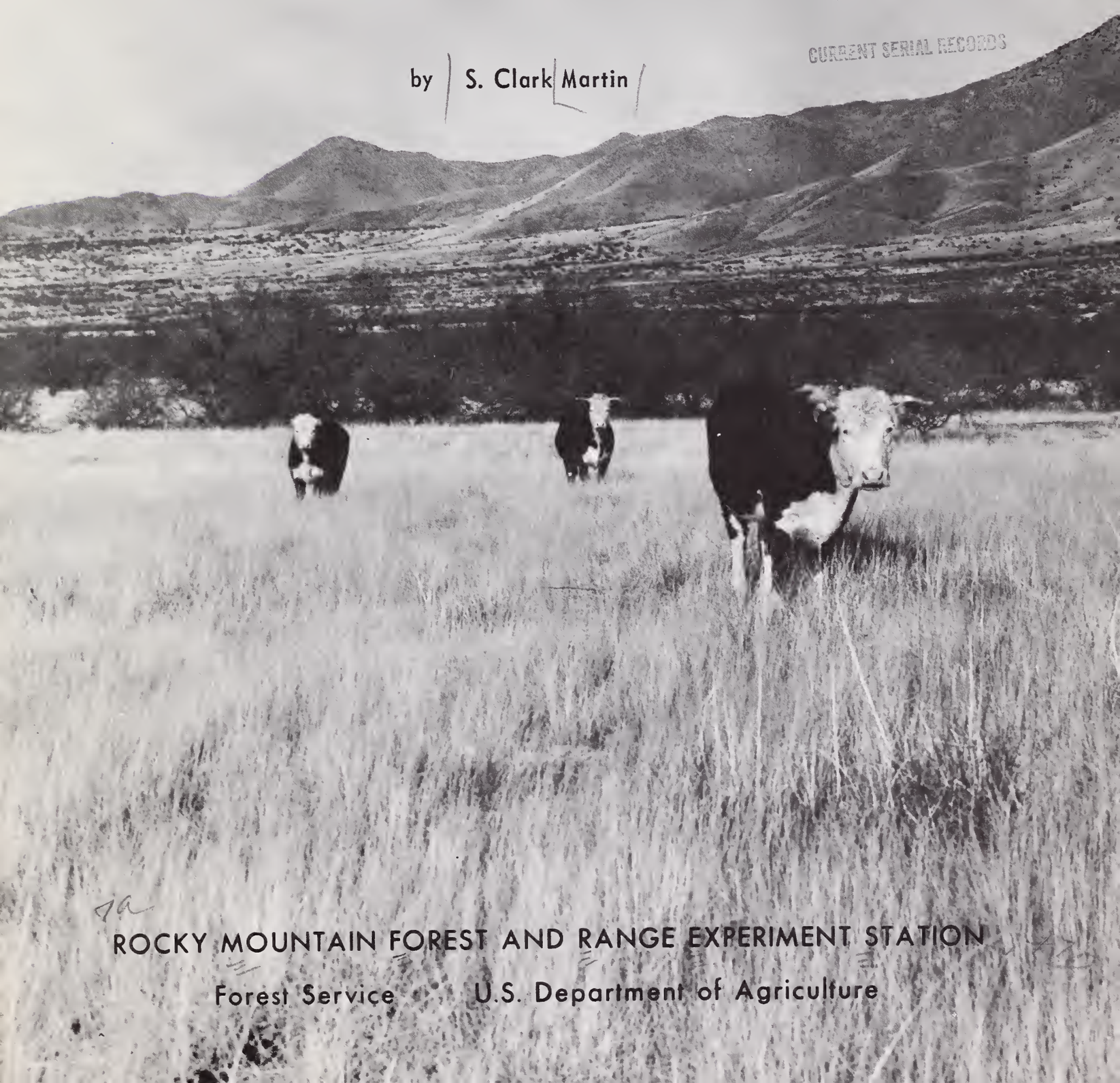
U. S. Forest Service
Research Paper RM- 22

# THE SANTA RITA EXPERIMENTAL RANGE

## A Center for Research on Improvement and Management of Semidesert Rangelands



by S. Clark Martin



ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service U.S. Department of Agriculture

# COOPERATORS

Many agencies and individuals cooperate in conducting research on the Santa Rita Experimental Range. Among those currently involved are:

The University of Arizona
Agricultural Research Service
Soil Conservation Service
Bureau of Sport Fisheries and Wildlife
Arizona Department of Game and Fish
Keith S. Brown
H. H. Robinson
Feliz Ruelas

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# THE SANTA RITA EXPERIMENTAL RANGE

## A Center for Research on Improvement and Management of Semidesert Rangelands

by

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Rocky Mountain Forest and Range Experiment Station[1]

[1]Central headquarters maintained in cooperation with Colorado State University at Fort Collins; author is located at Tucson in cooperation with the University of Arizona.

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# THE SANTA RITA EXPERIMENTAL RANGE

**A Center for Research on Improvement and Management of Semidesert Rangelands**

S. Clark Martin

## DESCRIPTION OF THE RANGE

The Santa Rita Experimental Range, 30 miles south of Tucson, Arizona is maintained by the Forest Service, U.S. Department of Agriculture, for research on semidesert ranges grazed by cattle. The 50,000-acre Experimental Range, established in 1903, is representative of about 20 million acres of semidesert grass-shrub range in southern Arizona, New Mexico, and Texas (fig. 1). Research is conducted in cooperation with State and other Federal agencies, and with cooperating cattlemen.

The Range lies on a broad, sloping plain cut by many shallow, dry washes. The elevation rises from less than 2,900 feet at the northwest corner to over 4,500 feet along the foothills of the Santa Rita Mountains.

### CLIMATE

Average yearly rainfall increases with elevation from 10 inches at 2,900 feet to almost 20 inches at 4,300 feet (fig. 2). About 60 percent of the rain comes between July 1 and September 30 (fig. 3). No effective rainfall is expected in April, May, or June.

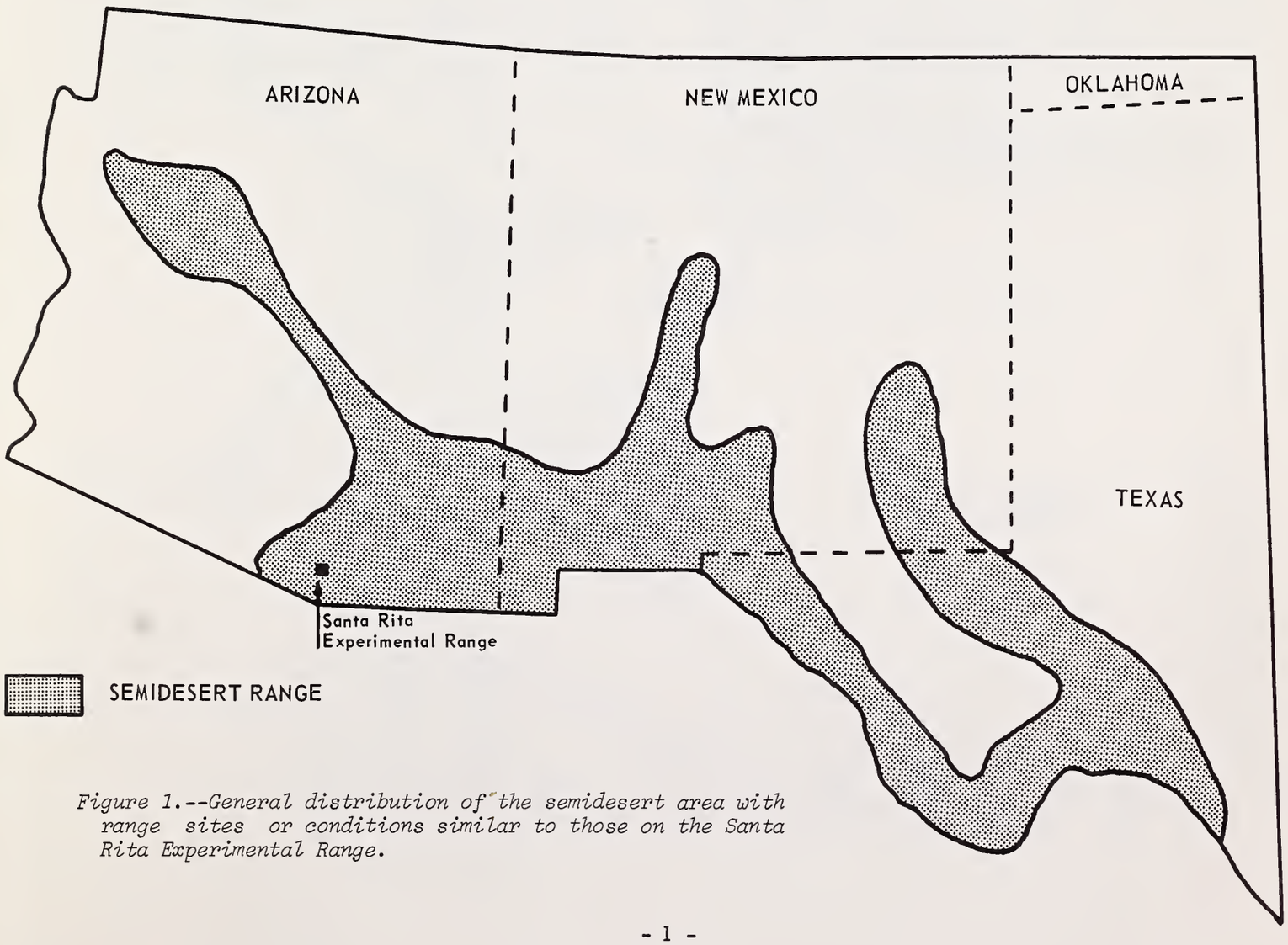



*Figure 1.--General distribution of the semidesert area with range sites or conditions similar to those on the Santa Rita Experimental Range.*

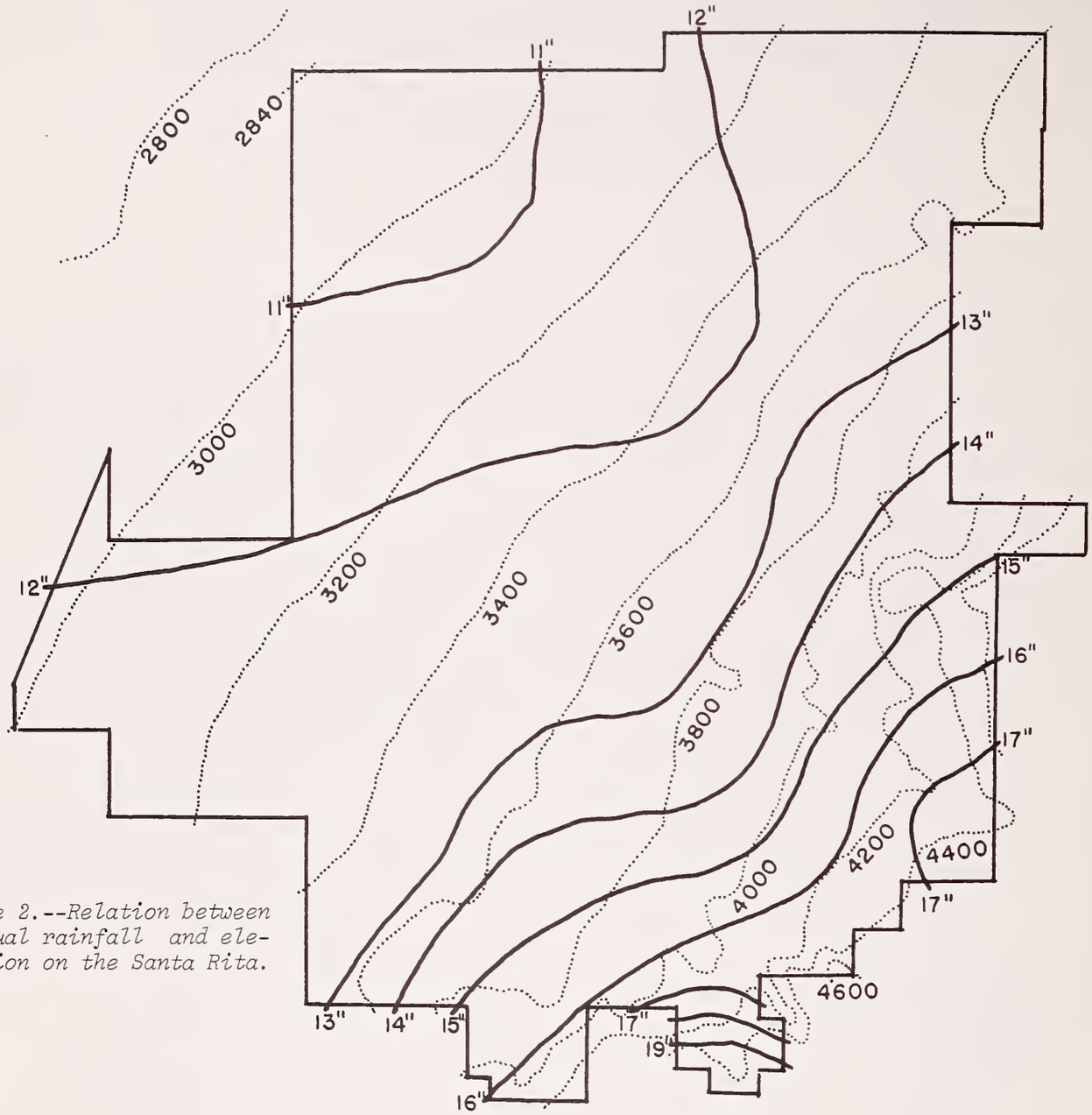



*Figure 2.--Relation between annual rainfall and elevation on the Santa Rita.*

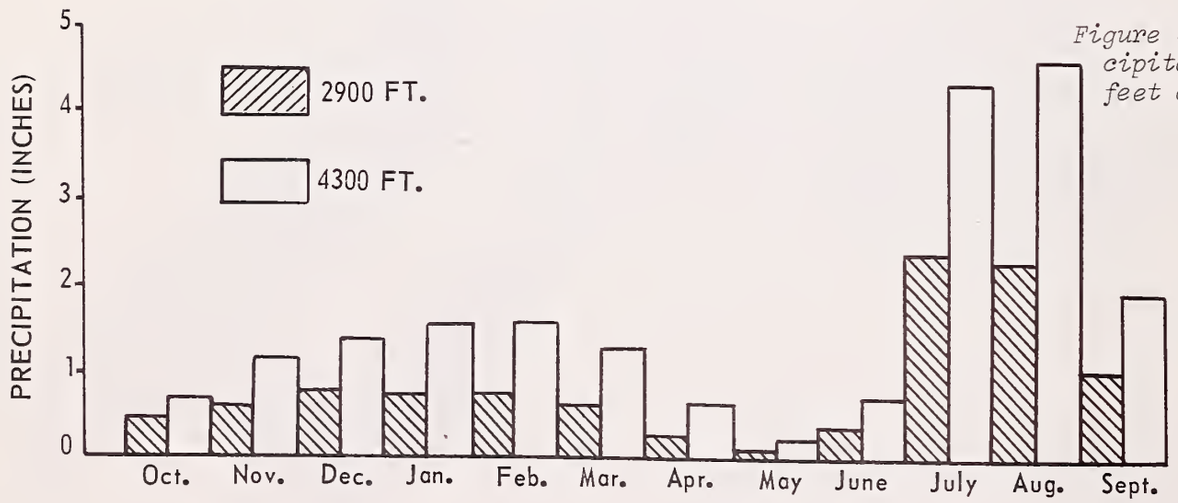



*Figure 3.--Monthly precipitation at 4,300 feet and 2,900 feet.*

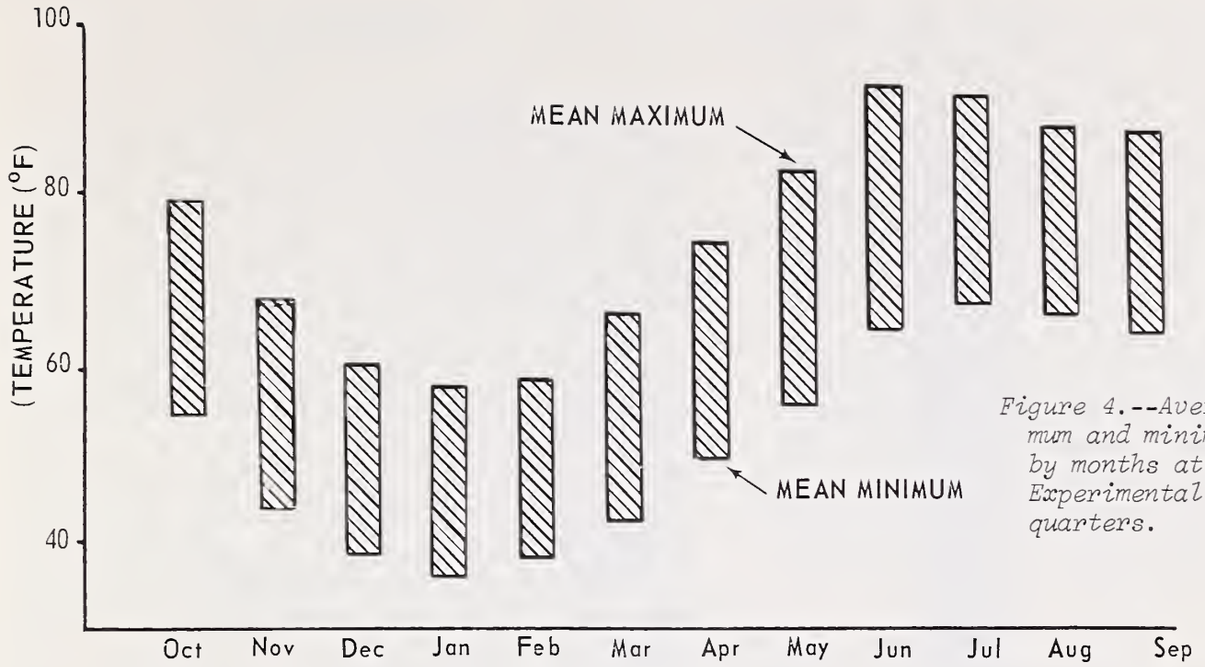



*Figure 4.--Average daily maximum and minimum temperatures by months at the Santa Rita Experimental Range Headquarters.*

Average daily maximum temperatures at the Range headquarters exceed 90° F. in June and July. Daily mimimum temperatures average below 40° F. in December, January, and February (fig. 4). The frost-free period is about 8 months, but growth of herbaceous plants usually is limited by lack of moisture to about 8 weeks.

## VEGETATION

The perennial vegetation is dominated by mesquite,[2] cactus, and other shrubs. Mesquite, burroweed, and cholla cactus reach their highest average densities between 3,200 and 3,600 feet elevation (fig. 5); mesquite and pricklypear cactus are major species even above 4,000 feet. Other shrubs, including **Acacia**, **Mimosa**, and **Calliandra**, make up only 21 percent of the shrub cover below 3,200 feet but comprise 65 percent of the shrub cover above 4,000 feet.

[2]*Common and scientific names of plants mentioned are listed on page 24.*

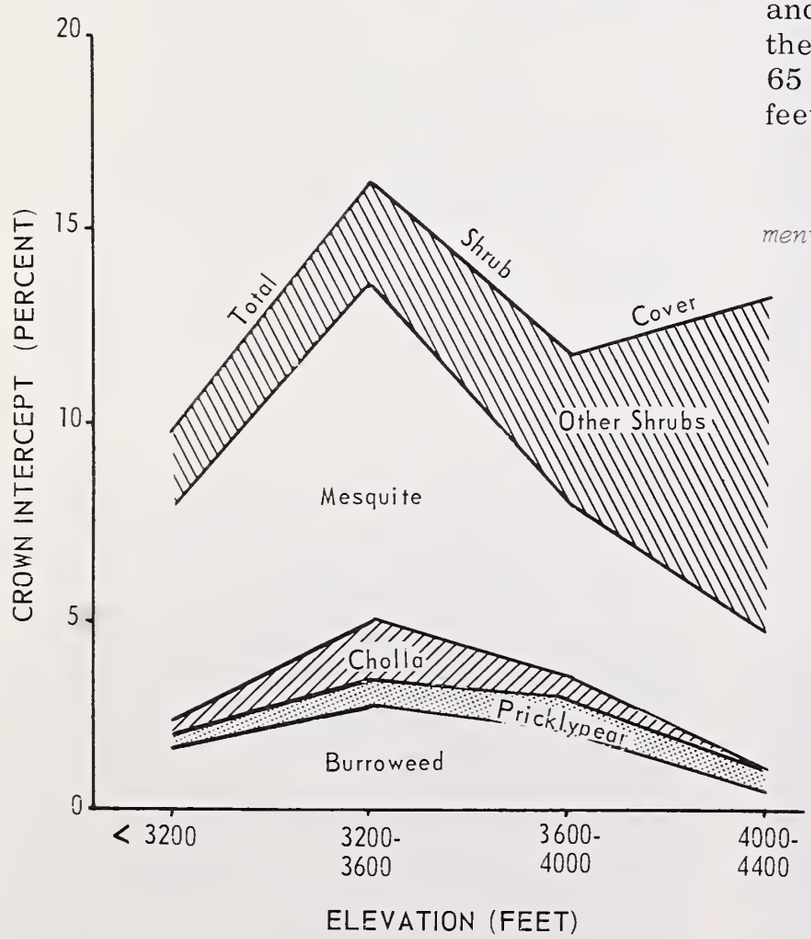



*Figure 5.--Crown cover of major shrub species and total shrub cover as a function of elevation.*

The abundance of perennial grasses increases with rainfall and elevation (fig. 6). The species composition of the perennial grass stand also changes with elevation and rainfall. The tall three-awns are common at all elevations (fig. 7). Santa Rita three-awn, Arizona cottontop, and Rothrock grama are major species at the middle and lower elevations but are minor species above 4,000 feet. Bush muhly makes up a greater part of the grass stand at the lower than at the middle elevations, and is scarce at the upper elevations. Other gramas including black, side-oats, slender, sprucetop, and hairy, make up over 60 percent of the stand at the upper elevations and are relatively scarce at the middle and lower elevations.

# RESEARCH

The objective is to learn how to attain maximum sustained forage and beef production on semidesert range with reasonable costs. The research program includes many kinds of studies. Most important of all is research to develop grazing practices that meet the long-time needs of the forage plants and the soil, as well as the immediate needs of the cattle and the rancher. Detailed studies of the growth requirements of desirable and undesirable range plants and their reactions to various kinds of grazing, climate, and soil are basic. Learning how to improve rundown ranges rapidly and economically by controlling unwanted plants, reseeding, or other cultural practices is another important area of research.

The Federal government owns the land and improvements; cattle for grazing experiments are furnished by private ranchers operating under cooperative agreements. The cattlemen furnish the kind, number, and class of cattle needed, and manage them according to a written management plan. Under this arrangement, grazing studies are carried out on a practical scale, thereby eliminating the need for pilot testing.

*Figure 6.--*
*Vegetation on the Santa Rita Experimental Range at:*

*Upper elevation*

*Intermediate elevation*

*Lower elevation*

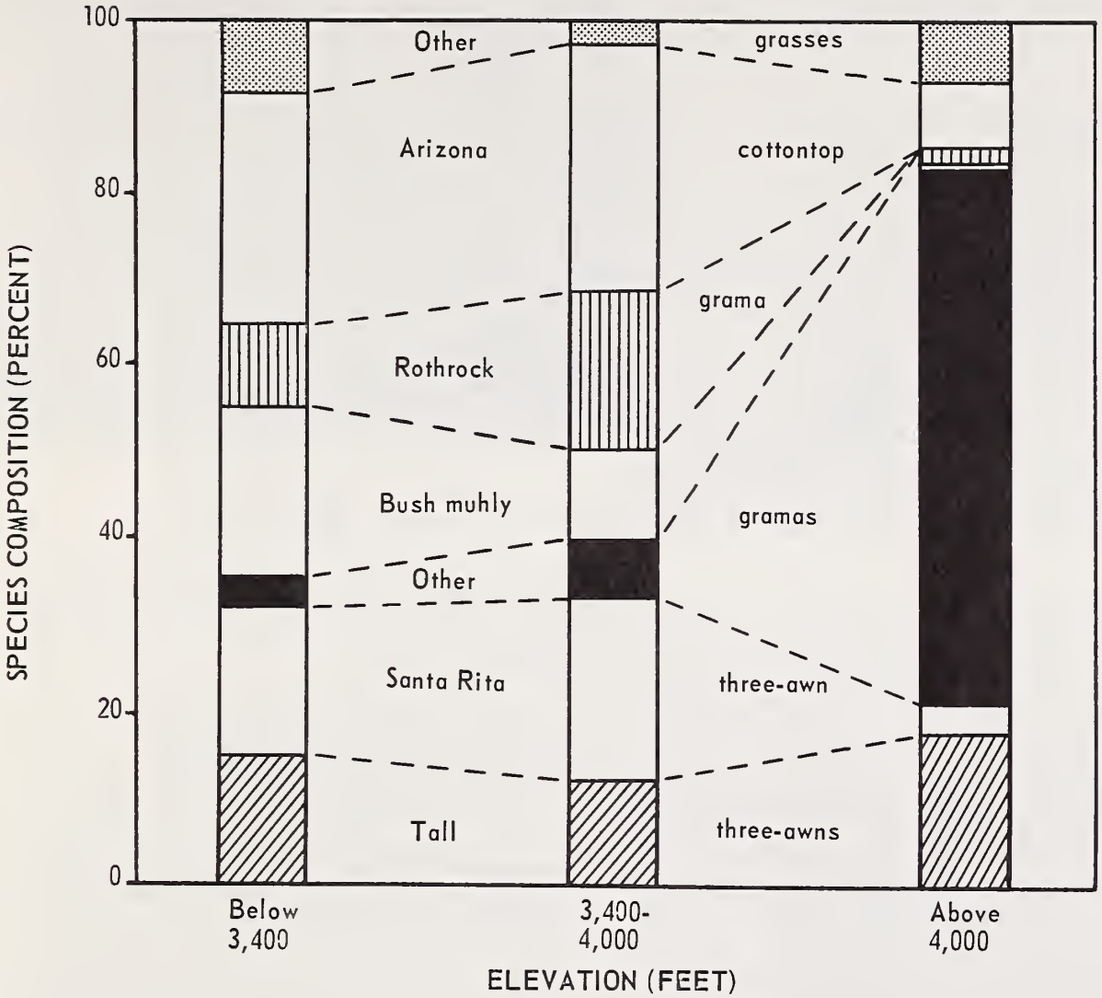



*Figure 7.--Relative abundance of perennial grass species at different elevations in June 1960.*

## FORAGE PRODUCTION

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

Perennial grasses are the most reliable forage. Most begin growth soon after the start of summer rains, and grow rapidly as long as effective rains continue. Growth rarely starts before July 1 and usually stops before September 30. In favorable years, some grasses also produce a little growth intermittently from February through June. However, more than 90 percent of perennial-grass growth is produced after summer rains begin. Height growth of flower stalks of Rothrock grama, slender grama, and Arizona cottontop illustrate the rapid growth during the brief summer growing period (fig. 8). Perennial grass production increases with increasing elevation and rainfall, as would be expected (fig. 9).

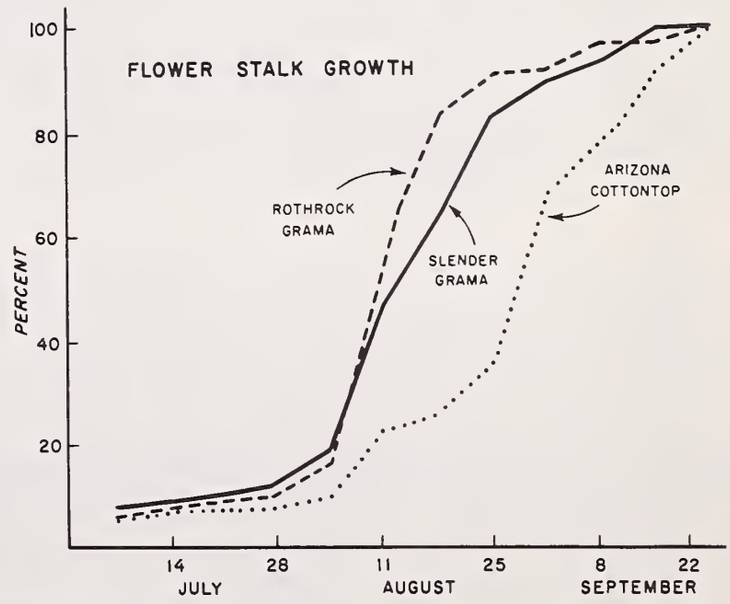



*Figure 8.--Height growth of flower stalks of slender grama, Rothrock grama, and Arizona cottontop during 1 summer on the Santa Rita Experimental Range.*

*Figure 9.--Perennial grass production is greater at the higher elevations:*

*On brushy, low-rainfall, low-elevation parts of the range, perennial grass yields less than 20 pounds of herbage per acre.*

*At the higher elevation where the rainfall is greater and the brush has been removed, perennial grasses produce almost 450 pounds of herbage per acre.*

### Annual grasses produce 80 percent of the grass herbage on brushy, low-rainfall ranges

Grass production fluctuates extremely from year to year on brushy, low-rainfall range (fig. 10). Here, perennial grass yields may average less than 20 pounds per acre. Still, the perennial grasses are more stable than the annuals, which may produce several hundred pounds of herbage in a wet year and nothing at all in a year of drought (fig. 11).

### Perennial grasses produce 70 percent of the grass herbage on mesquite-free ranges where annual rainfall is 16 inches

Year-to-year fluctuations in forage production are marked at the upper elevations, but substantial amounts of forage are produced even in the poorest years (fig. 12). Average annual perennial grass production on the most productive pasture on the Santa Rita was 443 pounds per acre for the 1954—1964 period (fig. 13), 26 times the average yield for the least productive pasture a few miles away. Yields of annual grasses on the best pasture averaged only three times as great as on the poorest pasture, but production of annual grasses in dry years was negligible at both locations. Some forage is obtained from mesquite and other browse plants on the poor range, but perennial grasses are the key to higher and more stable forage production on all parts of the range.

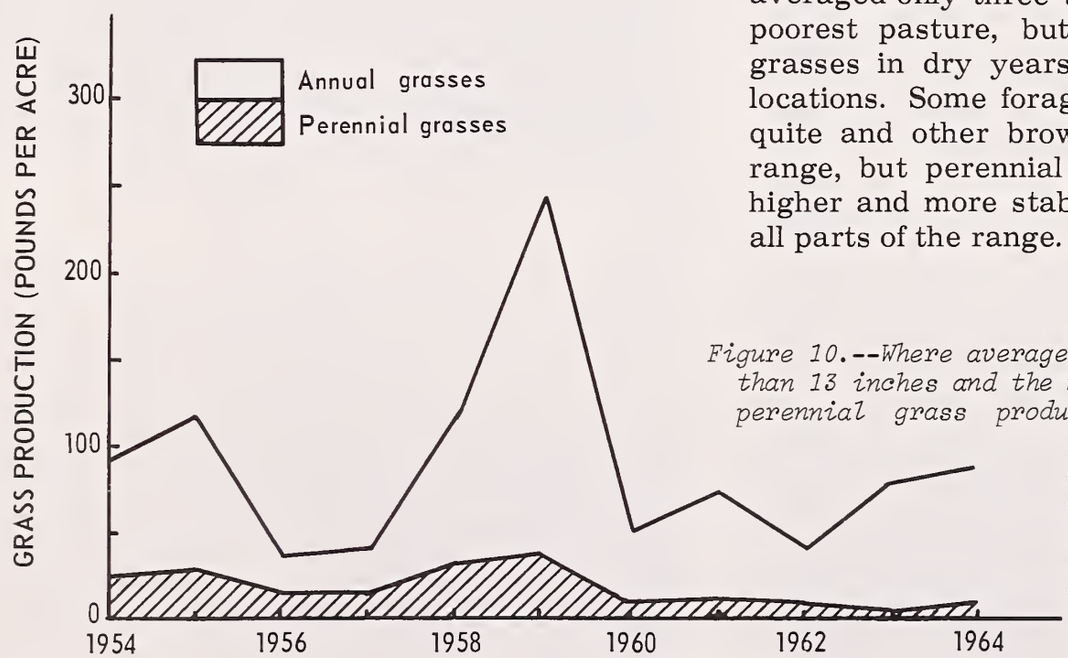
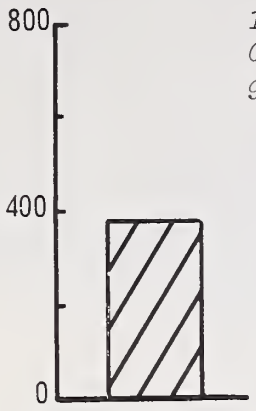


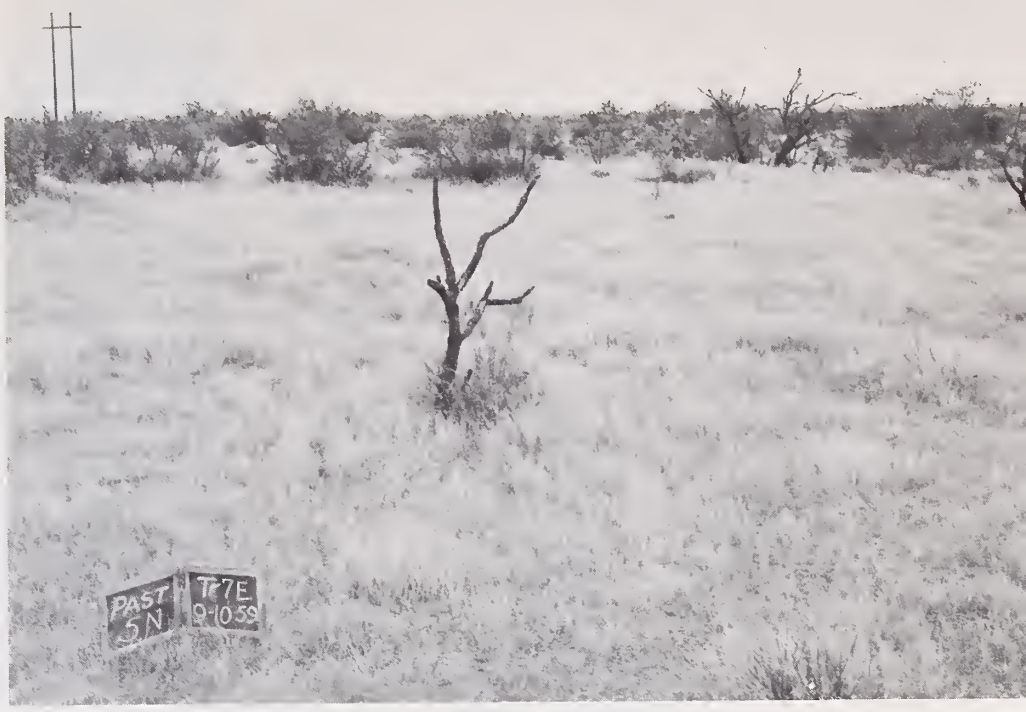

*Figure 10.--Where average annual rainfall is less than 13 inches and the mesquite cover is heavy, perennial grass production averages only 17 pounds per acre. Total grass production varies greatly from year to year due mainly to changes in the yield of annual grasses. Average total grass production is 89 pounds per acre.*

*Figure 11.--Grass yield and general appearance in September. Year-to-year changes in herbage production are dramatic.*

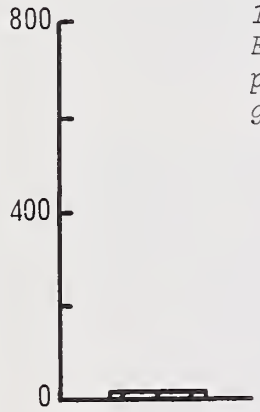
*LOW-ELEVATION, LOW-RAINFALL RANGES*



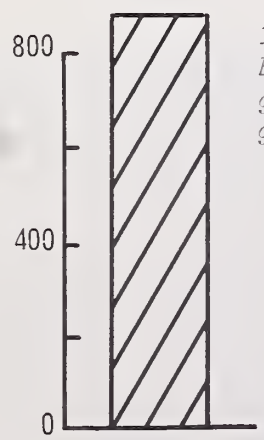

*1 9 5 9 - - Good summer growing season*




GRASS PRODUCTION (POUNDS PER ACRE)




*1 9 6 2 - - Exceptionally poor summer growing season*

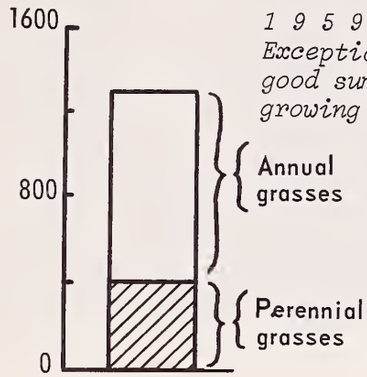




*1 9 6 3 - - Exceptionally good summer growing season*

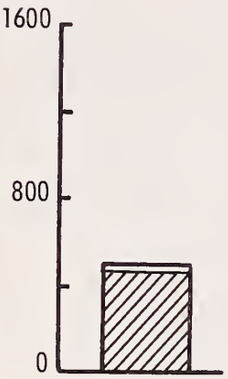
*Figure 12.--Grass yield and general appearance in September. Fluctuations in yield are much less for perennial than for annual grasses.*

*HIGH-ELEVATION, HIGH-RAINFALL RANGES*

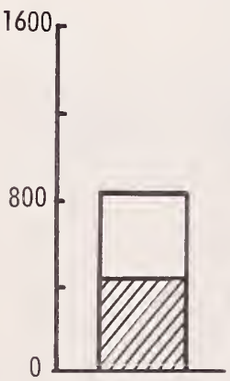
GRASS PRODUCTION (POUNDS PER ACRE)




*1 9 5 9 -- Exceptionally good summer growing season*




*1 9 6 2 -- Poor summer growing season*


*1 9 6 3 -- Good summer growing season*

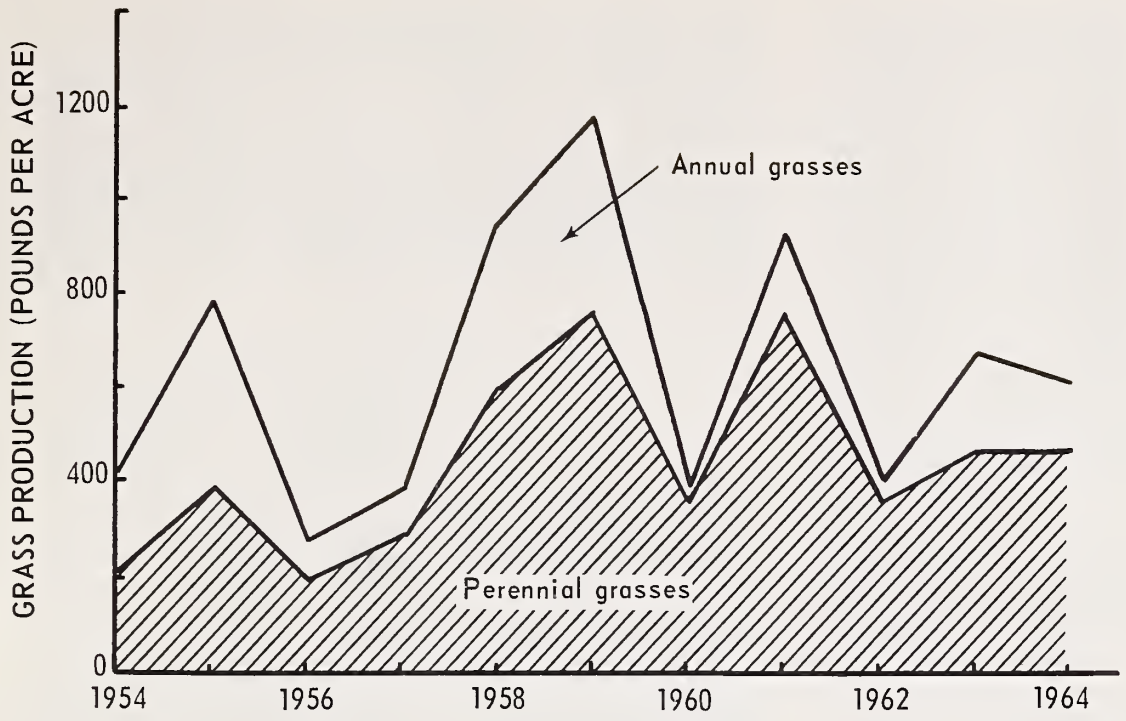



*Figure 13.--Where annual rainfall averages 16 inches or more and the mesquite has been killed, average yields of perennial grass and total grass are 443 and 633 pounds per acre, respectively. In years of low rainfall and low total grass production (1956, 1957, 1960, and 1962) the annual grasses produce very little.*

### Grazing capacities of semidesert range vary from 5 to 25 head per section

The number of cattle that can be supported on semidesert grass-shrub range depends on the basic potential of that range and its condition. In the Southwest in general, rainfall increases with elevation, so the higher elevations have a higher potential for forage production. On the Santa Rita, ranges below 3,300 feet receive an average of 12 inches annual rainfall or less. Those above 4,000 feet usually receive 16 inches or more. Approximate grazing capacities of the upper, middle, and lower elevation ranges are listed in Table 1.

Table 1.--Estimated average yearlong stocking rates, by elevation and condition class, Santa Rita Experimental Range

| Elevation (Feet) | Range condition | | |
|---|---|---|---|
| | Good to excellent | Fair to good | Very poor |
| | Animal units per square mile | | |
| Upper (Above 4,000) | 20-25 | 15-20 | < 15 |
| Middle (3,300-4,000) | 15-20 | 10-15 | < 10 |
| Lower (Below 3,300) | 8-10 | 6- 8 | < 6 |

## GRAZING MANAGEMENT

Perhaps the most persistent factor that contributes to the improvement or decline of semidesert ranges is the grazing use. The season of grazing, the number of animals, and, to some extent, the intensity and distribution of grazing use can be controlled. Without such control, cattle graze forage from the best forage plants on the most accessible parts of the range 365 days per year. The natural end result of this process is that the most productive parts of the range eventually become the least productive. By forcing cattle to graze less on favorite parts of the range and more in areas where they ordinarily would not go, a higher percentage of the total forage crop can be harvested without damage to the most accessible areas. Improved grazing management probably is the most effective and economical tool for improving the productivity of semidesert cattle ranges.

### Moderate grazing maintains range productivity

Grazing too closely or too frequently weakens perennial grass plants and cuts down seed production. Approximate standards of proper use developed for several important perennial grasses on the Santa Rita are as follows:

| | Herbage removal (Percent by weight) |
|---|---|
| Arizona cottontop | 40 |
| Bush muhly | 35 |
| Curlymesquite | 40 |
| Dropseed | 35 |
| Grama: | |
| Black | 45 |
| Hairy | 45 |
| Rothrock | 55 |
| Side-oats | 45 |
| Slender | 50 |
| Sprucetop | 40 |
| Tanglehead | 40 |
| Three-awn | 50 |
| Wolftail | 40 |

## Cattle select the more nutritious forage

The quality of range forage, as measured by crude protein content, is highest during the summer growing season and lowest during the May-June drought. The protein content of hand-picked grass samples usually is less than 6 percent, except during the summer growing season. Even so, cattle selected plants and plant parts in such a way that the crude protein content of their diet was 9 percent or higher, an amount considered adequate for range cattle, in all months but January, May, and June (fig. 14).

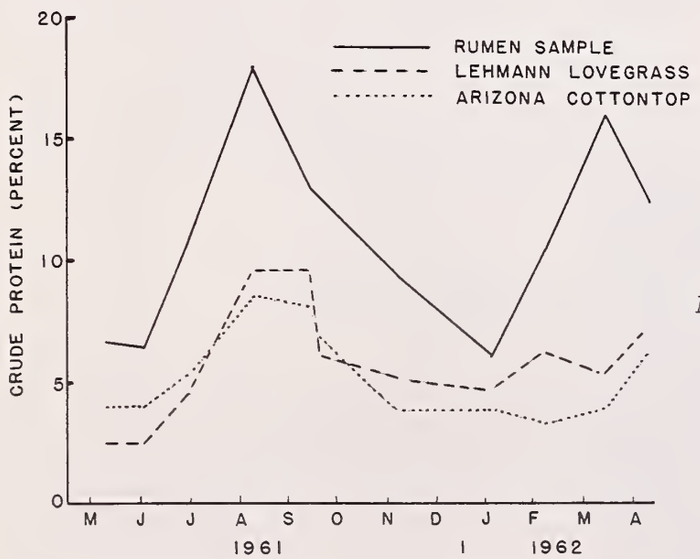



*Figure 14.-- Crude protein content of Arizona cottontop, Lehmann lovegrass, and of herbage samples taken from steer rumens at intervals of about 1 month from May 1961 to April 1962.*

## About half of the grass plants should be ungrazed at the end of the grazing year

Tests show that the percentage of plants that remain ungrazed at the end of June can be used to estimate the degree of utilization (fig. 15). The stocking rate is about right if

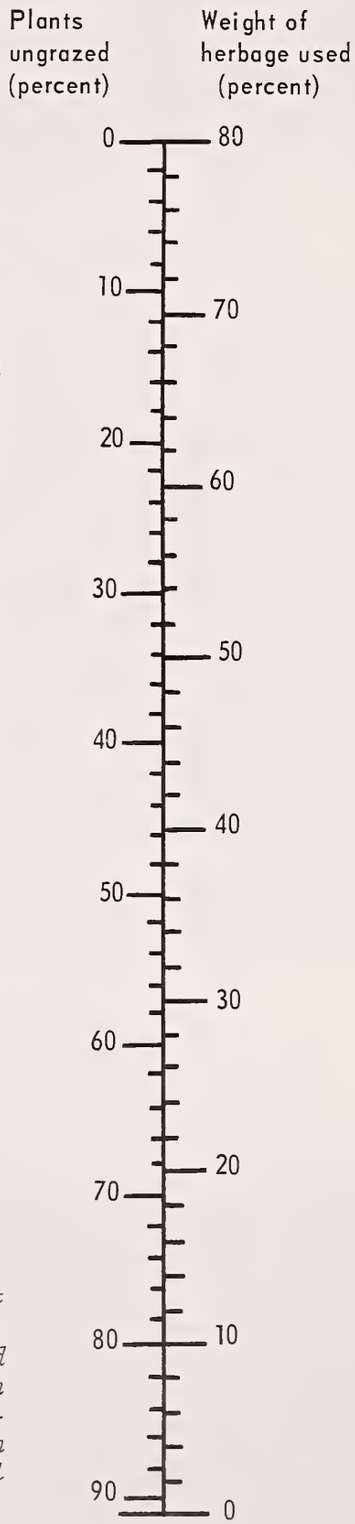



*Figure 15.-- Line scale showing relationship between percent of plants ungrazed and percent of perennial grass herbage consumed.*

40 percent of the herbage produced by perennial grasses is used each year. This level of use has been achieved if 46 percent of the perennial grass plants remain ungrazed when effective summer rains introduce the new forage year. This level of use also leaves an appreciable quantity of herbage on the ground (fig. 16).

### Moderate to heavy yearlong grazing reduces number of seedlings of taller grasses

Seedlings or sets of 11 perennial grass species studied for 17 years became established every year. Species were black, hairy, side-oats, Rothrock, sprucetop, and slender gramas, Arizona cottontop, mesa three-awn, tanglehead, wolftail, and curlymesquite. More seedlings of tanglehead, black grama, and side-oats grama were established in exclosures than on grazed areas, but the grazed areas produced more seedlings of wolftail, Arizona cottontop, Rothrock grama, curlymesquite, sprucetop grama, and slender grama (fig. 17). The number of seedlings per year on meter-square plots ranged from 0.5 for Arizona cottontop on ungrazed areas to 29 for Rothrock grama on grazed plots.

### Yearlong grazing shortens life of mid-grasses, lengthens life of grasses with dense basal foliage

Black grama, mesa three-awn, Arizona cottontop, and sprucetop grama are long-lived grasses, with some plants living 10 years or more (fig. 18). Rothrock grama, with maximum age of 5 years and average age of 1.3 years, is the shortest lived perennial on the Santa Rita. Except for Arizona cottontop, the species that lived longer on grazed plots were short grasses with mostly basal foliage. On the other hand, the plants that lived longer under protection were mainly mid-grasses. These differences in response to grazing help explain why the percentage of mid-grasses increases in response to moderate to light grazing, and decreases under heavy grazing.

### Moderate stocking and alternate-year summer deferment improve rundown ranges

In 1954, the mesquite was killed on two pastures and was left undisturbed on two others. Since 1957, each pasture has been deferred during the summer growing season every other year and utilization of perennial grasses has averaged around 40 percent when measured in June. Grazing capacities have increased on both pairs of pastures (fig. 19). The estimated number of animal units required to graze 40 percent of the perennial grass crop increased by 169 percent between 1954 and 1961 on the mesquite-free pastures, an average of 2.5 head per section per year. Where the mesquite was alive, grazing capacity increased 62 percent, an average of 1.1 head per section per year during the same period.

*Figure 16.--Appearance of the range near the end of June varied with the level of use:*

*In 1960, use was moderate (35 percent)*

*In 1964, use was heavy (58 percent)*

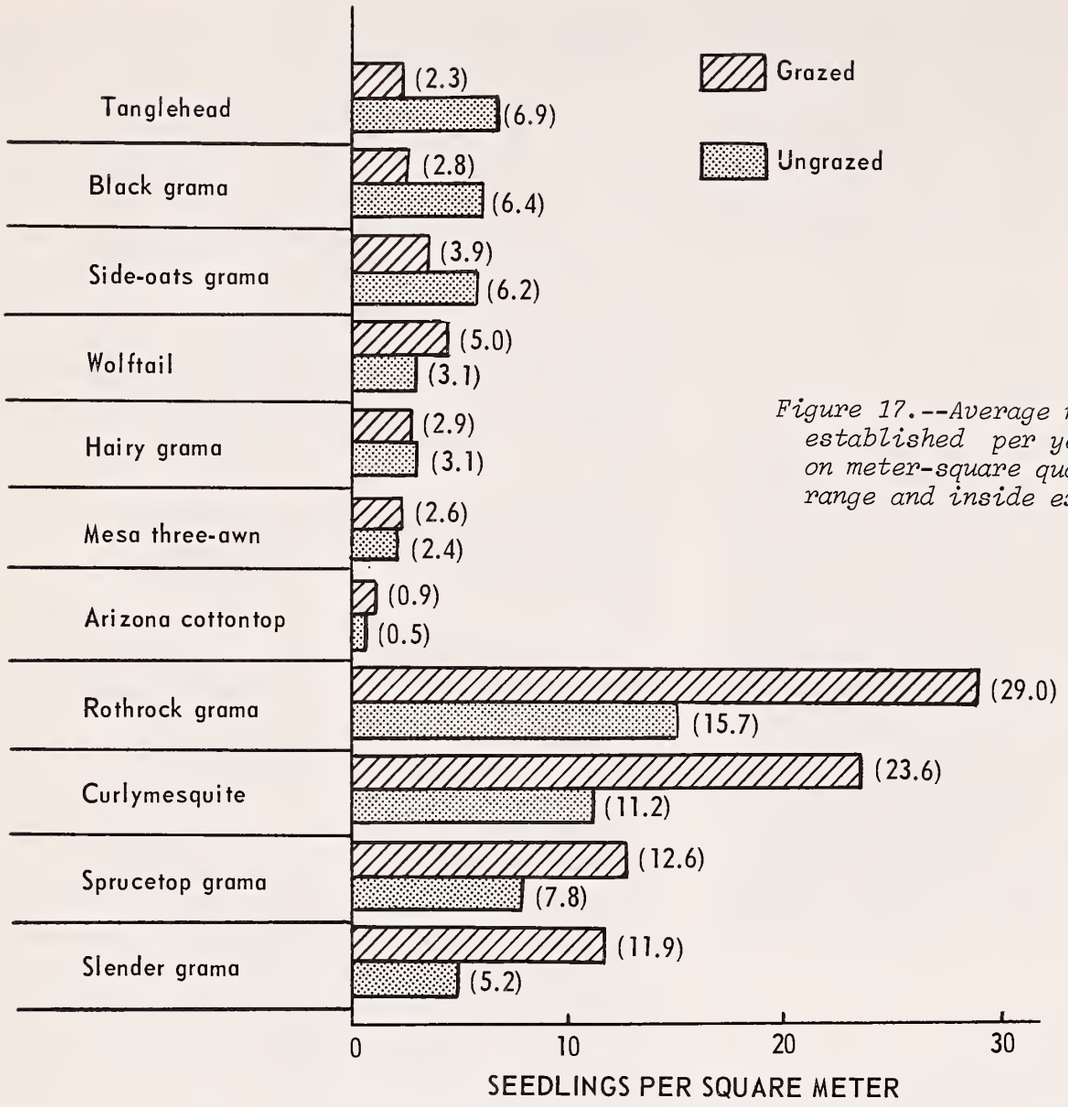



*Figure 17.--Average number of grass seedlings established per year over a 17-year period on meter-square quadrats on yearlong cattle range and inside exclosures.*

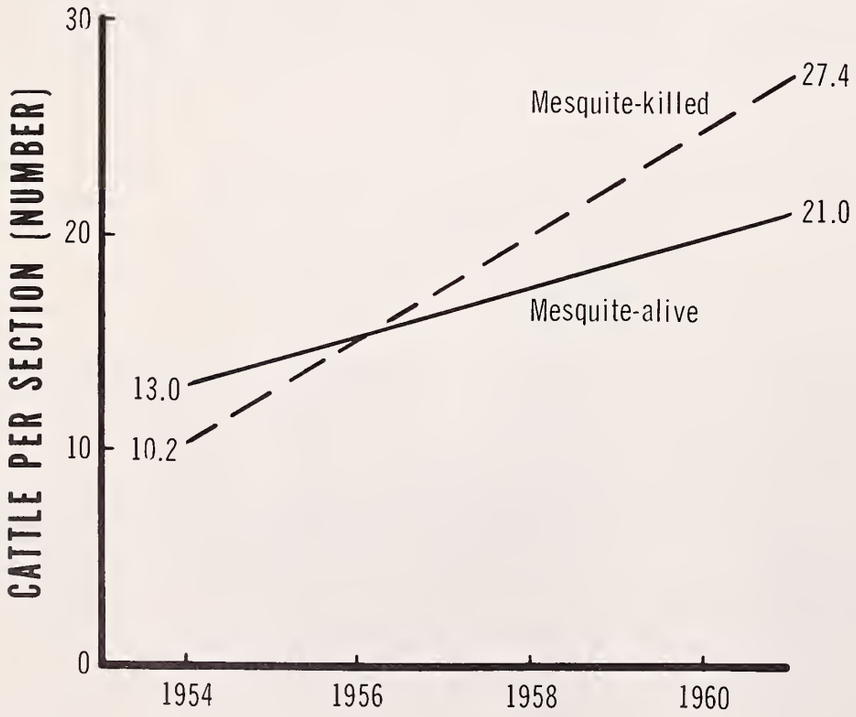



*Figure 19.--Changes in number of animal units required to graze 40 percent of the perennial grass crop.*

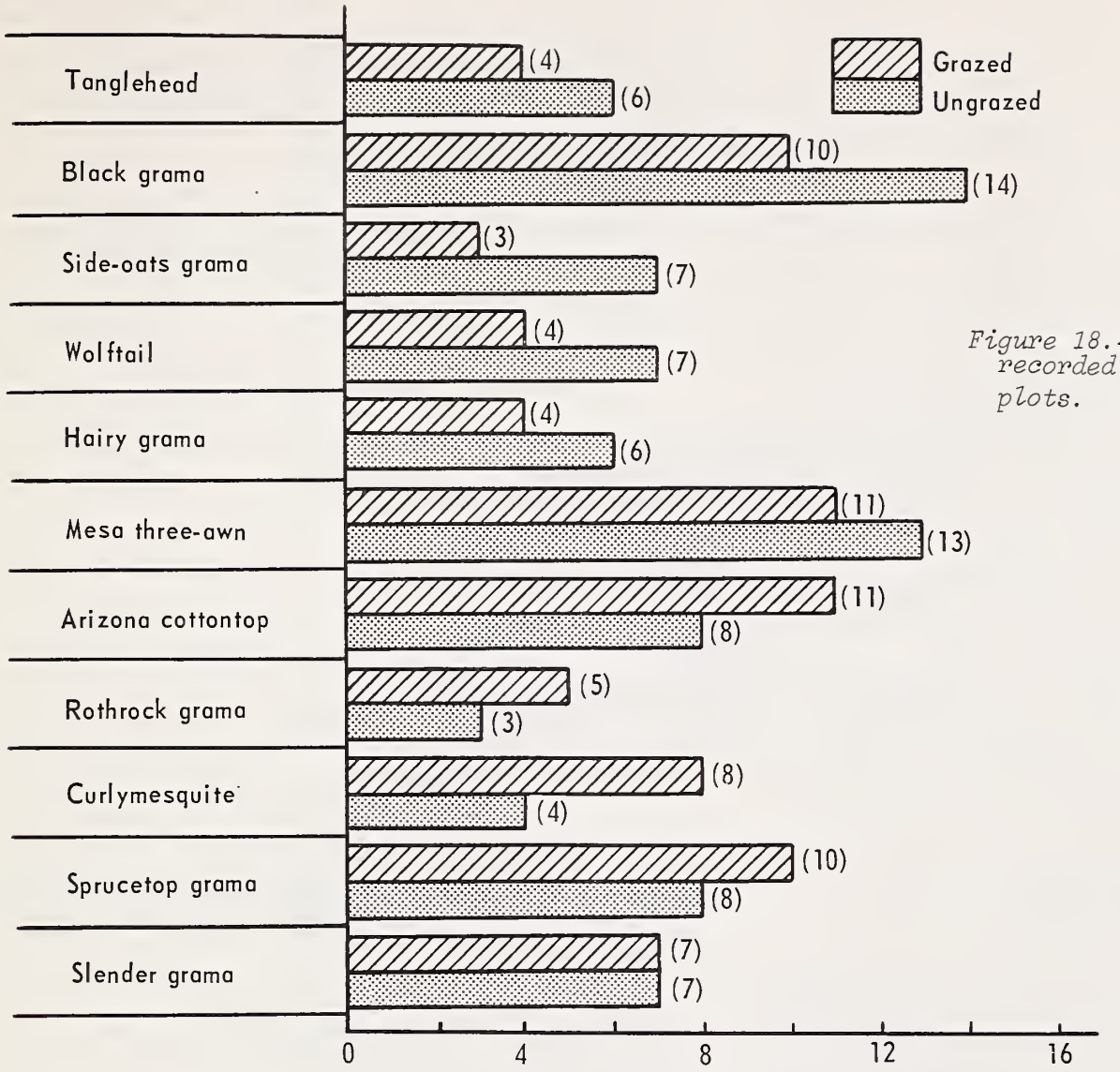



*Figure 18.--Ages of oldest plants recorded on grazed and ungrazed plots.*

## MESQUITE GROWTH

Mesquite now covers almost twice as much southwestern rangeland as it did in 1900. Where mesquite has taken over, forage production has declined (fig. 20). Mesquite produces some forage, but mesquite leaves and beans will feed fewer cattle than would the grass it crowds out. When mesquite completely replaces perennial grasses, forage production is reduced to less than one-third of capacity (fig. 21).

*Figure 20.--Changes that accompany mesquite invasion.*

*In 1903, this relatively brushfree area had enough perennial grass to cut for hay.*

*In 1964, the same spot supported only scattered tufts of perennial grasses, with most of these protected by crowns of mesquite, burroweed, or cactus.*

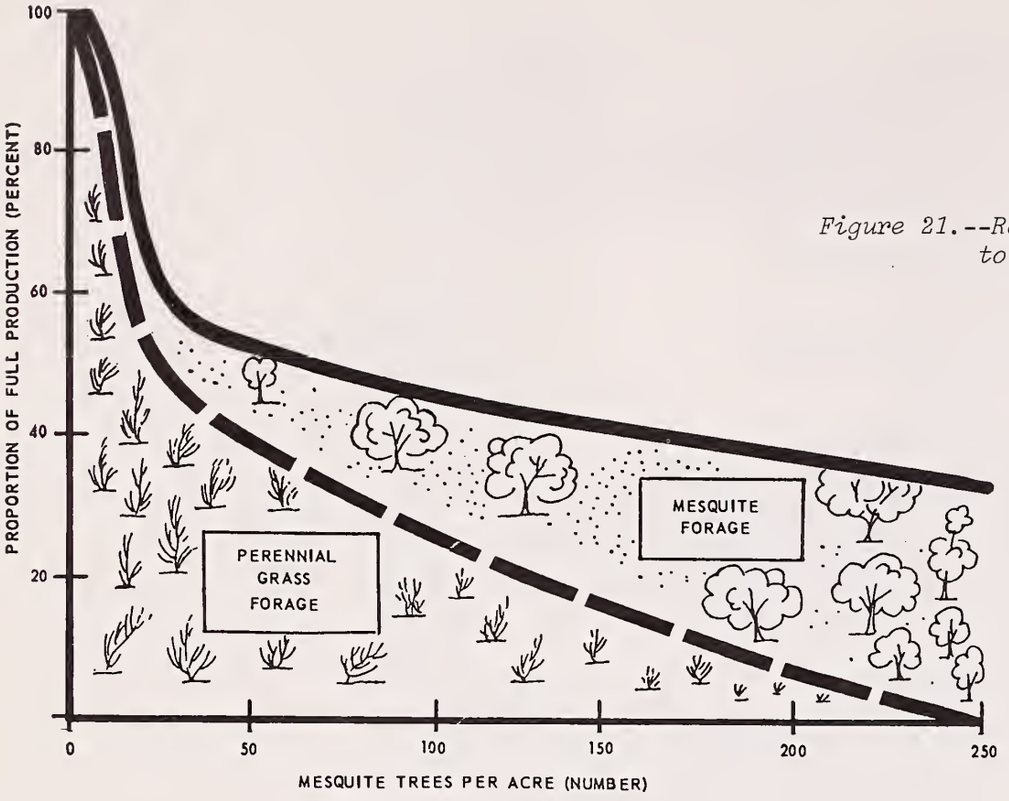



*Figure 21.--Relation of mesquite abundance to forage production.*

**Vigorous grass stands retard spread of mesquite**

Dense, vigorous stands of deep-rooted perennial grasses can almost prevent the spread of mesquite. Grasses reduce the number of seedlings that are established during the summer, and eliminate additional plants during the period October through July of the first year (figs. 22 and 23). In small plot tests, Arizona cottontop, black grama, and bush muhly inhibited the establishment of mesquite seedlings, bush muhly most effectively. Grasses retarded the development of lateral roots on the mesquite seedlings. Early mortality was attributed to shading as well as to competition for moisture.

**Cattle spread mesquite seeds**

It is well known that mesquite seeds are distributed in the droppings of livestock and other animals (fig. 24). A single cow chip may contain 1,500 or more mesquite seeds, of which ½ to ¾ are viable. Obviously the rancher who is trying to clear mesquite from his range should avoid bringing such quantities of new mesquite seed to cleared range. It takes about 8 days to clear mesquite seeds from the digestive tract of cattle. This means that cattle should be kept on a mesquite-free ration for a week before they are put on cleared range.

**Some mesquite seeds live at least 10 years in the soil**

Just how long mesquite seed will remain alive in the soil is uncertain, but 60 percent of a 50-year-old lot of seeds from a herbarium sheet at Tucson germinated. Seeds buried in the soil for 2, 5, and 10 years showed rapid declines in the percentage of sound seeds recovered, but the viability of the apparently sound seed did not decrease greatly with time (fig. 25). A recently germinated seed dug up at the end of 10 years was evidence that mesquite seed could remain in the soil for many years and still germinate naturally. Thus, any mesquite control program must reckon not only with existing mesquite plants and seed carried from other areas, but also with dormant seed in the soil.

**Favorable growing conditions do not always increase height growth of mesquite in first year**

A comparison of field-and nursery-grown mesquite seedlings showed that the more favorable conditions of the nursery were ex-

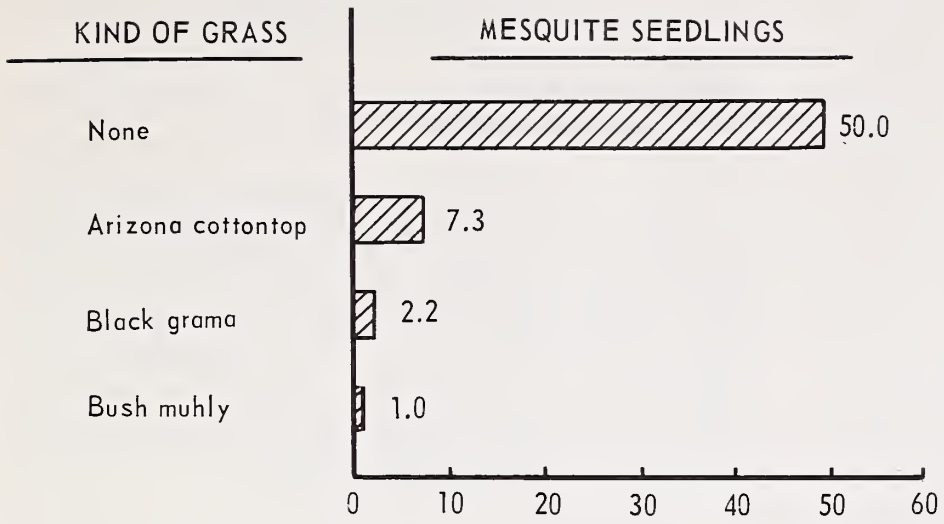



*Figure 22.--Number of live mesquite seedlings in October per 100 seeds planted in July.*

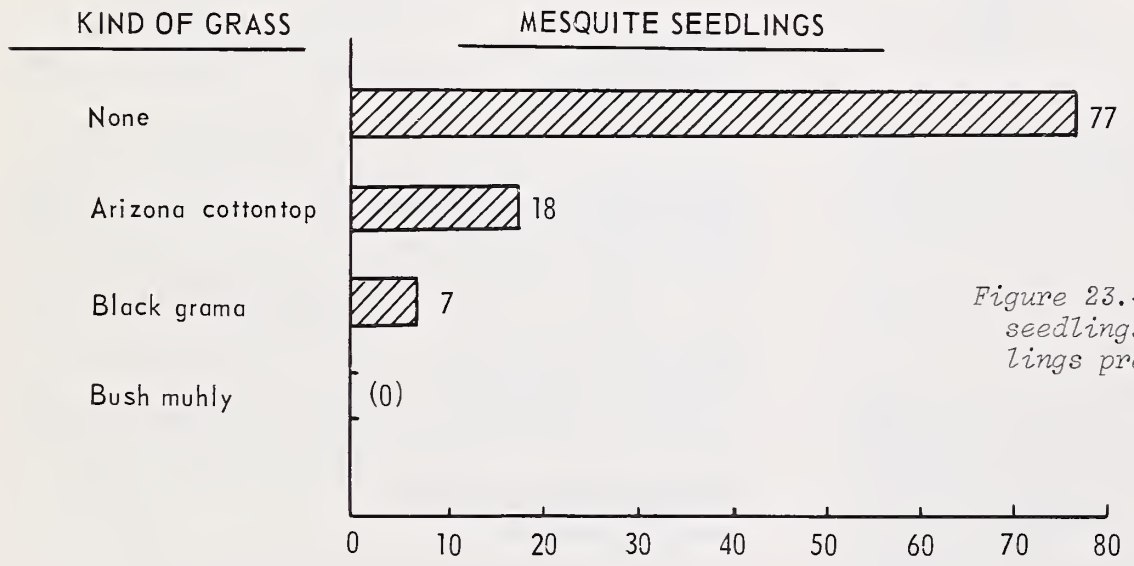



*Figure 23.--Number of live mesquite seedlings on July 1 per 100 seedlings present the preceding October.*

*Figure 24.--Mesquite seeds are distributed in the droppings of livestock and other animals.*

*Cattle have a marked preference for mature and nearly mature velvet mesquite pods, and graze them avidly even in the presence of grass.*

*In a dense mesquite forest where little other forage was available, partially disintegrated cow chips were composed mainly of undigested pod segments and contained up to 1,670 seeds per chip.*

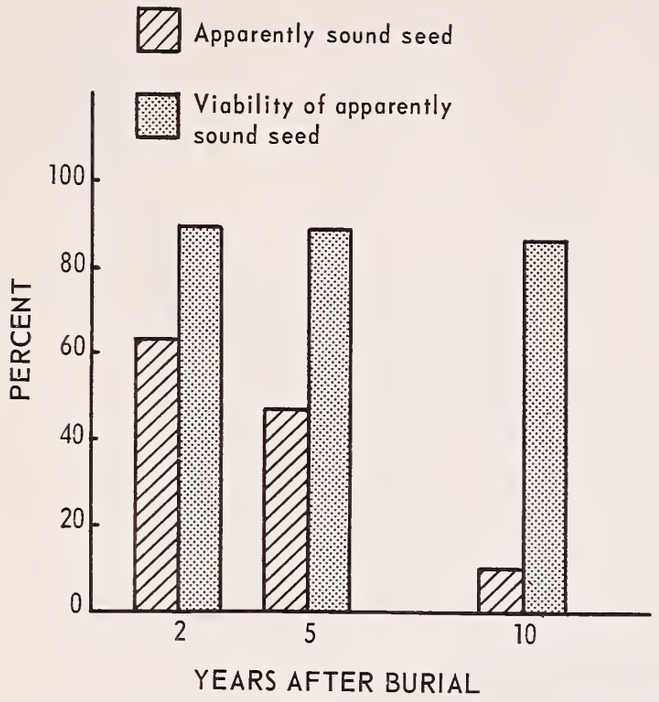



*Figure 25.--Percent of mesquite seeds still apparently sound 2, 5, and 10 years after burial, and viability of apparently sound seed.*

pressed in additional height growth of mesquite seedlings beginning in the second growing season. Slow height growth during the first growing season, even with adequate moisture, accounts in part for the susceptibility of mesquite seedlings to competition from perennial grasses. Because of frequent dieback and browsing, mesquite seedlings on the range may gain little height for many years (fig. 26).

*Figure 26.--This mesquite seedling, established in 1949, was only 9 inches tall when photographed in December 1964.*

## MESQUITE CONTROL

### Costs depend on size of trees and job

The most efficient method for controlling mesquite depends on a number of considerations. The number of trees per acre, their size and growth form, and the number of acres to be treated are all important (fig. 27). Costs vary greatly from job to job for many reasons. Approximate average costs for several methods are listed below:

| Treatment | Equipment and labor | Chemical and materials | Total |
|---|---|---|---|
| | Costs per tree | | |
| Grubbing | $ 0.015 | ____ | $ 0.015 |
| Diesel oil | .035 | $ 0.015 | .05 |
| | Costs per acre | | |
| Cabling and chaining | 4.00 | ____ | 4.00 |
| Foliage spraying (two treatments) | 3.00 | 2.00 | 5.00 |

### Small mesquites are easily grubbed

Plants 1 inch in diameter or smaller at the root crown can be easily killed by hand grubbing at any season of the year. Plants cut off 1 or 2 inches below the root crown do not sprout. Fewer plants will be overlooked if the range is traversed in marked strips and if grubbing is done in May and June when the new mesquite leaves contrast sharply with the dry grass. Grubbing is especially adapted for dense clusters of small mesquites around water, and for widely scattered seedlings on otherwise mesquite-free range. The cost of hand grubbing depends on the density of the mesquite, the wage rate and efficiency of the labor, and the relative stoniness of the soil.

### Large machinery works best on large mesquite

Large bulldozers, with or without "stinger" attachments, are well adapted for uprooting scattered stands of relatively large trees.

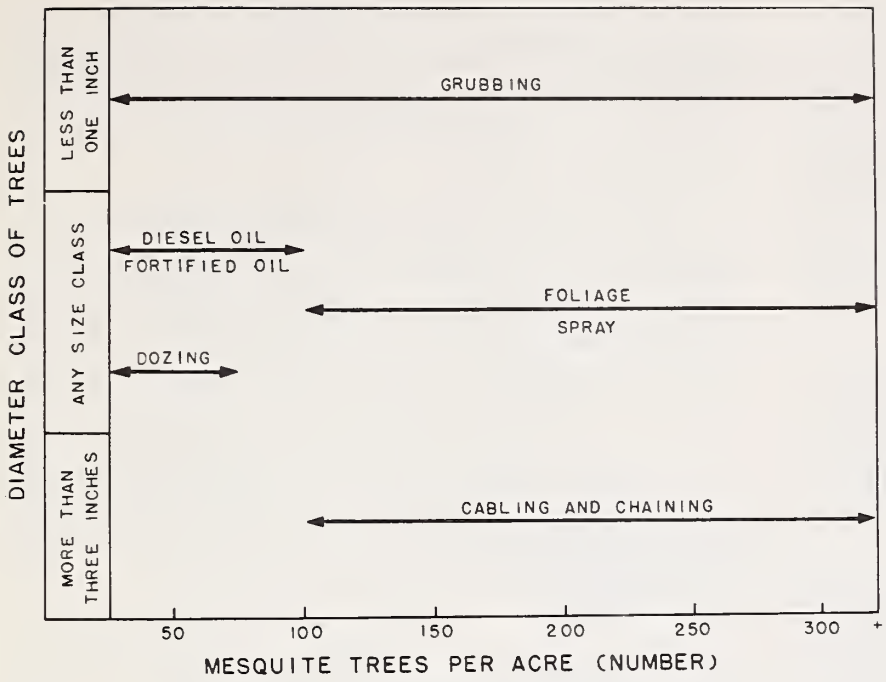



*Figure 27.--The most efficient method for controlling mesquite depends on the size and number of plants per acre.*

Dense stands of relatively large trees can be effectively opened up by chaining or cabling. However, chaining and cabling usually result in dense stands of mesquite sprouts from small mesquites that are broken off or roughed up but not uprooted by the chain or cable.

Large bulldozers are not recommended for small mesquite because too many are missed. Cabling and chaining usually require followup to kill sprouts from small plants that are not killed.

Large tractor-drawn root plows have not been used enough to determine their best place in mesquite control. More data are needed on costs, degree of mesquite control, and on the short- and long-time effects of root plowing on important forage grasses.

The cost of mechanical mesquite control varies so much due to so many factors that each job requires independent negotiations between the rancher and the contractor.

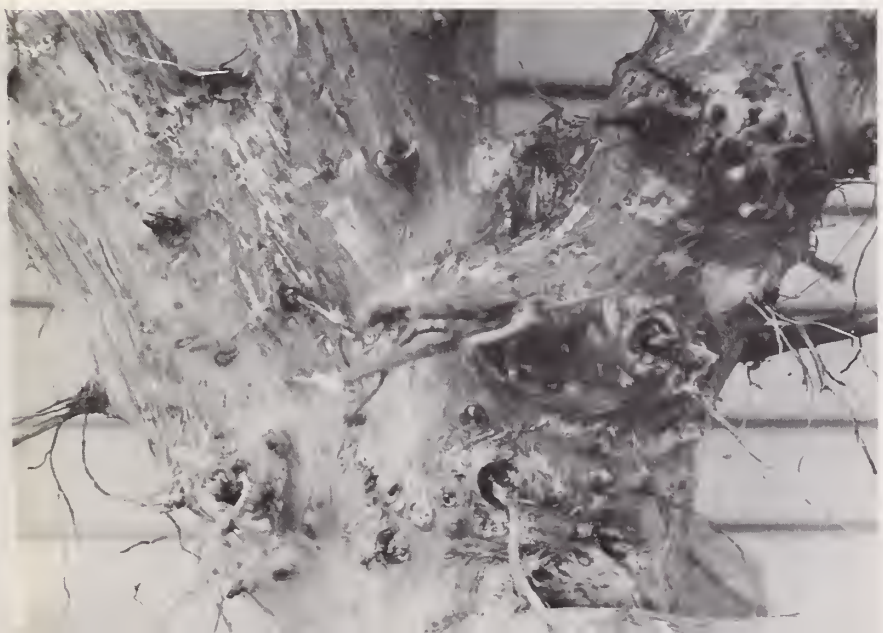
## Diesel oil applied to stem bases is effective on trees of all sizes

Low-grade diesel oil or kerosene will kill mesquite at any time of year. Oil should be sprayed against the bark just above the ground line (fig. 28). Enough oil should be used to saturate the bark and flow down into the soil

*Figure 28.--Treatment of mesquite with diesel oil:*

*Dormant buds are numerous in the root-stem transition zone. Oil is applied to kill these buds and to chemically girdle the tree.*

*A 2- to 4-gallon compressed-air sprayer equipped with a 3-foot piece of 1/4-inch copper tubing is a good device for applying the oil.*



on all sides of the stem and in the crotches of low-branching trees. Trees with two or three stems up to 3 inches in diameter require about a pint of oil per tree. Diesel oil works well on mesquite that has a single stem or from two to four branches arising at or above the soil line. Results are best on sites where there has been no deposition of soil around the stem base.

Diesel oil is not recommended for flood-plain sites where the sprout buds are deeply buried by silt, or for the multiple-stemmed, low-growing form of mesquite that has no definite trunk.

The cost per tree of killing mesquite with diesel oil depends on the cost of the oil, the wage rate and efficiency of the labor, and the size and density of the mesquite. In mesquite stands of about 100 plants per acre, where plants range in size from seedlings to stems 5 inches in diameter, a good worker should treat 40 trees per hour, and a gallon of oil will treat 6 to 8 trees.

### Airplane spraying with 2,4,5-T controls dense, extensive mesquite stands economically

Under ideal conditions, airplane spraying with 2,4,5—T (2,4,5—trichlorophenoxyacetic acid) in an oil-water emulsion top-kills more than 90 percent of the mesquite, and kills up to 50 percent of the plants outright (fig. 29). The most effective formulation is 1/3 to 1/2 pound acid equivalent per acre of a low-volatile ester of 2,4,5-T in 1/2 gallon of diesel oil and enough water to make 4 gallons of spray mixture. Continuous agitation of the mixture is essential. Two applications are necessary, 1 or 2 years apart.

The proper time for spraying is between April 15 and July 15. Mesquite should be sprayed when the new leaves are full-size, twig elongation has stopped, and developing pods are about one-half inch long. It is better to be a few days late than a few days early.

For jobs of 100 acres or more, the cost for herbicide and flying for two sprayings would range from $3.00 to $5.00 per acre at rates charged commercially in 1964.

### Burning to kill mesquite most effective on small plants in June

Broadcast burning experiments in February, June, and November resulted in kills of 4, 29, and 10 percent respectively for mesquite of all size classes. The June burn was most effective for all sizes of mesquite, and mortality was much higher on small plants than larger ones (fig. 30). The percent kill on plants less than 0.5 inch in diameter was almost twice as great as for plants with stems between 0.5 and 1.0 inch, and three times as great as for plants 1.0 to 2.0 inches in diameter. These results suggest that burning to control mesquite should be done in June, and that results are best when the plants are small.

*Figure 29.--Low-yielding, mesquite-covered range can be improved.*

*Unimproved range.*

*Range improved by spraying with 2,4,5-T to control mesquite, then seeding to Lehmann lovegrass.*

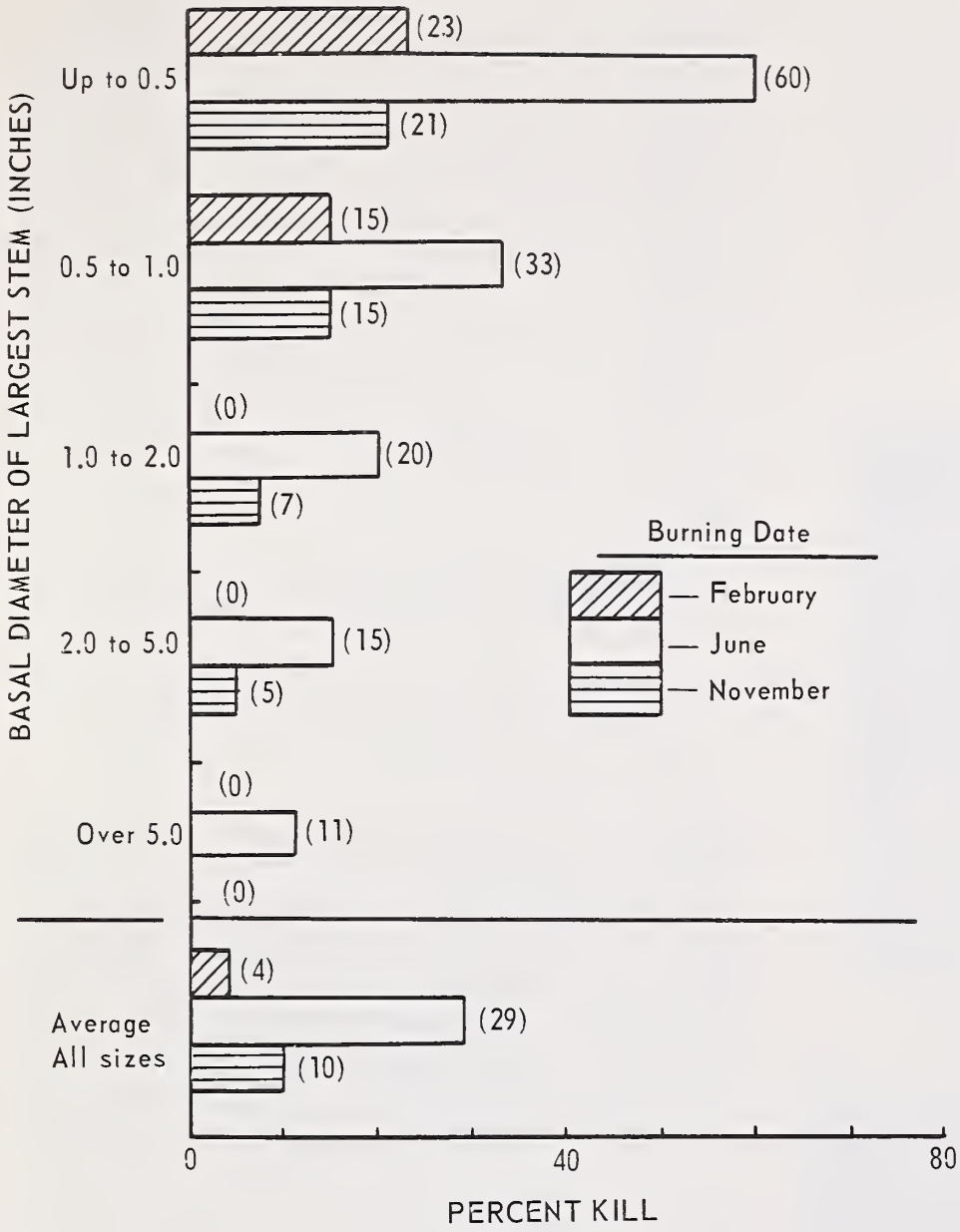



*Figure 30.--Mortality of mesquite by size classes after burning in February, June, and November.*

Perennial grasses recover quickly from a June burn if grazing is deferred during the summer rainy season immediately after the burn, and if the amount and distribution of rainfall are favorable. If summer drought or heavy grazing follow burning, the mortality of perennial grasses may be severe.

### Mesquite control increases benefits of reseeding

Range that was seeded to Lehmann lovegrass by airplane in 1954 improved more rapidly where the mesquite was controlled by aerial applications of 2,4,5-T in 1954 and 1955 than where the mesquite was not controlled. Spraying killed about 90 percent of the top wood and over half of the plants. The cost of seeding was $3.00 per acre; the cost of seeding and mesquite control combined was $9.50 per acre. The sprayed range showed the greatest advantage in grass production during the second, third, and fourth seasons after spraying (fig. 31a). Cumulative net returns on the sprayed range returned more than the cost of spraying and seeding within 3 years (fig. 31b). Cumulative net returns on unsprayed range did not exceed the cost of seeding until the fourth year. These results show that rundown mesquite-grass ranges can be improved by seeding and management alone, but that the rate of recovery can be greatly increased by controlling the mesquite.

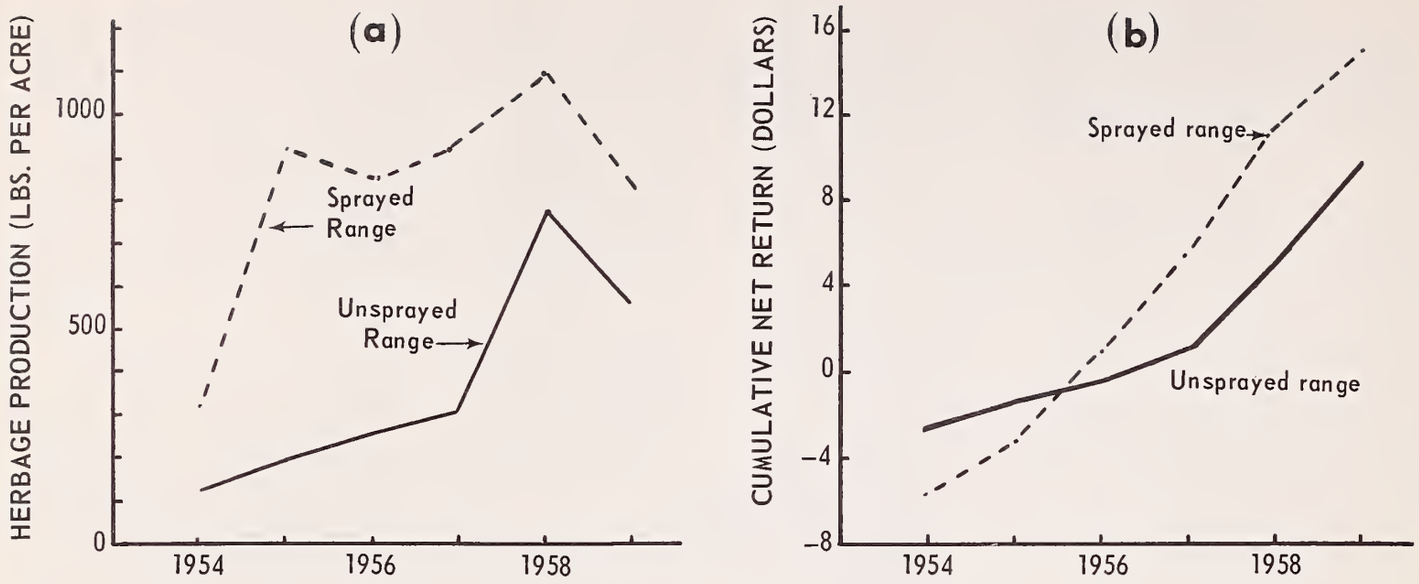



*Figure 31.--One range was sprayed with 2,4,5-T in 1954 and 1955 to control mesquite; an adjacent range was not sprayed. In 1954, both ranges were seeded by airplane to Lehmann lovegrass.*

*Figure 32.--Changes in jumping cholla cactus: A, 1905; B, 1941; C, 1962.*

## JUMPING CHOLLA AS A RANGE PROBLEM

Jumping cholla is a nuisance on the range. It may not seriously reduce grass production, but it does interfere with the handling and movement of livestock. Cattle do eat some cholla fruits when green forage is scarce, but it is doubtful whether the food value obtained offsets the discomfort and injury involved.

New cholla plants rarely become established from seed, but dense stands of new plants are frequently established from scattered joints. Jumping cholla is not a fixed or ever-increasing component of the vegetation on any part of the Experimental Range. Instead, stands become established, develop rapidly for a few years, mature, and then decline (fig. 32). The decline may be dramatic, with 90 percent of the plants dying in 2 or 3 years.

Cholla can be killed with chemicals now on the market, but only if high rates of material are used. Completely wetting sprays of 2,4,5-T or TCA (trichloroacetic acid) will kill individual plants. Low-volume aerial applications, as applied to mesquite, are completely ineffective. Burning in June kills about one-third of the cactus, if there is enough fuel to carry a fire. Within a year or two after burning, however, large numbers of young cholla plants may become established from joints dropped off the partially burned parent plants. Mechanical measures such as chaining or cabling knock over and uproot most of the large cactus, but numerous new plants usually start from scattered joints. Studies to test the feasibility of controlling cholla by combinations of mechanical treatment and fire are in progress.

## BURROWEED AS A RANGE PROBLEM

Invasions of grassland by burroweed have concerned cattlemen in southern Arizona since the turn of the century. Mature burroweed is a long-lived, woody half-shrub with a strong taproot. Occasional severe livestock losses from burroweed poisoning have been reported, but most of these have involved either a shortage of forage or cattle that were not familiar with burroweed. No cattle losses from burroweed poisoning have been recorded on the Experimental Range, where moderate to heavy stands of burroweed have persisted for many years. Cattle that grow up with burroweed apparently learn to leave it alone.

### Invasion varies with cool-season precipitation

Burroweed does not invade grassland at a steady rate. Large numbers become established only in years of high winter and spring precipitation. Burroweed stands fluctuate greatly and sometimes quite rapidly (fig. 33).

*Figure 33.--Burroweed stands become established in years with favorable winter-spring moisture, then decline from natural mortality until conditions permit the establishment of a new crop of seedlings: A, 1920, before burroweed invasion; B, 1935, dense mature burroweed stand; C, 1958, the old stand is about gone, but new seedlings are evident; D, 1962, the new crop of burroweed is approaching maturity.*



### Burning is more effective than chemical control

No satisfactory chemical method of control is available for burroweed. In years when there is an adequate supply of grass herbage, however, 90 to 100 percent of the burroweed may be killed by broadcast burning in June. Most of the burroweed that survives such fires is found in unburned or lightly burned islands. Burning is reasonably effective from mid-April to mid-September (fig. 34).

### Burroweed control increases yields of annual grasses

Average yields of annual grasses during a 10-year period were higher on burroweed-free plots than where the burroweed was not removed. Burroweed control increased annual grass yields in the presence of mesquite as well as on plots where mesquite was killed (fig. 35). Yields of perennial grasses, on the other hand, were greater in the presence of burroweed. It is suspected that heavier grazing on the burroweed-free plots was responsible for the decrease in perennial grass production. Whatever the cause, the results of this study do not justify controlling burroweed to increase perennial grass yields.

## RANGE RESEEDING

Range reseeding studies began on the Santa Rita soon after the Range was established in 1903. Studies to date have indicated that: (1) grasses should be seeded in May or June immediately before the start of the summer rainy season, (2) burroweed, mesquite, cactus, or other competing brush should be removed before seeding, and (3) the chances for success are improved by preparing a good seedbed.

The best sites for reseeding have productive, medium-textured soils, are above 3,500 feet elevation, and receive 14 inches or more rainfall annually. On these sites, Lehmann and Boer lovegrasses are the best species to use.

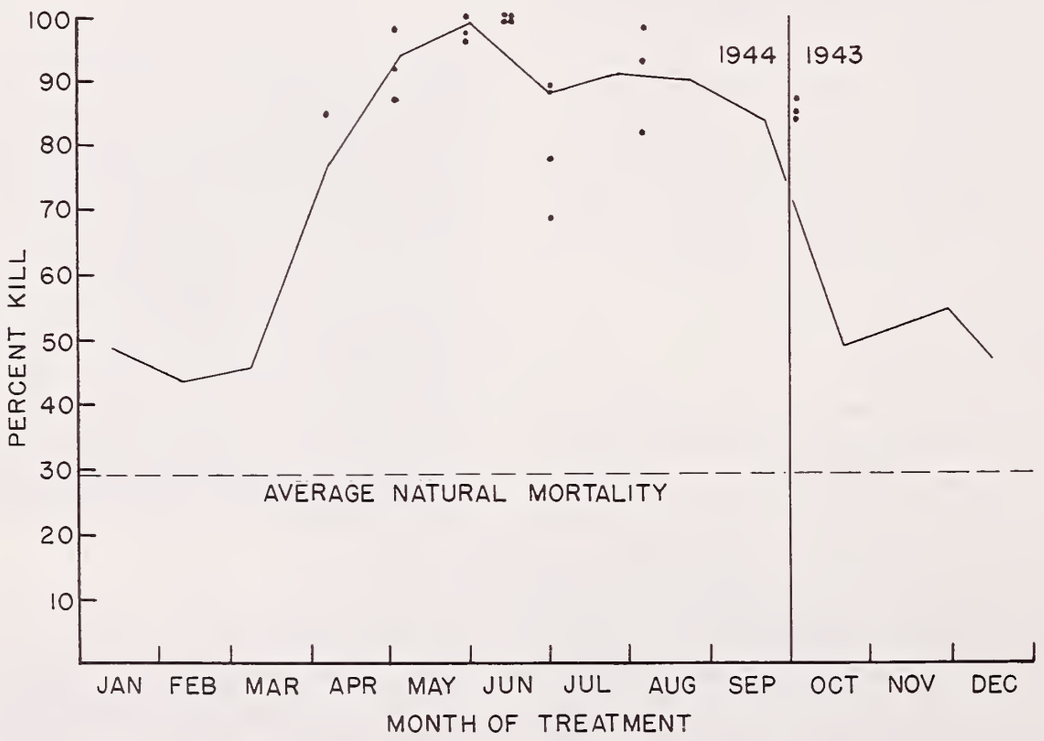



*Figure 34.--Percentage of burroweed after burning at 4-week intervals from October 21, 1943, to September 21, 1944. Each point marked by a dot represents a burn on the date indicated but at a different location and usually in a different year.*

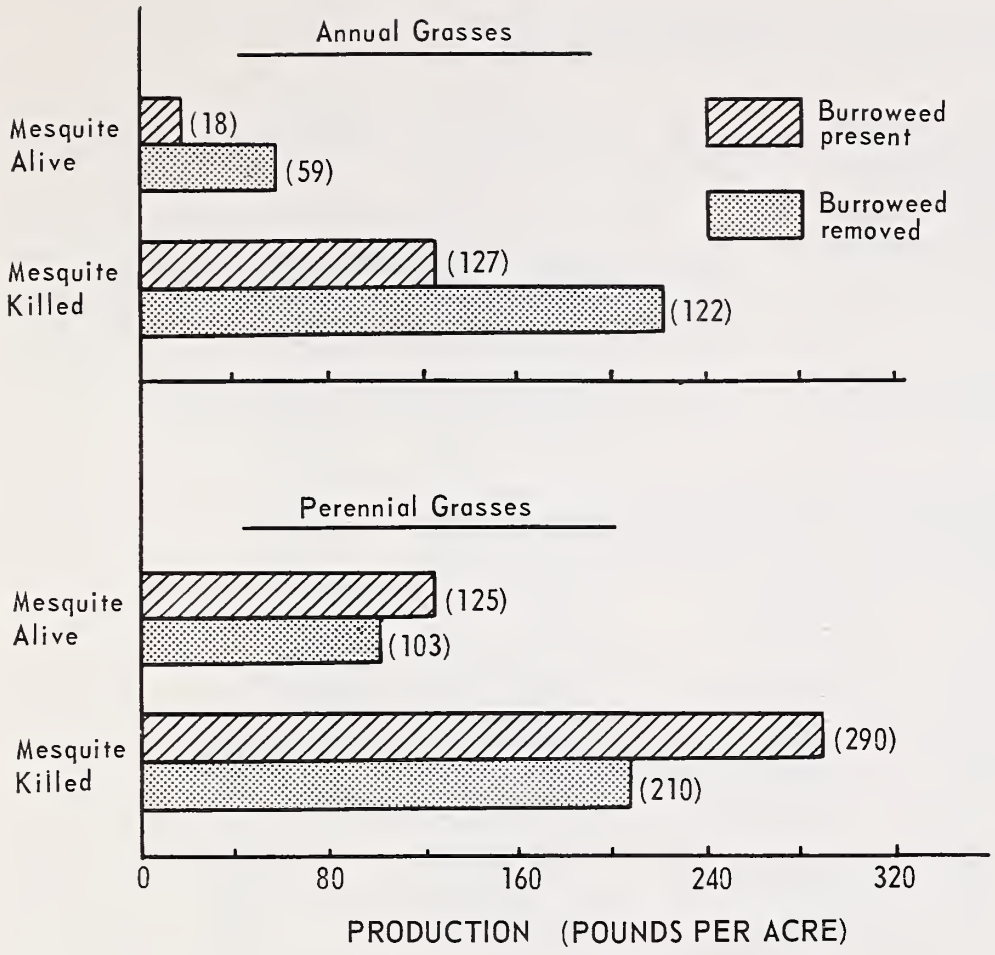



*Figure 35.--Effects of burroweed control on yields of annual and perennial grasses on mesquite-infested and mesquite-free range.*

Lehmann is easier to establish, but Boer is more palatable and longer lived. Arizona cottontop and black grama are more difficult to establish. Weeping lovegrass and side-oats grama are suitable for the more moist sites. Wilman lovegrass can be used where temperatures do not fall below 10° F.

On upland areas receiving less than 14 inches of rainfall, Lehmann lovegrass is the only species that can be generally recommended. Reliable species and methods have not been developed for reseeding ranges that receive less than 11 inches of precipitation yearly.

## RODENTS AND RABBITS

Rodents and rabbits use vegetation that would otherwise be available for livestock, and thereby lower the overall grazing capacity of the range. In 1937, it was estimated that rodents and rabbits consumed about two-fifths of the total forage. Animal numbers for the Experimental Range, and their forage consumption, were as follows:

| Species | Animals | Forage consumed per animal per year | Forage consumed per year |
|---|---|---|---|
| | (no.) | (lbs.) | (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 than cattle to range vegetation, because they graze much closer and may even dig up root systems during dry periods. Also, certain species, particularly kangaroo rats, help establish unwanted shrubs by storing seeds in small caches about 1 inch below the soil surface. Seeds not used by the rodent are planted at an ideal depth, and thus frequently give rise to new plants. Jackrabbits and some kangaroo rats are more abundant on ranges in poor condition, where their activities tend to perpetuate the undesirable condition of the range. A relatively small rodent population can consume the entire seed crop of forage grasses on low-rainfall range in poor condition.

# EDUCATIONAL OPPORTUNITIES

The facilities of the Santa Rita Experimental Range are often used for training schools, for undergraduate field work, for field meetings of range management and conservation groups, and for training programs of the Foreign Agricultural Service.

Opportunities for graduate students to undertake fundamental research in the ecology and management of semidesert ranges are excellent.

Visitors are always welcome. To obtain more detailed published information about the experimental work, ask the resident technicians, or send a request to the Director, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

# COMMON AND SCIENTIFIC NAMES USED

| | |
|---|---|
| Acacia | *Acacia* spp. |
| Burroweed | *Aplopappus tenuisectus* (Greene) Blake |
| Cactus | *Opuntia* |
| Jumping cholla | *fulgida* Engelm. |
| Pricklypear | Principally *engelmannii* Salm-Dyck |
| Calliandra | *Calliandra* spp. |
| Cottontop | *Trichachne* |
| Arizona | *californica* (Benth.) Chase |
| Curlymesquite | *Hilaria belangeri* (Steud.) Nash |
| Dropseed | *Sporobolus* spp. |
| Grama | *Bouteloua* |
| Black | *eriopoda* Torr. |
| Hairy | *hirsuta* Lag. |
| Side-oats | *curtipendula* (Michx.) Torr. |
| Slender | *filiformis* (Fourn.) Griffiths |
| Sprucetop | *chondrosioides* (H.B.K.) Benth. |
| Rothrock | *rothrockii* Vasey |
| Lovegrass | *Eragrostis* |
| Boer | *chloromelas* Steud. |
| Lehmann | *lehmanniana* Nees |
| Weeping | *curvula* (Schrad.) Nees |
| Wilman | *superba* Peyr. |
| Mesquite | *Prosopis* |
| Velvet | *juliflora velutina* (Woot.) Sarg. |
| Mimosa | *Mimosa* spp. |
| Muhly | *Muhlenbergia* |
| Bush | *porteri* Scribn. |
| Tanglehead | *Heteropogon contortus* (L.) Beauv. |
| Three-awn | *Aristida* |
| Mesa | *hamulosa* Henr. |
| Santa Rita | *glabrata* (Vasey) Hitchc. |
| Wolftail | *Lycurus phleoides* H.B.K. |

Martin, S. Clark.
1966. The Santa Rita Experimental Range. U. S. Forest Serv. Res. Paper RM-22, 24 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Research was begun in 1903 on the Santa Rita, south of Tucson, Arizona, to learn how to attain maximum sustained forage and beef production on semidesert range with reasonable costs. Results reported cover forage production, including dependence on perennial grasses, grazing management, and methods and advantages of controlling mesquite and other undesirable plants.

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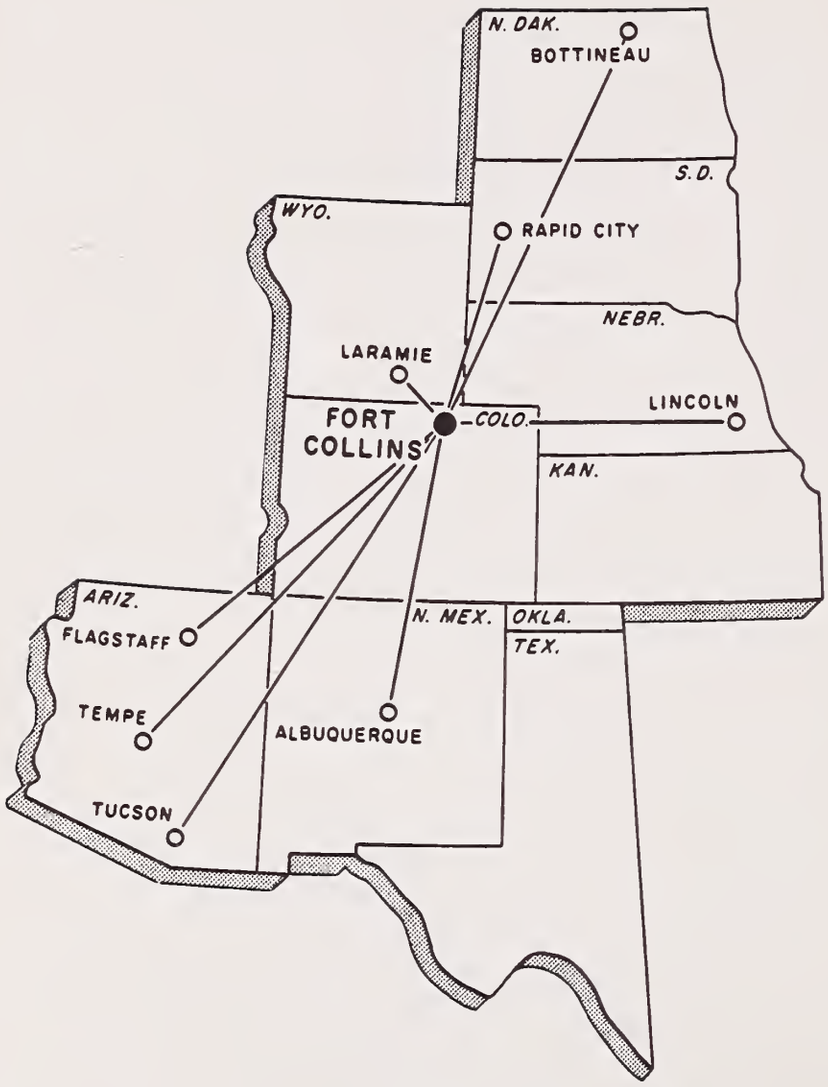
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OKLA.
TEX.
FLAGSTAFF
TEMPE
ALBUQUERQUE
TUCSON