UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

Study No. FS-1-r3-2 (SR #1) (STUDY 1706-12)

A comparison of vegetation and grazing capacities on mesquite-free and mesquite-infested semidesert ranges in southern Arizona.

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RR-RM

RESEARCH PROGRAM Tucson, Arizona

Study Plan June 1957

STUDY PLAN

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I. The Problem

About 9,000,000 acres of Arizona's rangeland are occupied by mesquite stands of varying density and stature. It is safe to assume that most of this area would produce more grass if the mesquite were removed. However, the average annual income per acre from Arizona rangeland is too low to justify spending more than from a few cents to a few dollars per acre for mesquite control. In many cases we don't know what it is reasonable to expect in the way of increased income or other good and bad results of mesquite control. In such cases we can only guess about the economic feasibility of mesquite control.

Besides the questions: Will mesquite control pay? And, how much will it pay? there are numerous other effects to be considered. These include the responses of perennial grasses, the effects on cattle in both good and poor years, the rate of re-invasion by mesquite, the value of mesquite as a forage producer, and the interaction of mesquite with other factors of soil and site.

A primary concern on the Santa Rita Experimental Range is whether by removing the mesquite it will be possible to restore the range to its former productivity. If mesquite alone is responsible for the decline in forage production on the Santa Rita through the years then mesquite control together with reasonably good grazing management should bring it back. But, if loss of soil or fertility, improper grazing or other factors are also important, then mesquite control will do only part of the jog. Plot studies on the Santa Rita show that grass production increases greatly following mesquite control. Will the same thing occur following pasture-wide clearing? How long will the benefits last? How should the range be managed to realize the most benefit from mesquite control?

II. Literature Review

Velvet mesquite (Prosopis juliflora var. velutina) has been considered a noxious range plant for many years. That mesquite seriously competes with perennial grasses for moisture and nutrients thereby reducing herbage production has been pointed out by Parker and Martin (3), Glendening and Paulsen (1), and many other range technicians and ranchers. A vast amount of time and effort has also gone into research and action programs directed toward control or elimination of mesquite. At the present time, the basal application of diesel oil as described by Martin (2) and Roach (4) appears to be the most positive and practical mesquite-control method for the Santa Rita Experimental Range and similar areas. Even so, the diesel oil method is slow and relatively costly. Consequently, there is some doubt as to the economic feasibility of clearing extensive areas by this method. This study is designed to determine some of the economic and ecological consequences of mesquite control on a practical scale.

III. Objectives

A. To determine the changes in production density and composition of perennial grasses and production of annual grasses that occur on both cleared and uncleared range.

B. To determine the relative grazing capacities of cleared and uncleared mesquite-grass range that is deferred during the growing season every other year.

C. To determine rate of establishment of mesquite on cleared and uncleared range.

IV. Methods

A. General plan of study.--The study will evaluate differences in vegetation and livestock between two cleared and two mesquite-infested pastures (fig. 1 page 22a [not included in digital file]).

B. Variables under test.--Variables under test will include changes or differences in vegetation and livestock that occur between pastures cleared of mesquite and pastures that are not cleared. These variables will include:

1. Number of cattle in pasture.

2. Herbage yields of perennial grasses by species.

3. Total density of perennial grasses by species.

4. Apparent condition of cattle and weights where possible

5. Numbers of mesquite seedlings.

6. Herbage yields of annual grasses

7. Amount of range supplement fed.

8. Percent utilization of perennial grasses.

C. Data to be taken are as follows:

1. Density and species composition of perennial grasses as measured on permanent line transects.

2. Utilization of perennial grasses by species as measured by the tuft-count method.

3. Herbage yields of perennial grasses by species as obtained by double sampling on 1' x 9.6' plots.

4. Herbage yields of annual grasses/obtained by double sampling as in (3).

5. Range condition as recorded by photographs from permanent transect locations.

6. Mesquite counts on permanent belt transects.

7. Stocking records by pastures.

8. Calf crops by pastures.

9. Individual and group photographs of cows and calves.

10. Kind and amount of supplement fed.

D. Analysis of data and sensitivity of tests.--From a statistical standpoint the study has weak spots. Only 4 pastures are involved with the major comparisons to be made between 2 cleared and 2 uncleared pastures. Differences between pastures as to soil type and livestock ownership also exist. For example, Brown's cattle are purebreds, but those belonging to Proctor and Ruelas are grades. Also, pastures 7 and 1 contain a higher percentage of "open" type soil than do pastures 8 and 10. These differences will obviously be confounded with those imposed by treatment, thereby reducing the chances for statistically significant treatment effects. In view of these obvious shortcomings in design, it seem unlikely that a simple analysis of variance using pasture totals or averages for any single year's data will prove to be "significant". However, the pooling of data from several observations may well provide valid tests. It may be possible, too, to isolate the effects of any consistent inherent differences among pastures or livestock herds by analysis of covariance. In this way, the contributions of initial or of inherent differences in such factors as grass density, herbage production, or cow weights can be calculated separately from treatment effects. However, it is apparent that because of differences in quality of cattle and methods of management among cooperators there is very little likelihood of obtaining significant outcome data on livestock.

The basic analysis of variance for pasture means for variables listed in paragraph IV C is:

Analysis I

Source of Variance Degrees of Freedom

Blocks 1

Years 9

Treatments 1

Blocks x Years 9

Blocks x Treatments 1

Discrepancy 9

To test the sensitivity of Analysis I, a set of data having prescribed characteristics was drawn from a table of random numbers. This was done by establishing an arbitrary range of values for each pasture and drawing 10 random numbers within that range for use in a trial analysis. The ranges of values used for pastures 1, 7, 8, and 10 were 125-700, 95-500, 60-190, and 40-200, respectively. Pasture means turned out to be 392.0, 269.1, 144.3, and 110.7. The analysis of these sample data showed that differences between treatments were not significant but that interactions of treatment with blocks and with years were significant at the 1 percent level. Differences between years and between blocks were not significant. The test used in each was that of dividing the mean squares of the main effects (i.e. treatments, blocks or years) by the mean squares of appropriate first order interactions. The variances of first order interactions in turn were tested against the mean-square for discrepancy.

There may be some question as to whether it is desirable to set up the analysis to test for "Block" differences in the manner indicated. However, the known differences between pastures and livestock operators between the two pairs of pastures seem to warrant such treatment.

The basic analysis for variables 2, 3, 5, and 6 listed in paragraph IV-C, is shown below as Analysis II. However, the basis of this test is such that a "significant" test applies to these pastures only and cannot imply that other pastures would behave similarly if similarly treated.

Such an analysis for a single year might be:

Analysis II

Source of Variance Degrees of Freedom

Treatments 1

Blocks 1

Treatments x Blocks 1

Error 76

Total 79

The above analysis assumes 20 samples within each pasture without stratification as to soil type, distance from water, degree of slope, or other apparent within-pasture variations.

The replication within pastures for variables 2, 3, 5, and 6 will permit relatively sensitive intermediate analysis after only 1 or more years' data are collected.

For example, after a 10 years' observation the following type analysis can be made on the line transect data:

Analysis III

Source of Variance Degrees of Freedom

Blocks 1

Years 9

Blocks x Years 9

Treatments 1

Treatments x Blocks 1

Treatments x Years 9

Treatments x Blocks x Years 9

Reps. Within pastures (transects) 76

Error 684

Total 799

A preliminary analysis of perennial grass density data for 1956 shows a significant block-treatment interaction but no significant differences attributable to either block or treatment alone. Failure of the main effects (block and treatments) to be additive in this first set of data is a good indication of the lack of similarity among pastures. However, if year-to-year change rather than totals are subjected to analysis it should be possible to determine significant effects even from a single year's data. Sample calculation for Analysis I and II are included as pages 23 to 26 in the appendix [not included in digital file].

V. Presentation of Expected Results

A. Audience and organ.--This study should be provide information that will be useful to ranchers throughout the range of velvet mesquite. When completed, the results of the study will be considered for publication as a USDA circular or bulletin. Intermediate results can be released as station notes and through appropriate livestock journals.

B. Form in Which data will be presented.--The complete results of the study will first be summarized in tables which list pasture totals or means by years. One such table will be prepared for each type of data taken. Depending on the outcome of the study, pertinent summary type data from these tables will be recombined into less complicated tables which will be used to supplement the text of the final report. Other data will be used as the basis for graphs or charts to illustrate the text. Finally, it is hoped that some of the pictures taken during the course of the study can be used to add interest and meaning to the final report and publication.

VI. Responsibility and Cost

A. Assignment.--Bohning, Martin, and field assistants.

B. Estimated cost for 10-year study:

1. Manpower

Field Assistants 4 wks/yr $2700.00

Technical (field) 5 wks/yr 7250.00

Technical (office) 4 wks/yr 5800.00

Clerical 2 wks/yr 1350.00

Labor (field) 1 wks/yr 680.00

2. Materials

Photography supplies 150.00

Automotive Expense 600.00

Plot stakes 40.00

Witness posts 60.00

Total 18,630.00 (1)

(1) This tabulation does not include the cost of clearing pastures 1 and 7 of mesquite. A very crude cost estimate for the clearing job would be around $5,000.

C. Time of completion.--The study is scheduled to run 10 years and will be completed in 1967 or 1968.

APPENDIX

A. Location and Description of Study Area

The study will be conducted on the Santa Rita Experimental Range using pastures 1, 7, 8, and 10 (fig. 1, p. 23a [not included in digital file]). Because of location and differences in grade of livestock, pastures 7 and 10 are considered as Block I and pastures 1 and 8 as Block II.

B. Selecting and Marketing Transects

Transects in each pasture will be located at random within strata. Transect locations will be marked by using a steel fence post for a witness post near the 0 (zero) end of each transect. Transects will be 100-feet long with permanent steel stakes at each end and at two or three intermediate points. The location of each transect will be indicated by compass bearing and direction from marked iron witness stake along the nearest road (figs. 2 and 3, p. 26b and 22c [not included in digital file]).

C. Treatments

The major treatments affecting vegetation and livestock are mesquite control and grazing management.

1. Mesquite control.--The mesquite-control treatment will consist of killing all mesquite in pastures 1 and 7 with diesel oil but leaving the mesquite alone in pastures 8 and 10.

2. Grazing management.--All pastures will be grazed on a flexible basis. Each pasture will be deferred during the growing season (July-Sept.) In alternate years. Cattle numbers will be adjusted each fall in accordance with the production of perennial grasses. The average utilization objective for perennial grasses will be 40 percent. Actual use may range from 30 to 50 percent.

a. Method for adjusting livestock numbers:

(1) Determine total amount of perennial grass herbage by forage survey.

(2) Multiply total for perennial herbage by 0.40 to determine amount of usable herbage--or forage.

(3) Determine average daily disappearance of perennial grass herbage per animal unit day from past records of forage production, actual stocking, and utilization on each pasture.

(4) Divide "total usable herbage" (item 2) by "average daily disappearance" (item 3) to determine total animal days forage.

(5) Divide "total animal days" by the number of days remaining in the grazing year to determine the number of animal units.

b. Schedule and plan of deferment:

(1) Pastures 7 and 8 in 1957, 1959, 1961, 1963 and 1965.

(2) Pastures 1 and 10 in 1958, 1960, 1962, 1964, and 1966. All cattle will be removed from the pastures during July, August, and September of the deferment years.

To accomplish this:

(1) Cattle from pasture 1 into 2S, 4, or 12A

(2) Cattle from pasture 7 into 6A.

(3) Cattle from pasture 8 into 2S, 4, or 12A.

(4) Cattle from pasture 10 into 9 or to National Forest.

D. Instructions for Taking Data

1. Photographs.--Photographs will be used to secure data on apparent changes or differences in vegetation and livestock. The photographic record will help round out the story on items 2, 3, 4, 6, and 8, as listed under paragraph IV-B (variables under test).

The photographic record of vegetation changes will consist of one photograph taken from the 0 (zero) end of the transect of from a designated "footmark" along the line. All photo stations will be photographed at the beginning of the study and at the end. In intervening years, every fourth photo station will be re-photographed. Thus, plots 1, 5, 9, etc., will be retaken every year.

The photographic record of cattle condition will be made up of pictures taken at each roundup. The following types of pictures are suggested.

a. A group of cows taken looking down on cattle from horseback or corral fence, to show general condition of the group.

b. A group of calves.

c. One or more of the wet cows that are in best condition.

d. One or more of the wed cows that are in poorest condition.

e. Typical cow and calf.

All pictures will be taken on 4x5 black and white film. Prints and negatives will be appropriately labeled and filed with other data in the study file.

2. Line transects.--Line transect measurements will provide data primarily for variable 3. Line transect data will be recorded on the regular Santa Rita line transect record form (page 12a [not included in digital file]). For each grass tuft or shrub intercepted, both the distance from 0 (zero) and the length of intercept will be record.

In laying out permanent line transects the tape is placed against the right hand side of the stakes as the observer stands at the 0 (zero) end and looks toward the other end of the line. The 0 (zero) mark of the tape is placed at the 0 (zero) stake. The tape is then stretched as close as possible to the ground in a straight line from the 0 (zero) stake to the outer stake. On 100-ft lines it is helpful to put intermediate stakes at the 33- and 67-ft marks, or at 25, 50, and 75 feet to aid in re-establishing the line. Where intermediate stakes are used the tape is placed against the right hand side of all stakes.

After the tape is pulled straight and fastened at both ends the vertical intercept of perennial vegetation is measured and recorded. In the following instructions the letter in parenthesis refers to a longhand letter on the attached sample "line transect record". Each item letter is followed in order by the item name as it appears on the form, then by underscored words indicating the kind of data to be entered and finally by the explanation of what is to be recorded and how.

Data to be Recorded on the "Line Transect Record"

(Identification Data)

(a) Study-title.--Enter brief title of study or project

(b) Pasture-number.--Enter number of pasture in which transect is located.

Plot "number" or "none".--Enter number of plot on which transect occurs, or if there is no plot number involved enter the word "none".

(d) Transect-number.--Enter number of transect.

(e) Date-day-month-year.--Enter date of observation listing day first, month second, and year third.

(f) By-initials.--Enter initials of observers. Record initials of observer first, recorder second.

(Data on Perennial Grasses)

(h) Intercept (.01 ft.)-lengths of intercepts.--Enter as a whole number length of each intercept in 0.01 ft. Each species is to be recorded separately opposite the proper symbol. Separate individual measurements by dashes. The intercept of perennial grasses is measured at the ground line. Only the live rooted portion of the tuft is measured. The smallest unit of measurement is 0.01 ft.

(I) Intercept (.01 ft.)-total by species.--Record total intercept for each species.

(j) Grass species-symbol.--Enter species symbol for any perennial grass that intercepts the line and whose symbol is not listed on the form.

(k) Intercept (.01 ft.)-total all spp.--Compute and record total intercept of all perennial grasses.

(Data on Shrubs)

(m) Intercept (.01 ft.)-lengths of intercepts.--Record length (in .01 ft.) of live crown intercept as a whole number. Measure entire live crown intercept but do not include conspicuous openings or areas of dead crown.

(n) Intercept (.01 ft.)-totals by spp.--Enter total intercept for each shrub species.

(o) Shrubs-symbol.--Record symbols for species that are intercepted but not listed.

(p) Intercept (.01 ft.)-total all spp.--Enter total intercept for all shrub species.

Line transect data will be taken in 1957, 1958, and 1959, and in 1964, 1965, and 1966, preferable in late August or early September.

3. Utilization estimates.--Utilization estimates will provide data on "variable" 8 and will serve as a rather coarse check on the reliability of herbage estimates for adjusting cattle numbers to meet the stated use objective.

Utilization checks using the tuft-count method will be made annually on the 100' x 200' plot surrounding each transect.

The paced-transect method of sampling will be used to select tufts on which utilization is to be observed. At the end of each full pace the perennial grass tuft nearest the left (or right) toe will be observed for utilization. If no grass tuft occurs within about two feet of the toe another pace will be taken, etc., until 100 tufts have been observed. The paced transects will be run parallel to the line transect at intervals of 15 to 20 feet. Since the vegetation is very sparse on some parts of the study area, several parallel courses across the plot will be necessary in order to encounter 100 suitable perennial grass tufts. Grass tufts that are beneath shrubs or entangled in them will not be used in determining utilization because they are not readily available for grazing.

The 100 tufts in the utilization sample will be recorded on the "Utilization Record" by species and class of grazing use. In the following instructions for using the "Utilization Record" the letters in parenthesis refer to pen and ink letters on the attached sample form (page 16a [not included in digital file]). Item letters are followed in turn by the item name as it appears on the form, then by underscored words indicating the kind of date to be entered and finally by an explanation of how the data is to be obtained.

Data to be recorded on the "Utilization Record"

a. Study-title.--Enter brief title of study. In this case enter "Mesquite vs. Cleared".

b. Pasture-number.--Enter number of pasture in which data is taken.

c. Plot-number.--Enter number of plot.

d. Transect-number.--Enter number of transect.

e. Date-day-month-year.--Enter date data is taken in the order day-month-year.

f. By-initials.--Enter initials of observer.

(Data on Utilization)

g. Plants grazed-tally.--Record by tally opposite the proper species symbol each grass tuft is grazed. Specific names for the symbols listed are typed in on the sample form.

h. Plants grazed-total by spp.--After transect is completed enter total numbers of grazed plants by species.

I. Plants ungrazed-tally.--Record by tally opposite the proper species symbol each perennial grass tuft that is in the open but is ungrazed.

j. Plants ungrazed-total by spp.-After transect is completed, enter total number of ungrazed plants of each species.

k. Spp.-symbol.-If necessary, write in symbols for species not listed on form.

l. Plants grazed-total all spp.-Determine and record total number of grazed plants.

m. Plants ungrazed-total all spp.-Determine and record total number of ungrazed plants.

(Data on Vegetation Frequency)

Vegetation frequency data, as taken in the regular Santa Rita Utilization survey, will not be taken in this study.

4. Herbage production.-Herbage production estimates will be used to supply data on variables (2) and (7). Herbage production estimates will be made annually at each transect location. The herbage production estimate at each location will consist of five individual estimates on permanent 1' x 9.6' plots located at the 10-, 30-, 50-, 70-, and 90-foot marks along the right hand side of a 100-foot tape stretched parallel to the line transect and 10 feet to the right of it as one looks along the transect from the 0 (zero) end. A sixth plot will be estimated, then clipped, to provide a basis for adjusting ocular estimates. Plots to be clipped will be those located along the left side of the tape. The schedule calls for clipping the 0-9.6' plot in 1957, the 20-29.6 plot in 1958, the 40-49.6 plot in 1959; 60-69.6 in 1960; 80-89.6 in 1961; 10-19.6 in 1962; 30-39.6 in 1963; 50-59.6 in 1964; 70-79.6 in 1965; 90-99.6 in 1966; 0 - 9.6 in 1967; 20-29.6 in 1968. All herbage estimates will be made as soon as possible after the close of the summer growing season.

In the following instructions for use of the "Herbage Production Record" the letters in parenthesis refer to longhand letters entered on the attached sample form (page 18a [not included in digital file]). Item letters are followed in turn by the item name as it appears on the sample form, then by underscored words indicating the kind of data to be entered, and finally by an explanation of how the data is to be obtained.

Data to be recorded on the "Herbage Production Record"

(Identification Data)

a. Study-title.-Enter brief title of study.

b. Pasture-number.--Enter number of pasture in which observation is made.

c. Line-number.--Enter "line" or transect number.

d. Date-day-month-year.--Enter date of observation.

e. By-initials.--Enter initials of observer.

(Data on Yields of Perennial Grasses)

f. Estimated field weights-grams.--Enter estimated weight (to nearest gram) of each perennial grass species on each plot and record in appropriate cell. Portions of grass tufts that are protected from grazing by shrubs or cactus are not to be included in the herbage estimate. All herbage estimates for the first plot are to be recorded in column #1, for the second in column #2, etc. Species names for the symbols printed on the form are typed in on the sample.

g. Total by species-grams.--Total individual herbage estimates for each species and enter totals in "Total" column.

h. Clipped plot-number.--Enter number of plot that is clipped.

I. Actual weights (perennial grasses)-grams.--Record weights of herbage clipped (to the nearest gram) by species.

Perennial grasses will be clipped as close as possible to the ground line. Insofar as is practical, only the current season's growth will be collected. Most of the older dead material will be removed by (1) combing dead stems and leaves out of the tuft before clipping, and (2) shaking out short dead stubble after clipping by striking the base of the clipped herbage a few times with the shears.

Clippings of herbage from individual plots will be kept and accumulated until about 100 grams of herbage (field weight) of each class is available. These samples will be air-dried and reweighed to determine the dry weight factor for each herbage class.

j. Species-symbol.--Enter symbols for species that occur on the plots but which are not listed on the form.

k. Total-grams.--Compute and enter totals for all columns.

l. Avg. Green Wt.-grams.--Compute and record (in grams and tenths) the average yield (estimated field weight) of perennial grass per plot.

m. Avg. Dry Wt.-(perennial grass)-percent.--After the dry weight factor (item I) has been determined, multiply the average green weight (item l) by the dry weight factor to obtain the average dry weight of perennial per plot.

(Data on Annual Grasses)

n. Estimated field weights (annual grasses)-grams.--Add individual species estimates together and enter total amount for annual grasses.

o. Total estimated annual grasses-grams.--Add individual plot estimates together and enter total amount of annual grasses.

p. Actual weights and annual grasses-grams.--Enter field weight of annual grass herbage clipped from plot. Annual grasses are to be clipped as close to the ground as possible taking reasonable care to include only current year's growth (see items (h) and (I).

q. Average dry wt. (annual grasses)-number. Multiply total annual grasses (item o) by the appropriate dry weight factor for annual grasses (item m). Divide answer by number of plots to obtain plot average and record.

5. Mesquite tally.--The tally of mesquite will supply data for variable (6). The mesquite tally will be made on plots 100 feet wide x 200 feet long. Each plot will include one of the permanent line transects and will be so oriented that the line transect lies along the longitudinal axis of the plot midway between the end boundaries. One mesquite tally plot will be established at each line transect location. Plot corners will be marked by metal stakes at least 6 inches tall.

A complete tally of all mesquites on each plot will be made in the summer or late spring of 1957 or 1958 and 1966. The record for each mesquite will include its location, approximate height in feet, and approximate crown diameter in feet. Locations of mesquite will be established by stretching a 100-ft tape across the plot parallel to ends at points -25, 0, 25, 75, and 125 feet from the 0 (zero) end and recording the position by distance along the tape and the perpendicular distance (up to 25 feet) to the right or left.

E. Schedule of Field Work

1. Spring 1957--go over the plan in detail with cooperators.

2. Summer 1957--install 4 additional transects in pasture 8 to bring the total number up to 20 so that all pastures will have the same number of transects.

3. May-June, each year--check condition of livestock and take livestock photographs.

4. June each year--check utilization at each transect location.

5. Summer 1957 and 1966--make mesquite counts on all transect locations.

6. Summer 1957, 1958, and 1959 and 1964, 1965 and 1966 remeasure line transects.

7. September-October, each year--

a. Make forage estimates.

b. Take scheduled vegetation photographs.

8. November each year--take livestock photographs.

9. Monthly each year--check with cooperator on livestock records, supplemental feeding, precipitation, etc.

D. References

1. Glendening, George E., and Paulsen, Harold A. Jr., 1955. Reproduction and establishment of velvet mesquite as related to invasion of semidesert grasslands. USDA Tech Bul. 1127.

2. Martin, S. Clark. 1947. Controlling mesquite with diesel oil. Swn. For. & Range Exp. Sta. Res Note 115, Oct.

3. Parker, Kenneth W., and Martin, S. Clark. 1952. The mesquite problem on southern Arizona ranges. USDA Circ. 908, Oct.

4. Roach, Mack E. 1953. Controlling mesquite with diesel oil pays. Ariz. Stockman, pp. 16-17, Aug.