Santa Rita threeawn	34.1	24.9
Other	3.8	1.0
Total	64.7	71.7
Less desirable species:		
Grama:		
Rothrock	12.3	10.8
Slender	13.4	6.9
Threeawns, misc	9.6	10.6
Total	35.3	28.3
Total perennial grasses	100.0	100.0

Under summer deferment, grazing was from November through March each year, when the perennial grasses were mostly dormant. Over the 11 years, this range showed greater improvement than the adjacent check range grazed yearlong. Desirable grasses increased from about one-third of the perennial grasses to two-thirds whereas the less desirable grasses decreased from about two-thirds to one-third of the composition. Arizona cottontop, black grama, tanglehead, and bush muhly, all increased. Rothrock grama, a less desirable grass, decreased from about one-half of the total stand to about one-fifth.

The check range grazed yearlong was in better condition in 1937. It was also grazed conservatively during the study period. Under this type of use, the relative abundance of the desirable grasses increased slightly. They made up 65 percent of the perennial grasses in 1937 compared with 72 percent in 1948. The relative abundance of Arizona cottontop, bush muhly, sideoats grama, and tanglehead, all desirable grasses, increased materially. However, black grama, sprucetop grama, and Santa Rita threeawn decreased. Rothrock grama and slender grama, less desirable species, also decreased in relative abundance but not to the same extent as on the range receiving summer deferment.

Black grama is very palatable and it is perhaps the most important single species of grass-shrub ranges. Because it spreads by above-ground runners or stolons during the growing season, the species is severely restricted if these runners are grazed. Accordingly,

where black grama makes up a high proportion of the perennial grass composition, summer deferment is particularly beneficial.

On a well-managed range near Sonoita, Ariz., grazing is deferred during the summer growing season on one-fifth of the range each year, and the area deferred is rotated so that each area is rested once in 5 years. The excellent condition of this range testifies to the advantages of this recommended method of deferred grazing in combination with conservative stocking.

Proper Distribution of Animals

Full use of grass-shrub rangelands depends on proper distribution of grazing. Natural concentration sites such as salting areas, resting ground, ridges, bottoms and areas near trails, and watering places receive the heaviest grazing. Utilization tends to decrease with increasing distance from these sites. Studies made on Jornada Experimental Range in southern New Mexico show the relation of utilization to distance from water (*3*). On the range as a whole, black grama was greatly overutilized at water, about properly utilized at 1½ miles from water, and used only 40 percent of the proper degree at 3 miles from water. On lightly used ranges, heavy grazing of black grama was confined to ½ mile from water, on conservatively grazed ranges, to within 1 mile; but on heavily grazed ranges it extended to 3 miles.

Obtaining uniform distribution is not always a simple matter even where water is well distributed. This is illustrated in figure 11. Several range management practices can be used to improve distribution of grazing animals. These include watering, salting, supplemental feeding, and subdividing the range by fencing.

Watering

In the naturally dry climate of grass-shrub ranges, special attention should be given to the watering plan. As a minimum requirement, fairly permanent and dependable watering places should be 4 to 5 miles apart on flat and undulating land, 3 miles on rolling ranges, and 1 to 2 miles where the terrain is rough (*23*). When this requirement is met, costs largely determine the desirability of further water development.

The more watering places available within practical limits (fig. 12), the more uniform the utilization of forage. Once a primary network is established, many small watering places are better than a few large ones. Small, inexpensive watering places can often be constructed merely by throwing up a dirt embankment across a small gully or surface drainage, with provision for overflow. For large water impoundments, competent engineering advice is indispensable.

More uniform use of the range can also be achieved by hauling water, particularly during dry years. Where unused forage is available and the haul is not too great, it has proved to be a practical and profitable practice. On the experimental range, water was hauled 18 miles at a cost of 3 cents an animal day. Cattle used an

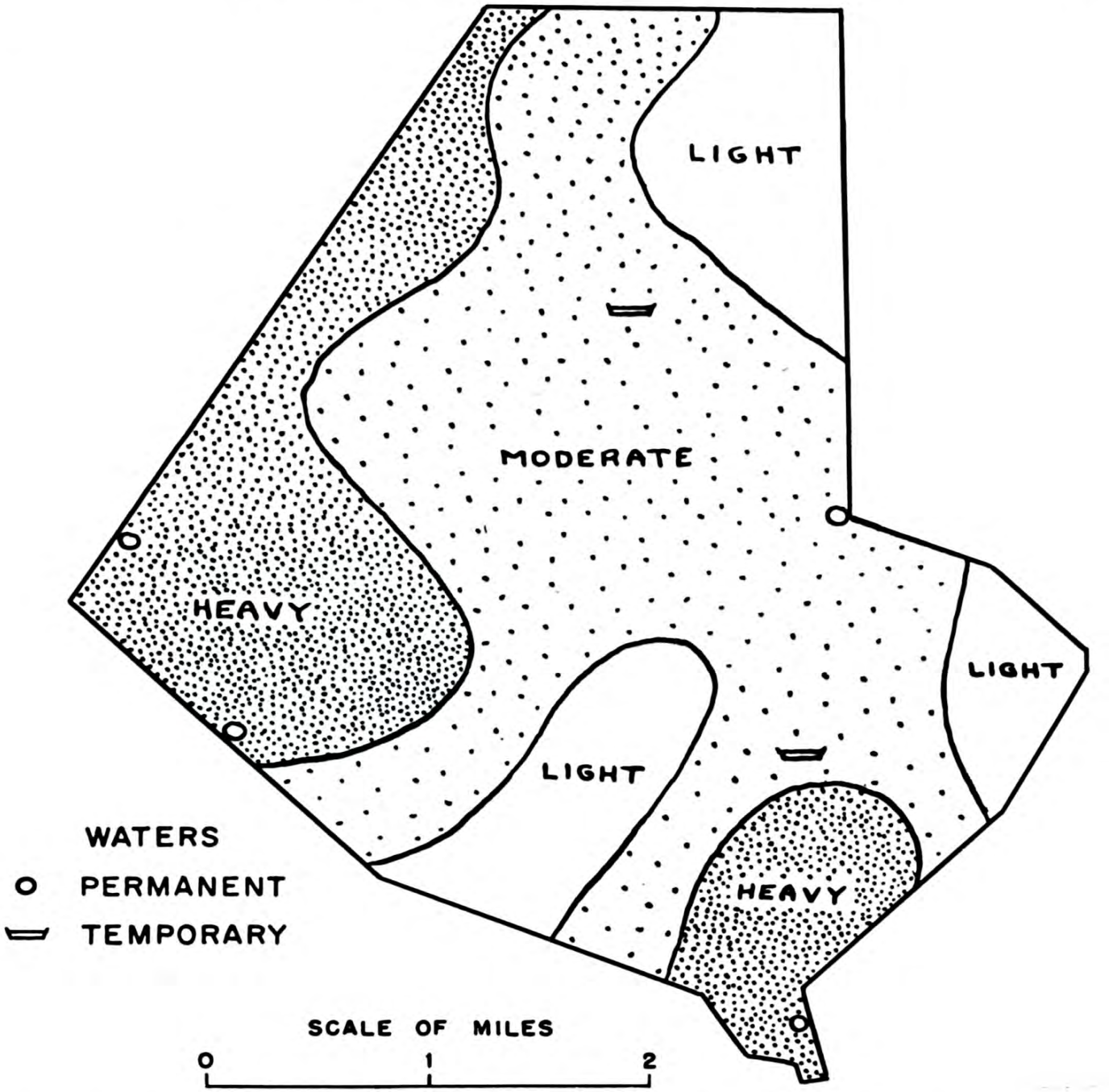

FIGURE 11.—Pattern of grazing at the end of the 1941 grazing season for a range unit of about 10,000 acres at an intermediate elevation on Santa Rita Experimental Range.

average of 8 gallons of water a day. This made use of the range possible during drought when many of the tanks failed to catch water. Because of such advantages, water hauling is becoming a common practice on many western ranges (*7*).

Since water is often the primary factor limiting use of forage, fencing permanent waterholes can facilitate proper utilization. In some circumstances summer deferment of grazing can be achieved by closing access to waters. It is most practical to close off permanent watering sites while temporary waters are available. Otherwise, full use of temporary water and utilization of the surrounding range may not be possible.

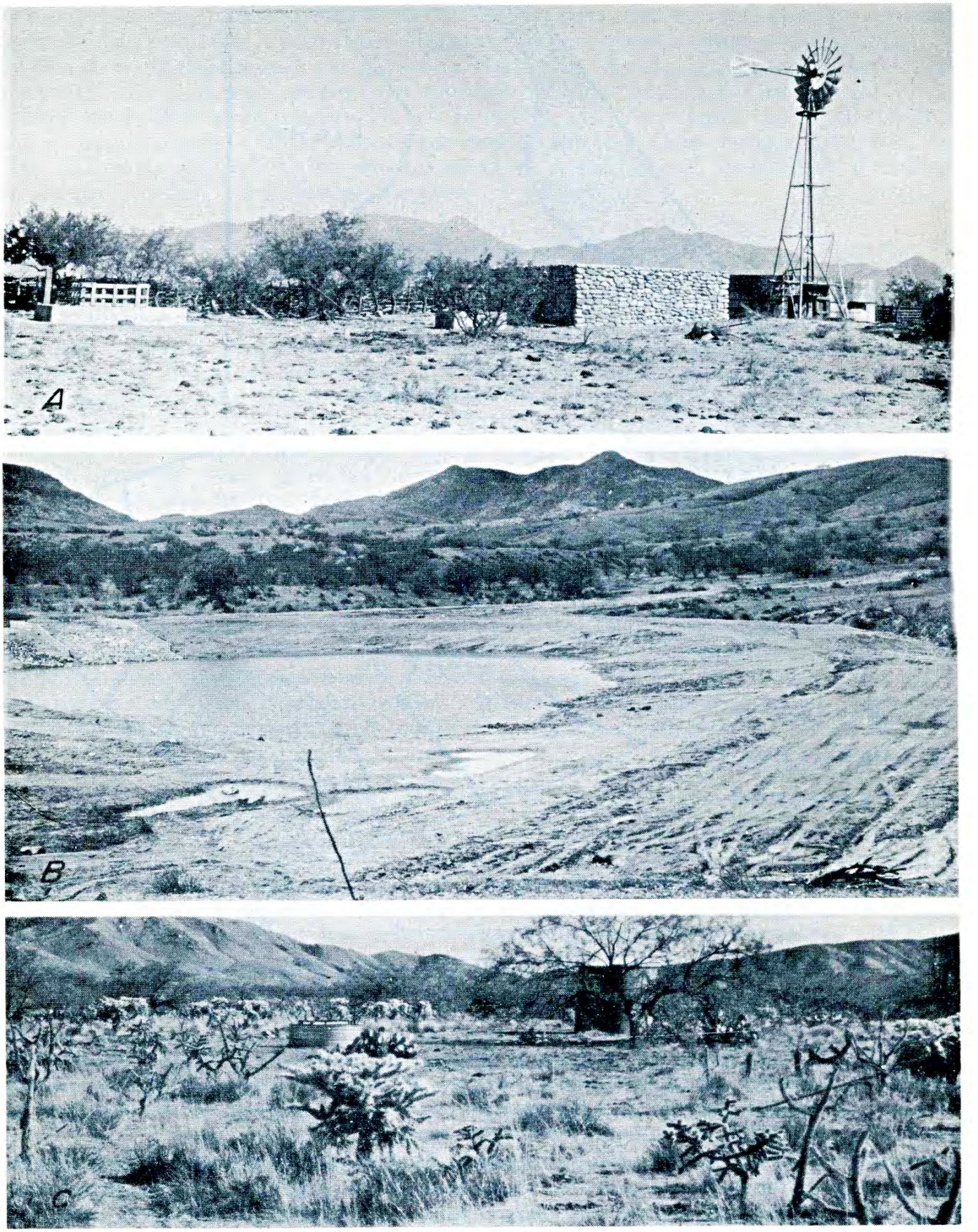

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FIGURE 12.—Three kinds of watering places: *A*, Permanent and dependable water to assure availability of water in each pasture; *B*, temporary surface tanks to improve distribution; *C*, storage tank and trough for hauled water to improve distribution and augment other water sources, especially during drought.

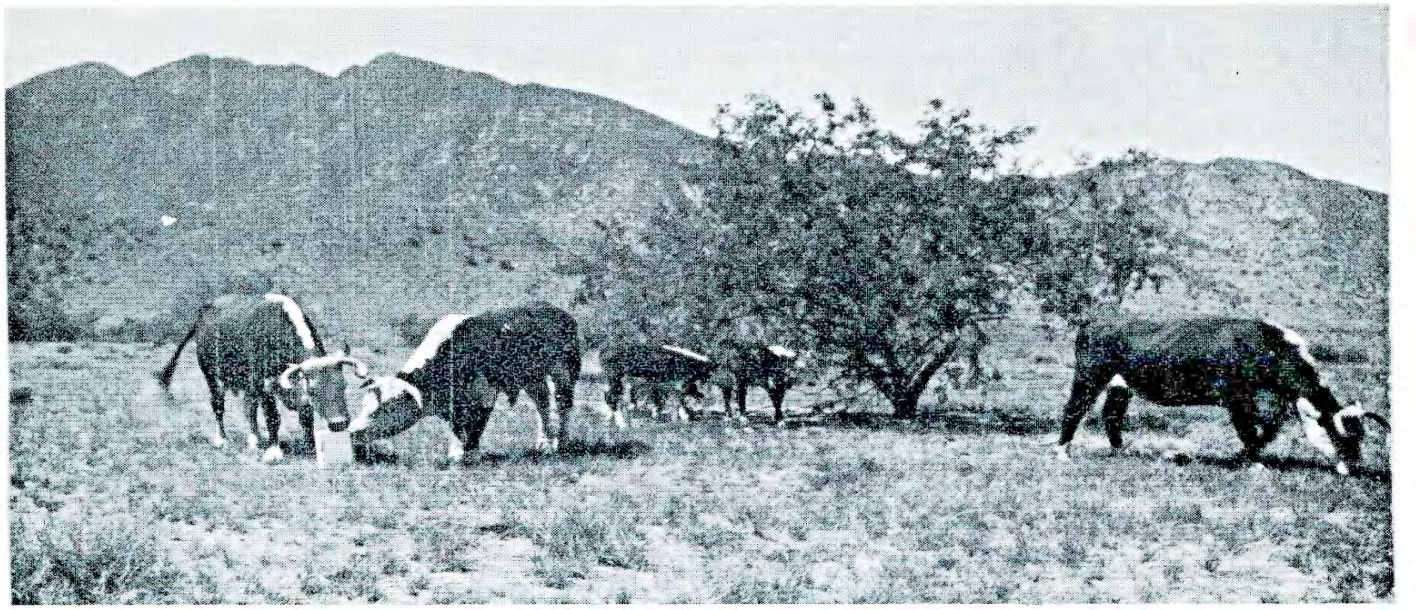

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FIGURE 13.—Proper placement of salt, especially during summer and early fall, helps to equalize distribution of cattle and to spread grazing to areas that may be underutilized.

Salting

Placement of salt away from water can extend the areas of proper utilization (fig. 13). This increases the number of animal units that a range can properly accomodate.

On the Jornada, salting away from water reduced utilization near water, and increased it about 10 to 15 percent at distances of more than 3 miles from water (*3*). During the summer when forage is green, about 2½ pounds of salt for an animal-unit month is usually needed (*22*). After forage matures, 1½ pounds of salt a month is sufficient. Annual salt requirement on yearlong ranges amounts to about 25 pounds a cow.

Supplementing

The judicious placement of supplements such as salt-meal mix and cottonseed cake will draw animals into lightly used areas (*2*). This practice is especially desirable during winter and spring when natural vegetation is low in nutritive value. "Supplementing" should be only what the name implies—adding something to the forage. Range supplementing should not be used to carry more animals than the forage supply will justify.

Range Subdivisions

Utilization can be improved by providing ranges of a size to accommodate 50 to 100 animals. This arrangement makes it easier to handle livestock and permits closer supervision. By subdivision, it is also possible to make better use of forage or to use the range seasonally.

Better calf crops often result from range subdivision. This is illustrated by records for two pastures on Santa Rita Experimental

Range (*10*).[4] One pasture contained 10,000 acres; the other, 7,800 acres. In 1937, the smaller one was divided into pastures of 3,200 and 4,600 acres. All calf crops improved somewhat in the 1937–45 period, but the increase was considerably greater in the subdivided pasture:

Period:	Pasture and treatment	Size (acres)	Calf crop (percent)
1926–36	I. No treatment	10,000	80.1
	II. ----do	7,800	75.8
1937–45	I. No treatment	10,000	85.9
	II. Subdivided:		
	Part A	3,200	92.4
	Part B	4,600	88.1
	Average	--------	90.2

Judging Proper Use

An annual survey of the range is desirable to determine whether the range is properly utilized. This requires decisions as to when, where, and how utilization is to be judged.

When to Judge

If only one check of utilization is made annually on ranges grazed yearlong, it should be during June. New growth commences in July. After this, recognition of utilized plants and general patterns of utilization becomes difficult. Utilization checks can also be used to determine whether it is necessary to shift animals from one range unit to another. These can be made any time after the growing season. When stocking adjustments are anticipated, a utilization survey in January or February is desirable. The amount of grazing remaining on the range for the same number of cattle can be determined by the following formula:

$$12 \text{ months} \times \frac{\text{proper utilization} - \text{observed utilization}}{\text{proper utilization}} = \text{number of months of grazing remaining}$$

In this relationship, utilization is expressed in percent.

Where to Judge

Utilization should be measured at either random or mechanically spaced intervals over the entire range. At least 16 samples should be located in each range unit. When a unit is larger than eight General Land Office sections, at least two sampling units per section should be taken (*5*). An average of all samples will give the average use of the unit. Zones of approximately equal utilization can be mapped to indicate needs for improving distribution.

[4] Cattle used in this study were privately owned, and were grazed under cooperative agreement from 1926 to 1945.

How to Judge

A simple, practical, and inexpensive method for measuring utilization is to determine percentage of grazed and ungrazed plants (*21*). Percentage of herbage removed from a range is closely related to the number of plants grazed. The relation between percentage of grazed plants and total percentage of use by weight should be checked annually for each key species.

The grazed-plant method requires no special equipment or training. For each species, plants are selected merely by pacing in a predetermined course, and the one nearest the right foot at the end of each pace is recorded as grazed or ungrazed. Percentages of grazed and ungrazed plants are determined directly when 100 plants are recorded. By reference to an established relation (fig. 14), percentage of utilization by weight for the sample can be determined. For example, if the survey showed 50 percent of the plants to be ungrazed, the chart shows that 36 percent of the herbage by weight was removed from the range. Also, by relating percentage of grazed plants to changes in range condition, proper levels of utilization can be determined for other ranges. Preferred species should be properly utilized if range condition is to be maintained or improved.

Making Stocking Adjustments

Proper utilization requires that 45 to 65 percent of the herbage produced by the better perennial grasses be left on the range each year. Large differences in herbage production from one year to the next, especially at low elevations, create the problem of how to stock in order to attain this goal.

The first requisite is stocking at a conservative level to allow for the effects of slight droughts. For example, if stocking is set at about 20 percent below average forage production, it can remain at this rate about 65 percent of the time. During the remainder of the time, adjustments will be necessary because of scarcity of forage or to take advantage of an abundance of forage (*17*).

There are several possible management systems for stocking grass-shrub ranges where the forage supply varies greatly. The most conservative approach is an exclusive cow-calf operation in which breeding animals do not exceed the number that would consume on the average 40 percent of the forage produced by the better perennial grasses. This system insures adequate forage except during the most severe drought, but it would make inefficient use of forage more than half of the time. The most liberal system would utilize all of the forage produced each year. This could conceivably be accomplished by annually purchasing weaners or older animals for full consumption of the available forage supply.

The most practical solution to stocking is some compromise between the ultraconservative and liberal systems. One system that has worked well on grass-shrub ranges is to reduce the number of breeding animals in the herd to 40–60 percent of the total. The excess forage during above average years is utilized by holding over weaners or by purchasing growing animals from some other source.

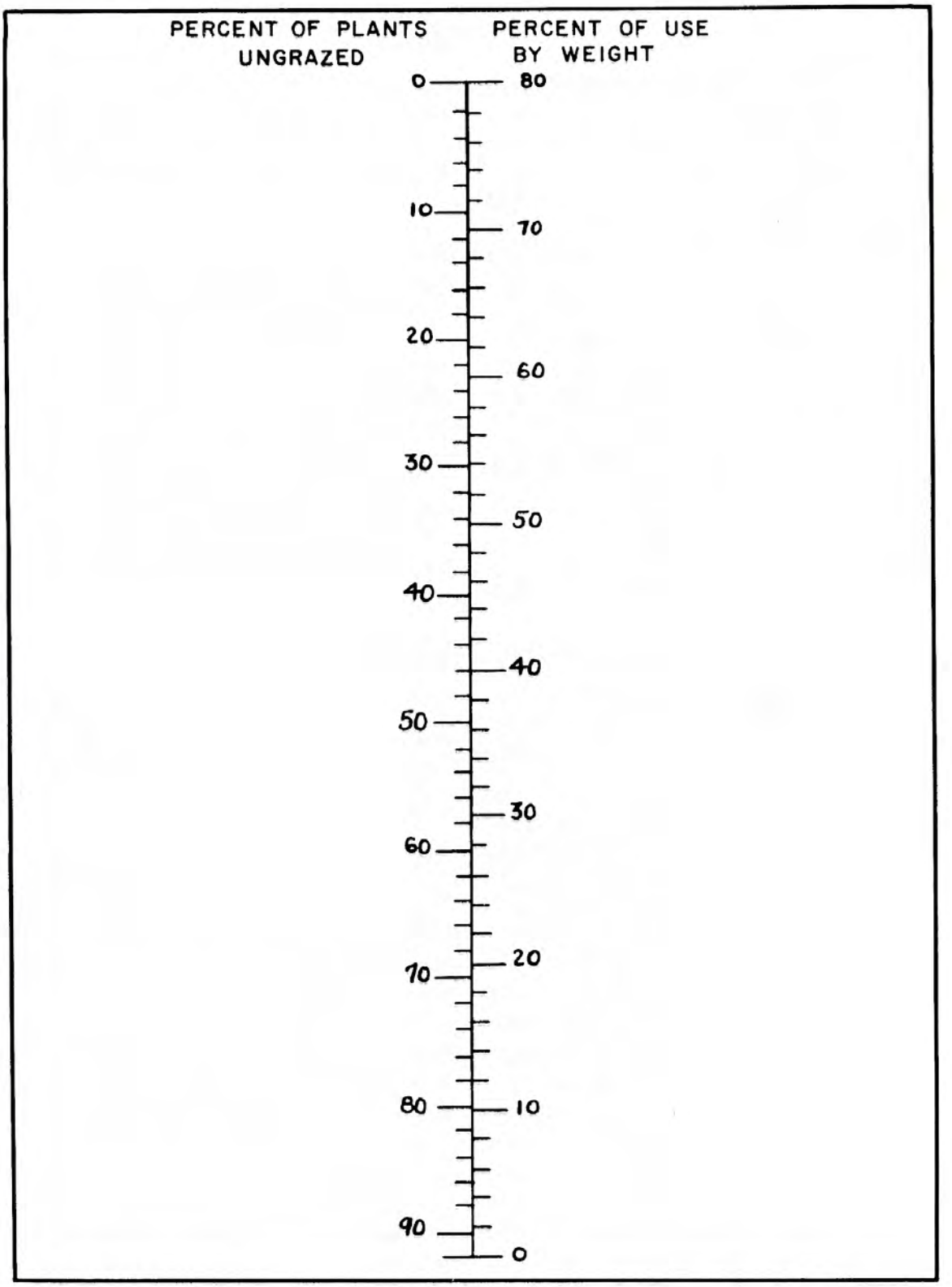

FIGURE 14.—Chart for approximating percent utilization by weight when average percentage of grazed or ungrazed key species has been determined by survey (*21*).

During dry years, all except breeding animals are sold. Such a system minimizes the adjustments necessary in the breeding herd, which may upset the results of years of effort in selection and grade improvement.

PROPER HANDLING OF LIVESTOCK

Methods of handling livestock have much to do with keeping grass-shrub ranges in good condition and maintaining high sustained production. Top production depends on proper husbandry of good animals. This section deals with some of the tested procedures that have benefited the range, the livestock, or both.

Adherence to a definite breeding season has many advantages. In the early days it was common practice to run the bulls with cows yearlong. Until 1936, this was the practice on Santa Rita Experimental Range. A regular breeding season of April through October was adopted in 1936. This resulted in a greater percentage of early calves and heavier calves at marketing time. Also, it reduced the number of late calves that had to be carried over for another year before marketing. Greater uniformity in calf weights resulted in better unit prices and higher overall income. The production of early calves also permitted cows to go into the winter in much better flesh.

Different ratios of cows to bulls have been tried on the experimental range, varying from 12 to 1 up to 25 to 1. No significant difference in calf crops was found within these limits for this range of gentle topography.

Under range conditions, breeding cows should be culled from the herd when between 8 and 10 years old; and bulls, when they are about 7 years old. It has proved to be a waste of forage and a loss in productivity to carry animals when they are no longer in top condition for reproduction.

Gentle methods and modern conveniences for handling livestock greatly reduce losses and injuries. Cattle are mostly injured by rough handling and roping on open range. Modern conveniences for doctoring, dehorning, and handling have lowered cattle losses substantially (fig. 15). Also, holding traps, corrals, squeeze and separating chutes, and branding tables greatly reduce labor costs. Trucking has now almost completely replaced trailing to shipping points. Better returns from trucking come from lower labor costs, less shrinkage in market animals, reduced injuries, and less weight loss among breeding cows.

RANGE IMPROVEMENT PRACTICES

Many ranges fail to produce maximum amounts of forage because of past use and shrub invasion. As greater production per unit area of grass-shrub ranges is demanded, measures for restoring ranges to full production will be adopted. This may require revegetation, shrub suppression, or both, in addition to the other range management practices previously discussed. Methods are now available for restoring some ranges, although all methods are costly. Better methods are also being developed.

Shrub Suppression

Of the invading woody plants that are seriously lowering range conditions, mesquite is the most detrimental (*16*). Choice of the best method for suppression depends upon many factors such as

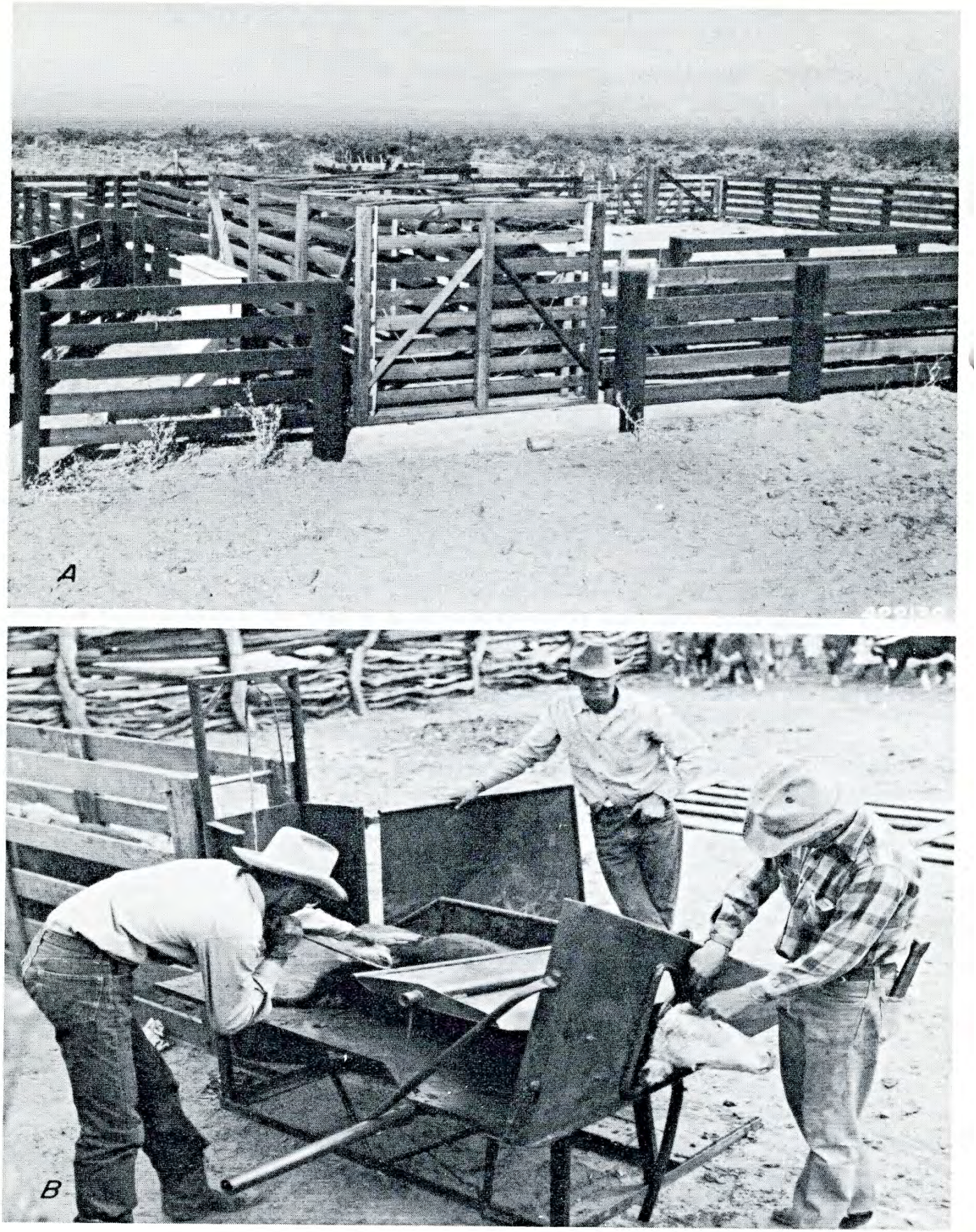

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FIGURE 15.—Modern conveniences for handling animals practically eliminate injuries and greatly reduce labor costs: *A*, A modern handling corral includes separating pens, a squeeze chute, and livestock scales; *B*, calf branding tables are a considerable improvement over the old method of roping out of a herd.

stage of infestation, availability of equipment, and site productivity (*20*). Hand grubbing by mattock is cheapest and most effective for trees less than 1 inch in diameter. Initial invasions can be handled easily by this method at a cost of only a few cents an acre. Low-grade diesel oil applied to individual trees is best for stands that do not exceed 100 stems an acre. Properly applied, diesel oil will give 90-percent kills at a cost of about 5 cents a tree.

Cabling or chaining reduces stand density effectively when trees are larger than 2 inches in basal stem diameter and when density exceeds 100 plants an acre. A 300- to 500-foot length of heavy anchor chain or 1-¾-inch multistrand wire cable is usually dragged between two (D-8 or equivalent) crawler-type tractors. Two passes in opposite directions are more effective than one. In stands of mesquite exceeding 225 trees an acre, especially in rough topography, spraying chemicals on foliage offers some promise. For southern Arizona conditions, ¾ pound of 2,4,5-T (low-volatile ester) to the acre in a mixture of 2 gallons of diesel oil and 6 gallons of water, has proved best. Timing of spraying is important: mesquite plants are most susceptible when leaves and blossoms are in full growth and developing pods are about ½-inch long. In some tests, up to 40-percent kills have been attained.

Burroweed has also increased greatly on many grass-shrub ranges (fig. 16). Invasion of this shrub is associated with declining perennial grass yields, especially of those species that grow in the spring. Under some conditions, burroweed is toxic to cattle.

Control methods have not been so thoroughly tested for burroweed as for mesquite. Where the fire hazard is not great and there is more than 500 pounds of fuel per acre, burning has proved to be an effective method for eliminating burroweed. Up to 90-percent kills have been attained from a range burn in June (*19*).

Cholla and pricklypear, both undesirable, are increasing on some ranges. Of the two, cholla more seriously reduces the number of animals that should be allowed to graze a range. The presence of cholla makes livestock handling particularly difficult. As with burroweed, fire, under appropriate conditions, can reduce the abundance of cacti. For example, a single June burn killed about 40 percent of the cholla and about 30 percent of the pricklypear (*19*). Individual plants can be killed by drench solutions of several chemicals, for example, a mixture of 2,4-D and 2,4,5-T and trichloroacetate, although treatment is expensive. Before undertaking burroweed or cactus control, the rancher should consult the local Agricultural Extension Service for the most recent information.

Revegetation

Some ranges are so seriously deteriorated that native grass will not recover in a reasonable time. Also, there are local livestock concentration areas on nearly all ranges where the native grass has been depleted and should be restored. More and better quality forage for seasons when forage is short, particularly in the spring, is desirable on some rangelands. Revegetation can correct some of these deficiencies (fig. 17).

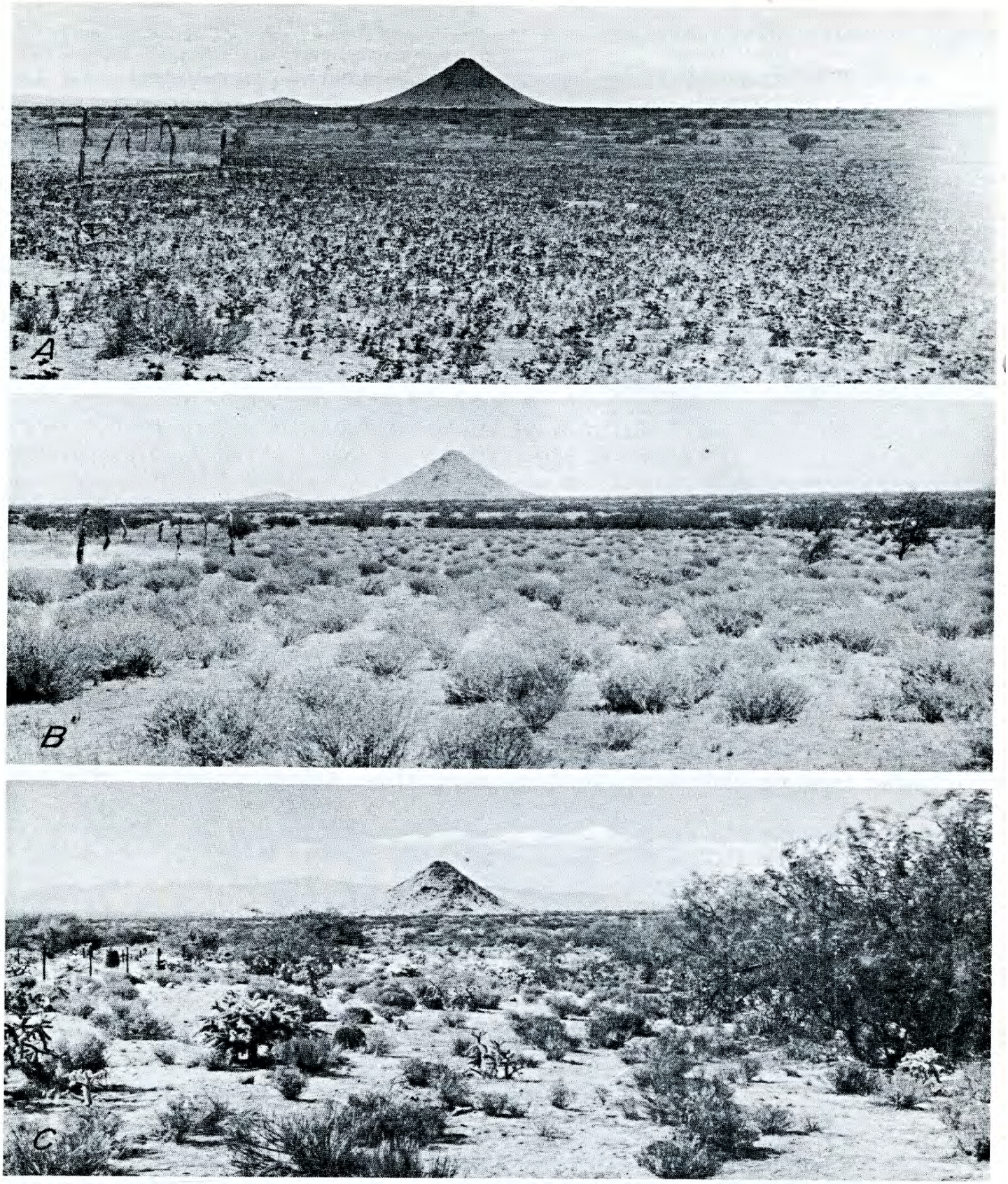

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FIGURE 16.—Woody plant invasion is one of the most serious problems confronting users of grass-shrub ranges. *A*, In the spring of 1919, only scattered burroweed and mesquite were evident at a 3,500-foot elevation on Santa Rita Experimental Range. *B*, By the spring of 1930, burroweed formed a dense stand and cactus was beginning to appear. *C*, By the spring of 1948, mesquite and cactus showed a remarkable increase. Unless this invasion of woody plants is suppressed, a former grassland site may be completely occupied by shrubs.

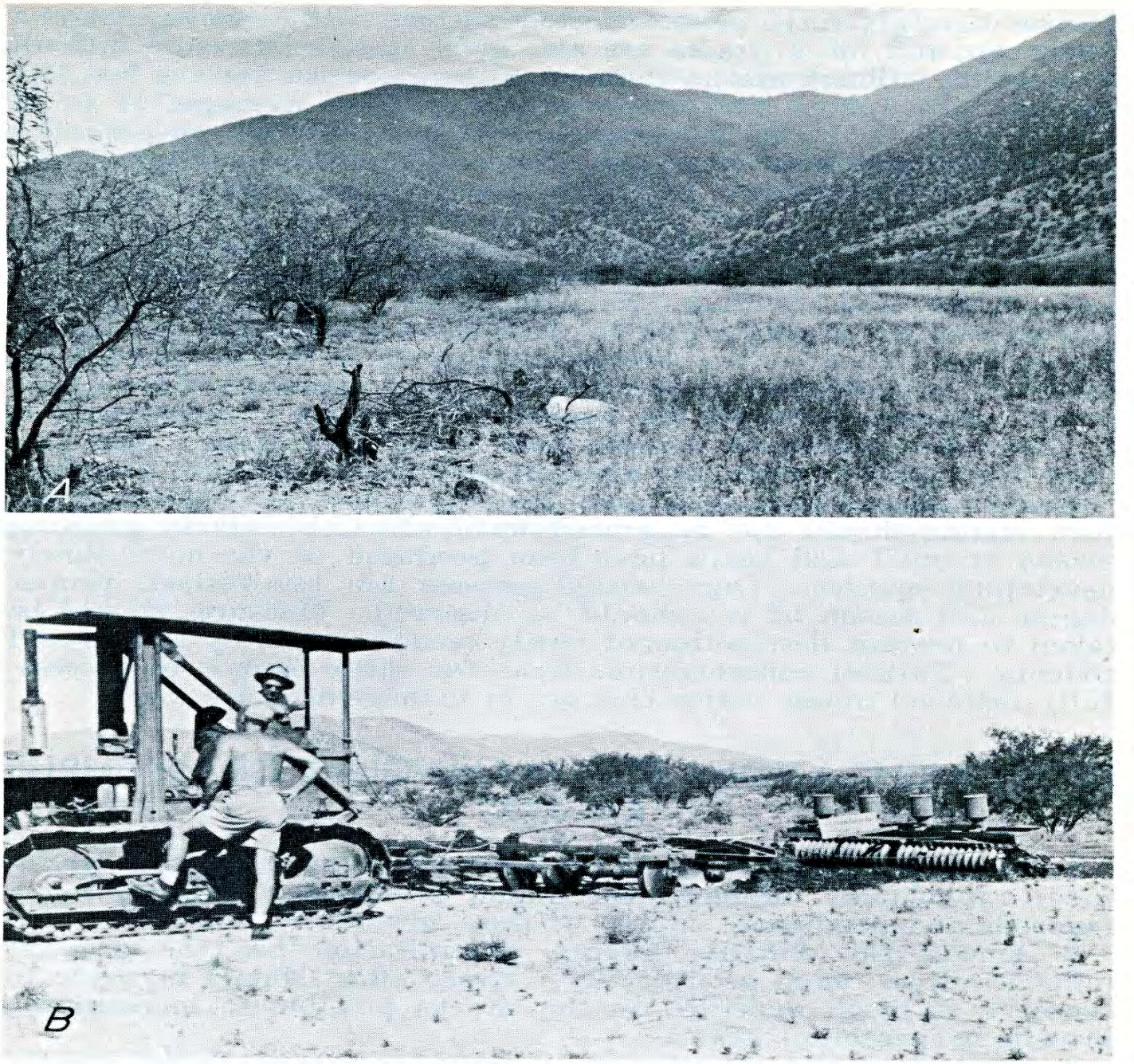

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FIGURE 17.—Some rangelands can be benefited by seeding. *A*, Lehmann lovegrass (right) is most widely used for seeding because of its ease of establishment, available seed source, and resistance to grazing. *B*, Site preparation that pits the soil to provide for additional moisture retention is desirable for heavy or eroded soils. Planting with a cultipacker seeder covers seed properly.

At present, reliable seeding methods are known for the better sites on grass-shrub ranges (*1*). Fairly level sites with deep, fertile, and medium-textured soils are best for seeding. Annual rainfall should exceed 11 inches. If more than scattered stands of mesquite, cactus, or burroweed are present, they should be controlled before seeding. Areas where seeding is contemplated should be subject to grazing control, and should be a part of the overall grazing management plan.

The best species for seeding vary with site. Above a 4,000-foot elevation and 14 inches of annual rainfall, Lehmann and Boer love-

grasses have given the most consistent success. Blue grama, Arizona cottontop, and black grama are also good species but more difficult to establish. There are no commercial seed sources for the last two species. On upland sites where annual rainfall averages 11 to 14 inches, only Lehmann lovegrass has been established consistently. On bottom-land sites or swales where moisture accumulates, blue panicum, Johnsongrass, Lehmann lovegrass, and Boer lovegrass grow well.

Soil treatment before seeding is essential for success. The main purposes of soil treatment are to remove competing vegetation, to provide for seed coverage, and to promote moisture penetration. Pitting with an eccentric disk has been the most consistently successful method. Contour furrowing and ripping have also given good results. Covering seed 1/8 inch for fine-seeded species, such as Lehmann lovegrass, to 1 inch for coarse-seeded species is recommended. A cultipacker seeder has proved best for seed coverage. May and June, just prior to summer rains, are the best months for planting.

Seeded grasses have their own special management requirements. New stands should not be grazed until after the second growing season or until seed heads have been produced on the more slowly developing species. Once seeded grasses are established, proper degree and season of use should be observed. Measures should be taken to prevent destruction of newly seeded stands by insects and rodents. Natural concentration areas for cattle cannot be successfully reseeded unless major changes in management are made.

RECOMMENDATIONS FOR MANAGING GRASS-SHRUB RANGES

1. Perennial grasses provide the most important forage on grass-shrub rangelands. Management should be aimed at maintaining a vigorous and productive supply of these grasses.
2. Among the climatic factors, precipitation has the greatest influence upon range productivity. Every effort should be made to conserve as much moisture on the site as possible to increase the growth of perennial grasses.
3. Production and composition of range vegetation varies greatly with annual rainfall and soil conditions. A rancher should recognize the desirable species and know their seasons of growth and periods of preference by livestock.
4. Ranchers should recognize and strive for the best possible range condition. The main factors affecting forage production are weather, mesquite or other woody plant invasion, grazing, rodents, and rabbits.
5. Range maintenance is dependent upon proper utilization of the annual forage crop. Annual and periodic adjustments in stocking are essential for proper use of the forage crop. Annual weight removal of perennial grasses should be between 35 and 55 percent.
6. The practice of making seasonal shifts of livestock on the range benefits both plants and animals. Where the opportunity exists summer annuals can be utilized during the summer period, perennial grasses during the winter, and browse during the spring. Black grama is particularly benefited by summer deferment.

7. Proper distribution of grazing is essential for optimum use of grass-shrub rangelands. This can be achieved by fencing range units of a size to accommodate 50 to 100 animal units, developing water to the extent practical, and using salt and supplements to draw animals into lightly used areas.

8. Periodic stocking adjustments are essential for proper use of the variable forage supply. By stocking at a conservative level, adjustments can be avoided most of the time. By maintaining a flexible herd with breeding animals making up 40 to 60 percent of the herd, downward adjustments can be made during dry years without reducing the breeding herd. In above-average years, excess forage can be utilized by holding over weaners or by purchasing growing animals from some other source.

9. A well-organized program of range improvement is desirable on grass-shrub rangelands. This should include plans for shrub suppression where there are invasions of mesquite or other undesirable woody plants such as cactus and burroweed. Also, on highly productive but severely depleted areas, forage restoration through revegetation should be considered.

COMMON AND SCIENTIFIC NAMES

Grasses

Bristlegrass, plains	*Setaria macrostachya* H.B.K.
Cottontop, Arizona	*Trichachne californica* (Benth.) Chase
Curlymesquite	*Hilaria belangeri* (Steud.) Nash
Dropseeds	*Sporobolus* spp.
Dropseed, sand	*S. cryptandrus* (Torr.) Gray
Fescue, sixweeks	*Festuca octoflora* Walt.
Fingergrass, feather	*Chloris virgata* Swartz
Fluffgrass	*Tridens pulchellus* (H.B.K.) Hitchc.
Grama:	
Black	*Bouteloua eriopoda* Torr.
Blue	*B. gracilis* (H.B.K.) Lag.
Hairy	*B. hirsuta* Lag.
Needle	*B. aristidoides* (H.B.K.) Griseb.
Rothrock	*B. rothrockii* Vasey
Sideoats	*B. curtipendula* (Michx.) Torr.
Slender	*B. filiformis* (Fourn.) Griffiths
Sprucetop	*B. chondrosioides* (H.B.K.) Benth.
Johnsongrass	*Sorghum halepense* (L.) Pers.
Lovegrass, Boer	*Eragrostis chloromelas* Steud.
Lovegrass, Lehmann	*E. lehmanniana* Nees
Lovegrass, plains	*E. intermedia* Hitchc.
Muhly, bush	*Muhlenbergia porteri* Scribn.
Panicum, blue	*Panicum antidotale* Retz.
Sacaton, alkali	*Sporobolus airoides* Torr.
Sprangletop, green	*Leptochloa dubia* (H.B.K.) Nees
Tanglehead	*Heteropogon contortus* (L.) Beauv.
Threeawns	*Aristida* spp.
Threeawn, mesa	*A. hamulosa Henr.*
Threeawn, Santa Rita	*A. glabrata* (Vasey) Hitchc.
Threeawn, sixweeks	*A. adscensionis* L.
Wolftail (Texas timothy)	*Lycurus phleoides* H.B.K.

Herbs

Deervetch	*Lotus* spp.
Heronbill	*Erodium* spp.
Indianwheat	*Plantago* spp.

Trees and Shrubs

Baccharis, shortleaf	*Baccharis brachyphylla* Gray
Burroweed	*Aplopappus tenuisectus* (Greene) Blake
Cacti	*Opuntia* spp.
Cholla, cane	*O. spinosior* (Engelm. and Bigel.) Toumey
Cholla, jumping	*O. fulgida* Engelm.
Creosotebush	*Larrea tridentata* (DC.) Coville
Eriogonum, Wright	*Eriogonum wrightii* Torr.
Ephedra, longleaf	*Ephedra trifurca* Torr.
Falsemesquite	*Calliandra eriophylla* Benth.
Hackberry, spiny	*Celtis pallida* Torr.
Mesquite	*Prosopis* spp.
Mesquite, velvet	*P. julifora* var. *velutina* (Woot.) Sarg.
Pricklypear, Engelman	*Opuntia engelmannii* Salm-Dyck
Ratany, range	*Krameria parvifolia* Benth.
Saltbush, fourwing	*Atriplex canescens* (Pursh) Nutt.
Zinnia, desert	*Zinnia pumila* Gray

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