GRASS PRODUCTION CHANGES WITH MESQUITE (*PROSOPIS JULIFLORA*) REINVASION IN SOUTHERN ARIZONA

by

Patrick Thomas Williams

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SIGNED: Patrick T. William

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

S. Clark Martin
S. CLARK MARTIN
Professor of Range Management

April 29, 1976
Date

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ABSTRACT

Mesquite density crown cover, and grass production were used to evaluate the rate and effect of mesquite reinvasion at five study areas. The mesquite elimination study consisted of sixteen 1-acre plots of which eight were cleared of mesquite in 1940. The four thinning study areas each consisted of one control plot and plots where the mesquite was thinned to leave 25, 16, 9, or 0 trees per acre in 1945. Analysis of variance and regression analysis were used to aid in the evaluation.

All mesquite trees were counted. Crown cover was based on a sample of ten trees per acre. Grass production on the elimination study was determined by clipping four randomized belt transects (4" x 33') per plot. Grass production on the thinning study was determined by double sampling using ocular estimates on two 5-plot samples per 2-acre treatment plot. Herbage from one plot in each sample was clipped and weighed.

In the mesquite elimination study, more grass was produced in 1974 on the treated areas than on the untreated. In the mesquite thinning study, grass yields generally were negatively related to thinning density.

These results show retreatment following mesquite control is not needed for at least 30 years if all of the mesquites are killed by the initial control job. Retreatment would be needed sooner following the average mesquite control project where about half of the mesquites resprout vigorously soon after treatment.

INTRODUCTION

Southern Arizona ranges are an important natural resource, but these ranges are threatened by the spread or invasion of mesquite trees (Prosopis juliflora var. velutina) into non-infested areas. Mesquite is now found on about nine million acres of Arizona range and on 70 million acres in Texas, New Mexico, and Arizona, the three states with a mesquite problem (Parker and Martin, 1952).

Why is mesquite a problem? Before the arrival of Europeans and their livestock into the Southwest, the range of mesquite was restricted to stream courses and washes. Mesquite has spread since then because: (1) grazing reduces competition from grasses, giving mesquite a better chance to become established; (2) cattle aid in the dissemination of mesquite by ingesting mesquite beans and depositing seeds on the ground in their feces; and (3) grazing removes potential fuel for range fires that would kill many small trees and seedlings. The presence of mesquite is undesirable because: (1) it reduces livestock carrying capacity because of decreased forage production; (2) increases cattle handling costs, if dense; and (3) increases erosion (Parker and Martin, 1952).

Mesquite has some positive aspects: it provides habitat for wildlife and shade for cattle; the wood is excellent firewood and is used for fence posts. Mesquite is difficult to control because the larger trees are fire resistant and dormant buds below ground level sprout vigorously if the top-wood is killed. Several methods of mesquite control have been developed, none of which rids the range of mesquite permanently.

Some methods kill most of the top-wood and leave half or more of the root systems alive. Others kill most of the large trees but leave the small plants. Regardless of the method used, reestablishment of new mesquite plants from seed already in the soil or from seeds carried in by animals is to be expected. Without followup, any area where mesquite is killed or removed eventually will be occupied by mesquite again.

A prime question for the rancher who implements a mesquite control program is, how soon should each area be retreated? To answer this question, I determined the size, crown cover, and number of mesquite and estimated gradd production on areas where mesquite was controlled in 1940 and 1945 and in adjacent undisturbed stands.

LITERATURE REVIEW

Humphrey (1953) considered the desert grassland a fire subclimax that becomes dominated by low trees, brush, and cacti in the absence of fire. That the desert grassland is becoming shrub-infested is documented by Hastings and Turner (1965), who attribute vegetation change to cattle, rodents, fire suppression, and climate. Brown (1950) cited two mesquite invasion theories: fire control and grazing. Evidence of rodent dissemination of mesquite is reported by Reynolds and Glendening (1949). Another factor aiding in mesquite establishment is its seeds. Mesquite seed have germinated after 50 years in storage and after 10 years in the soil (Tschirley and Martin, 1960).

Tiedemann (1970) found that soil under mesquite canopies was more fertile than soil between the trees and that native perennials did better in this "mesquite" soil. Martin (1947) found that the presence of mesquite reduced soil moisture and that elimination of mesquite made more water available for grass production.

Glendening and Paulsen (1955) found several characteristics that favor mesquite seedling establishment: (1) an abundance of long-lived seeds, well disseminated by animals; (2) high germination rate under a variety of climatic conditions; (3) rapid root development; and (4) dormant buds sprouting after injury or death to the top.

Martin and Cable (1974) reported on some positive aspects of mesquite. The leaves are a source of protein for cattle, especially from April to July when the grasses are not active and the bean is a good feed. But mesquite is a low producer and an inefficient user of water compared to perennial grasses.

Claveran (1967), Cable (1959), and Blydenstein (1957) all state that fire does not effectively control large mesquite (6 inch trunk diameter) trees. Claveran (1967) suggests that fire be used for more recently invaded range. Cable (1959) pointed out that drought had little effect on mesquite and Meril (1964) found that drought killed larger trees, but that young or many-stemmed trees survived. And Cable and Tschirley (1961) achieved a 58% mesquite kill (5 years after treatment) with 2,4,5-T.

Lehmann lovegrass (*Eragrostis lehmanniana*) is now present on the Santa Rita Experimental Range. Williams (1964) and Martin and Cable (1962) reported that this grass did not form dense, almost pure stands, on sites with less than 13 inches of rain per year. Cable (1965) found that Lehmann lovegrass provided enough fuel to kill 25% of the mesquite but that black grama (*Bouteloua eriopoda*) didn't carry a fire nearly as well.

Cotner (1963) discussed the economic aspects of long-term resource improvements and decision making with respect to juniper control. He recognized that several years benefits may be needed to pay for the treatment and that retreatment is often needed. He listed the variables to consider before venturing into resource improvements: (1) site potential -- physical and economic; (2) rate of depletion of resource; (3) rate of recovery following treatment; (4) discount rate; and (5) alternative treatments. He determined the optimum timing of control as when the rate of benefit increase is equal to the rate of cost increase.

DESCRIPTION OF STUDY AREAS

Areas used in old mesquite control studies were evaluated in this study. Throughout this paper they are called (1) the mesquite elimination study, and (2) the mesquite thinning study.

Location

The study areas are located on the Santa Rita Experimental Range of the Rocky Mountain Forest and Range Experiment Station, U. S. Forest Service, which is about 35 miles south of Tucson, Arizona. The mesquite elimination study is located in the NW1/4 of Sec. 1, T19S, R14E. The four study areas of the mesquite thinning study are located at: Study Area A -- SW1/4 of Sec. 18, T19S, R15E; Study Area B -- SE1/4 of Sec. 11, T19S, R14E; Study Area C -- NE1/4 of Sec. 4, T19S, R14E; and Study Area D -- SW1/4 of Sec. 29, T18S, R14E (all are of the Gila and Salt River Base and Meridian). Forest Service designations for these areas are listed in Appendix A.

Vegetation

The study areas are located on desert grassland with an abundance of mesquite and, on the mesquite elimination study, an abundance of cacti -- mostly prickly pear (Opuntia englemannii) and jumping cholla (Opuntia fulgida) and barrel cactus (Ferocactus wislizenii). Mesquite is the most abundant tree present. Others are: blue palo verde (Circidium floridium) and catclaw acacia (Acacia greggii). Of the shrubs, desert hackberry (Celtis pallida), desert zinnia (Zinnia pumila), false mesquite (Calliandra eriophylla), burroweed (Haplopappus tenuisectus), and others are present on the sites. Forbs found in the area include devils-claw (Proboscidea arenaria), deadly nightshade (Solanum sp.) and others.

Some of theprinciple perennial forage grasses are Arizona cotton-top (Trichachne californica), black grama, rothrock grama (Bouteloua rothrockii), sideoats grama (B. curtipendula), cane beardgrass (Andro-pogon barbinodis), Lehmann lovegrass, plains bristlegrass (Setaria macrostachya), Santa Rita three awn (Aristida glabrata), tanglehead (Heteropogon contortus), and wolftail (Lycurus phleoides). The scien-tific names for the vegetation are from Kearney and Peebles (1969).

Climate and Topography

The topography of the Santa Rita Experimental Range is typical of Sonoran Desert Grassland (Environmental Zone 41D3) as defined by the Arizona Interagency Range Technical Subcommittee (1973). The range is characterized by gently to strongly sloping, dissected old alluvial fans, ranging in elevation from 3,000 to 4,100 feet. The annual mean precipitation range is from 11 to 18 inches, with 63% of the rain coming between June and September. The summers are hot and the winters mild. All study areas are level to gently sloping.

The elevation of the mesquite elimination study is about 3,800 feet and the average annual rainfall is about 14 inches (Parker and Martin, 1952). The four study areas (designated A, B, C, and D) of the mesquite thinning study differed in elevation, rainfall, and mesquite density as shown in Table 1.

Table 1. Initial stand of mesquite, elevation, and precipitation at the four thinning study areas[a].

Study Area	Mesquite/acre Original stand	Elevation (approx.)	Average annual precipitation
	- - number - -	- feet -	- - inches - -
A	358	4,100	17.45
B	138	3,900	14.75
C	164	3,600	13.39
D	44	3,300	12.80

a. Source for this table is Parker and Martin (1952).

The dense, rocky subsoil on Study Area A distinguishes it from the other three study areas, and, consequently, the mesquite on Area A, though numerous, are not as large as on the other three areas.

Grazing Use

The mesquite elimination study area is located in a pasture that was grazed year-long prior to 1971, when the pasture was included in a three-pasture rest-rotation grazing system.

On the mesquite thinning study, Study Area A was grazed year-long until 1957, received alternate-year summer deferment until 1971, and has been grazed year-long since. Study Area B has always been used as a holding trap and usually has been grazed quite heavily but only in October and November each year. Study Areas C and D were grazed year-long prior to 1957, from May to October only from 1958 to 1971, then were included in a three-pasture rest-rotation grazing system in 1972 (data on file at the Rocky Mountain Forest and Range Experiment Station, Tucson, Arizona).

Design

The mesquite elimination study area was established in July, 1940. Sixteen one-acre plots were layed out in a Latin square design with four treatments: no treatment, all mesquite killed, all burroweed killed, and both mesquite and burroweed killed (Figure 1). The effects of burroweed elimination on grass density was only temporary (Parker and Martin, 1952), increasing grass density significantly only one year following grubbing. For purposes of my study, burroweed elimination was ignored and the eight plots with mesquite killed were compared with the eight untreated plots. Mesquite trees that were on the untreated plots

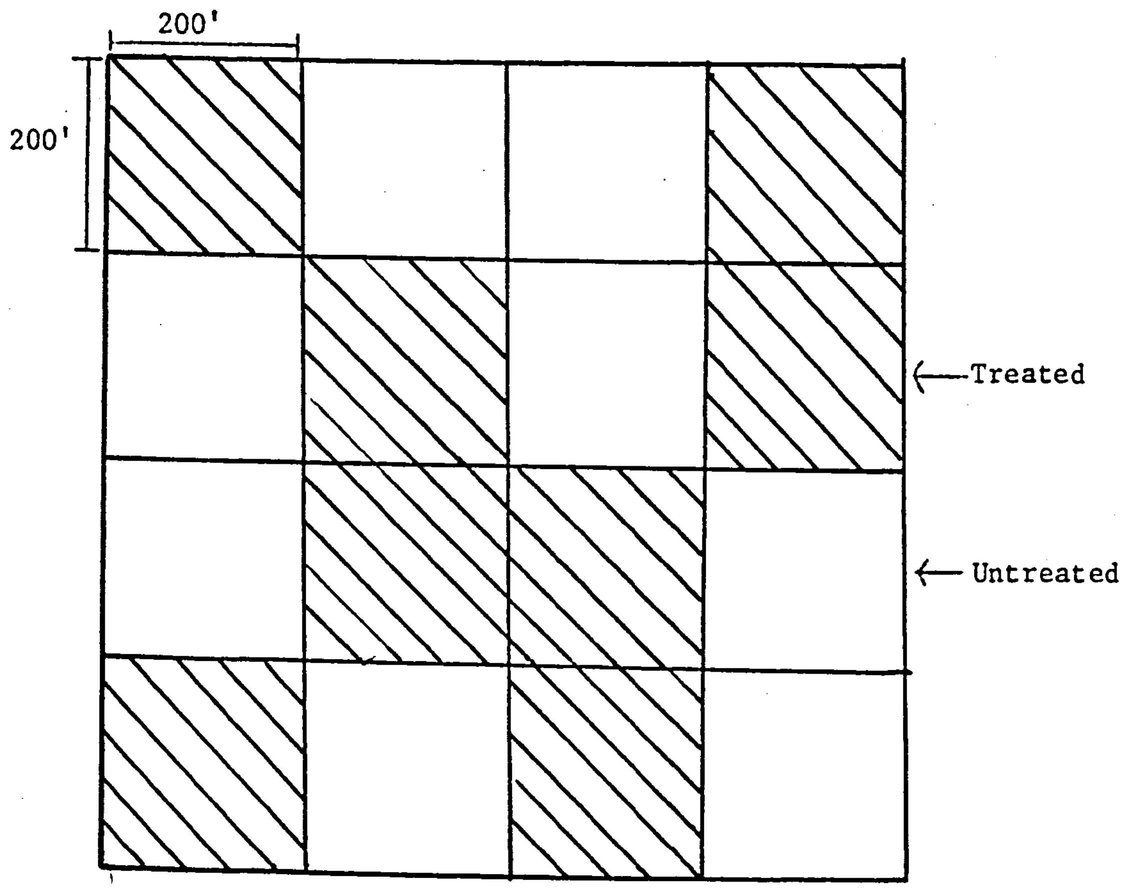

Figure 1. Arrangement of treated (mesquite killed in 1940) and untreated plots in the mesquite elimination study.

in 1940 are referred to as originals and those that have become established since the 1940 treatment as invaders.

The four mesquite thinning study areas were originally treated in the spring of 1945. The mesquite trees were cut for firewood by German prisoners-of-war (being held at Continental, Arizona) and the stumps were killed with diesel oil or sodium arsenite. Each study area consists of five two-acre plots, one of which was left unthinned. One each of the other four plots was thinned to leave 25, 16, 9, and 0 trees per acre, respectively (Figure 2).

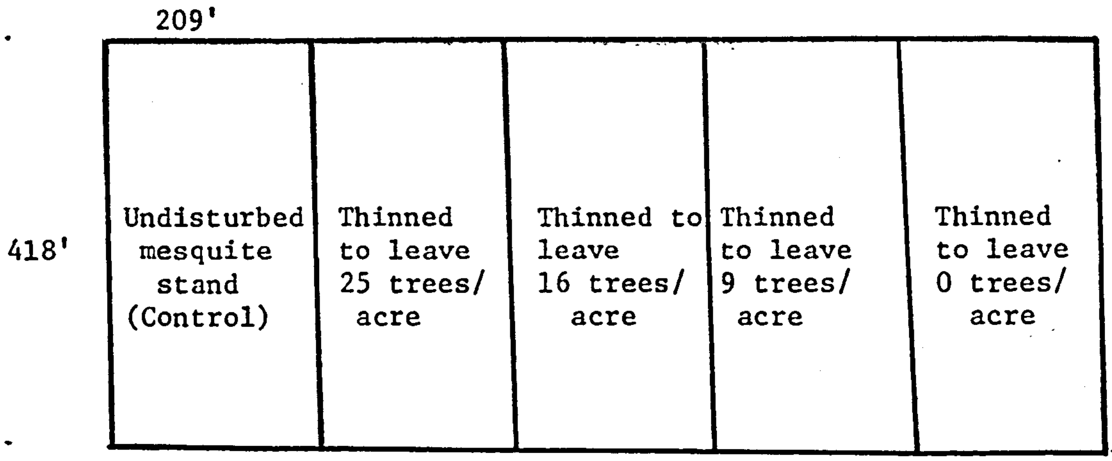

Figure 2. Arrangement of plots in the four areas of the mesquite thinning study.

METHODS

Plant count and crown cover data on mesquite were gathered in June, July, and August, 1974. Grass production was measured in October and November, 1974.

Mesquite Elimination Study

Number of Mesquite Trees Per Acre

Each plot was set off by string and every tree was counted. The original pre-treatment count was done in 1940, after which the mesquite on half the plots were killed.

Percent Crown Cover

A random sample of ten trees per plot was measured. Two crown diameter measurements were taken on each tree. The average of these two diameter measurements was used to compute crown area. On the untreated plots, crown diameter was measured only on the original trees and on the treated plots, on the invader mesquite. The average sizes of invader mesquite were assumed to be the same on treated and untreated plots. The mean crown area per tree of original and invader trees for each plot was computed and multiplied by the number of trees in each class to determine percent crown cover.

Grass Production

The sampling of grass production on the mesquite elimination study area was done in 1974 as it was in 1940-48. All production measurements were taken inside a tenth-acre sampling plot (33 x 132') centrally located within each acre-sized treatment plot (Parker and Martin, 1952). Four randomized belt transects (4" x 33') per plot were clipped and weighed in the fall after the summer growing season. All samples were weighed again when air-dry yields were then computed.

Mesquite Thinning Study

Number of Mesquite Trees Per Acre

A complete mesquite census was taken of the four study areas. The individual plots were set off by a string and every mesquite within each two-acre plot was counted. The average number of mesquite trees per acre per thinning treatment was computed.

Percent Crown Cover

Two groups of mesquite were measured for crown cover in the thinning study, just as in the elimination study. Crown diameter was measured on the original trees on the no treatment, 25, 16, and 9 trees per acre plots. Crown diameter measurements were taken for the invaders on all plots except for the untreated. Twenty trees were measured on each plot for both original and invader trees except for originals on the 9 trees per acre plots, where only 18 mesquite were available. The crown area of each tree was determined using the average of two diameter measurements. The mean crown area per acre and percent crown cover were then computed for each plot. Invader mesquite diameters on the untreated plots were assumed to be the same size as on the treated plots.

Grass Production

Grass production data on the mesquite thinning study areas were determined by regression adjusted ocular estimation (Wilm, Costello and Klipple, 1944). Two samples of five 9.6 square foot subsamples were taken on each two acre plot. Grass production was estimated by species and on one of the five subsamples grass was clipped and weighed for regression and dry weight determination. Regression constants are listed in Appendix B.

Statistical Analysis

The analysis of variance for both the mesquite thinning and the mesquite elimination studies (Table 2) uses a one-way classification with equal replication (Steel and Torrie, 1960). The treatments were considered to be fixed and the samples within treatments as random variables. This analysis was used for grass production and mesquite crown cover in both studies as well as for mesquite numbers in the mesquite elimination study. Grass production data from each area in the mesquite thinning study were analyzed separately using two samples per thinning plot. Appendices B and C have the results of the analysis of variance and the regression analysis.

Table 2. Analysis of variance of the mesquite elimination and mesquite thinning study areas, including expected mean squares.

Source	Degrees of Freedom	Expected Mean Squares
Treatments	t - 1	$\sigma^2 + rT_i^2$
Samples within treatments	t(r - 1)	σ^2

RESULTS AND DISCUSSION

Mesquite Elimination Study

Surprisingly, the treated plots had more trees (248) per acre in 1974 on the average than did the untreated plots (193) (Table 3). Presumedly this is because mesquite seedlings on the untreated plots had to compete with mature mesquite trees for light, water, and nutrients; whereas seedlings on the treated plots did not.

Still, average crown cover on the untreated plots (32.8%) was four times greater than on the treated ones (8.4%) (Table 4). This is to be expected because all mesquites on the treated plots were established since 1940, and were smaller than the original trees on the untreated plots.

Total grass production was greater on the untreated plots (475 pounds per acre) than on the treated plots (326 pounds per acre) (Table 5). This difference was significant at the 10% level. Since the higher production plots had lower crown cover and no trees older than 34 years but more mesquites than the untreated plots, it is apparent that small mesquites do not greatly depress grass production. Crown cover was significantly lower on the mesquite killed plots than on the untreated plots, but differences in perennial grass production, total grass production, and the tree count were not significant (Appendix Tables C1-C3). Perennial grass production was greater on the treated plots for both the 1940-48 and the 1974 data (Table 5 and Figure 3).

Table 3. Numbers of mesquite per acre on the mesquite elimination study plots before the mesquite was killed in 1940 and in 1974.

	Treated Mesquite Killed		Untreated Mesquite Killed	
	1940[a]	1974	1940	1974
	88	135	73	159
	75	183	73	127
	118	319	97	221
	111	371	109	214
	145	277	138	269
	97	266	134	217
	120	117	201	182
	116	317	134	151
Average	109	248	120	193

Table 4. Mesquite crown cover and average crown area per tree on the mesquite elimination study before the mesquite was killed in 1940 and in 1974.

	Treated-Mesquite Killed			Untreated-Mesquite Alive		
	Crown Cover		Average Crown Area-1974	Crown Cover		Average Crown Area-1974
	1940[a]	1974		1940	1974	
	- - percent - - -		square feet	- - percent - -		square feet
	12.1	6.9	22	8.4	26.2	72
	10.6	6.3	15	10.8	22.2	76
	13.0	7.7	11	8.5	20.3	40
	14.9	10.7	13	14.2	26.5	54
	18.4	10.4	16	13.2	29.9	48
	16.5	10.0	16	23.8	48.2	97
	12.0	2.7	10	22.9	65.9	163
	25.7	12.2	17	21.6	23.0	66
Average	15.4	8.4	15	15.4	32.8	77

a. Number before treatment -- no live mesquite in the fall, 1940.

Table 5. Grass production per acre in 1974 (pounds) on treated and untreated plots of the mesquite elimination study.

	Treated				Untreated			
	Annual Grass	Native Perennial Grass	Lehmann Lovegrass	Total Grass	Annual Grass	Native Perennial Grass	Lehmann Lovegrass	Total Grass
	44	192	17	253	17	176	35	228
	94	177	211	482	50	203	257	510
	24	192	74	290	9	179	56	244
	15	292	63	370	61	142	98	301
	44	307	190	541	2	386	61	449
	24	106	443	573	9	319	185	513
	102	268	227	597	0	61	28	89
	70	384	235	689	13	107	113	233
Average	53	239	183	475	25	197	104	326

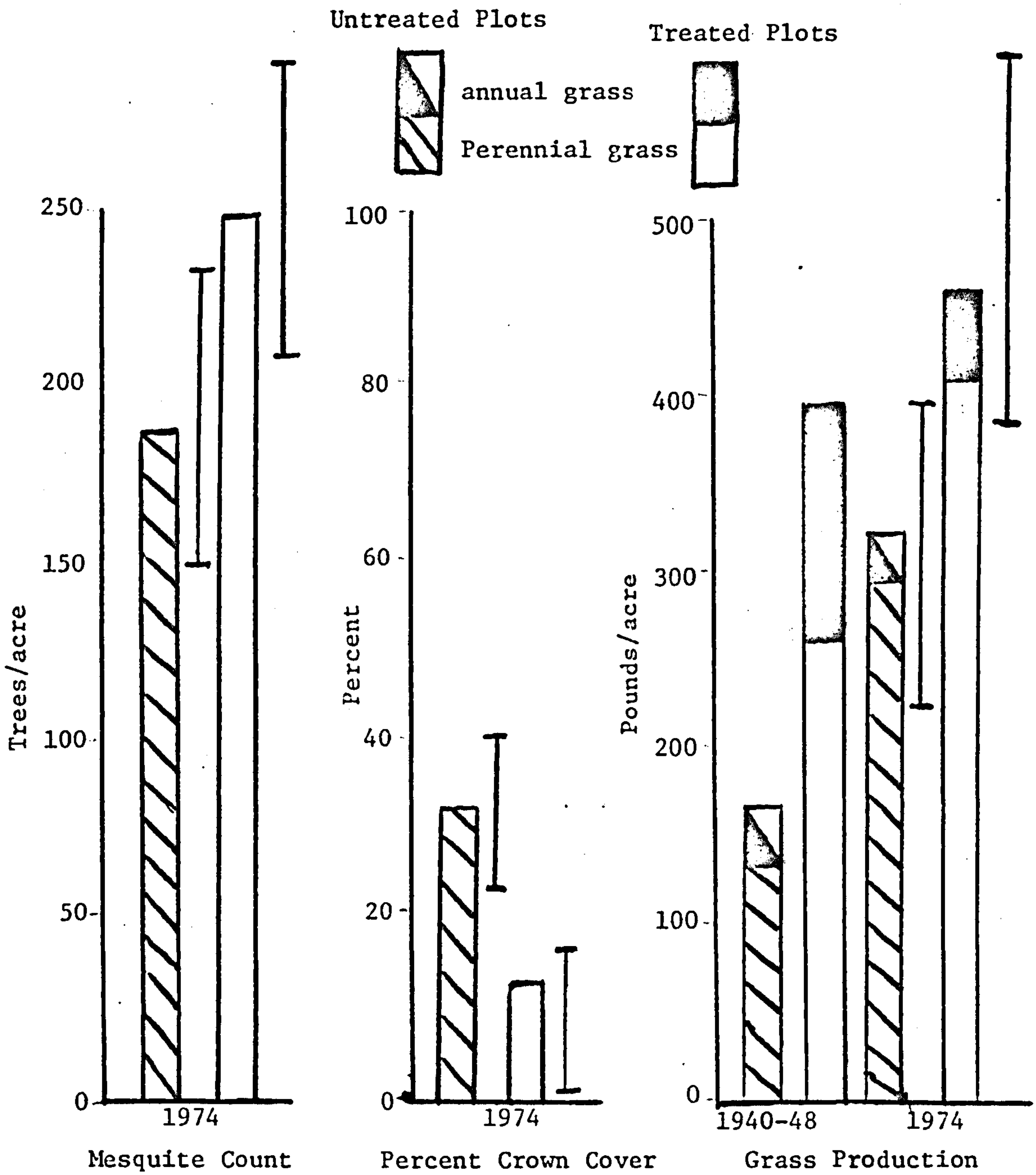

Figure 3. Mean values and 95% confidence intervals for tree count, percent crown cover, and grass production for the mesquite elimination study.

There was more native perennial grass and Lehmann lovegrass produced on the treated plots than on the untreated (239 and 183 pounds per acre, respectively for treated versus 197 and 104 pounds per acre, respectively for the untreated plots). More native perennial grass was produced on the average than Lehmann lovegrass in both treatments. This area was not seeded to Lehmann lovegrass so this grass has had to reach here through natural dissemination.

It is not the number of mesquite, but rather the size of the trees that makes a difference insofar as grass production is concerned -- the larger the mesquite, the more it competes with grasses. Crown cover has been shown to be indicative of overall mesquite size.

Mesquite Thinning Study

All mesquite plants on the four study areas were counted. In a sense, the four study areas constitute replications at sites differing in elevation, soil, and rainfall. Study Area A, which had the highest rainfall and elevation, had the greatest number of mesquite (Table 6). With one exception, mesquite counts were higher in 1974 than in 1945. The 1974 tree count of the untreated plot on Study Area C was 132 in 1974 compared to 164 in 1945. Since no dead mesquite were found on the area, it is assumed that the 1945 count was wrong. Mesquite numbers increased less on untreated plots than on the thinned plots at all four areas (Table 6). The thinned plots at Area A had gained most in population. But, the original trees on this area were smaller than at the other study areas.

Table 6. Number of trees per acre, invaders per acre, percent crown cover, and crown area per tree on the mesquite thinning study in 1974.

Area	Trees left per acre in 1945				
	All	25	16	9	0
Number of Trees per Acre in 1974					
A	358	148	188	147	172
B	138	73	37	34	46
C	132	47	83	72	85
D	44	67	82	95	88
Number of Invaders per Acre in 1974					
A	10	123	172	138	172
B	2	48	21	25	46
C	0	22	67	63	85
D	18	42	66	84	88
Percent Crown Cover in 1974					
A	84.3	12.8	12.3	8.1	2.8
B	17.6	8.4	5.7	4.3	0.5
C	52.3	12.9	12.3	5.3	2.4
D	22.3	11.3	12.5	6.8	2.6
Crown Area per Invading Tree (sq. ft.) in 1974					
A	8.3[a]	9.9	7.5	8.7	7.0
B	6.2[a]	3.0	5.9	6.2	9.8
C	7.3[a]	3.5	5.9	7.5	12.1
D	10.6[a]	4.7	14.1	10.8	12.8

a. Average of invader trees of other four plots.

The crown cover data show that the mesquite crown cover on the plots thinned in 1945 was still less than on untreated plots thirty years later. However, there was no difference between the untreated and treated plots in crown area per invading tree. The percent crown cover of the no treatment plot of Study Area A (84.3%) is extremely high. On the other hand, crown cover of the 0-trees per acre plot of Study Area B (0.5%) seems very low due in part to a fire that top-killed many of the small mesquite.

Grass production data for the years 1946-50, 1958, and 1974 are shown in Figure 4. Analysis of variance tables for 1974 grass production data appear in Appendix Tables C4-C11. The Lehmann lovegrass was seeded on a 66-foot wide strip across one end of each plot in July, 1945, just before the start of the summer rainy season (Parker and Martin, 1952). Lehmann lovegrass apparently competes better with mesquite than do the native perennials, especially on the higher rainfall areas (A and B). Lehmann lovegrass has spread entirely over these two study areas and is producing high yields even on the untreated plots (Tables 7 and 8). Lehmann lovegrass has not done quite as well on the lower, dryer sites (C and D) as on the more favorable sites. Here the native perennials appear to be holding their own in competing with Lehmann lovegrass rather than being crowded out as on the higher study areas.

With only one exception, thinned and clearcut plots outproduced the untreated plots on each study area (Figure 4). Among thinned plots, too, yields were generally related negatively to the number of mesquite although there were inconsistencies. The data generally supported the

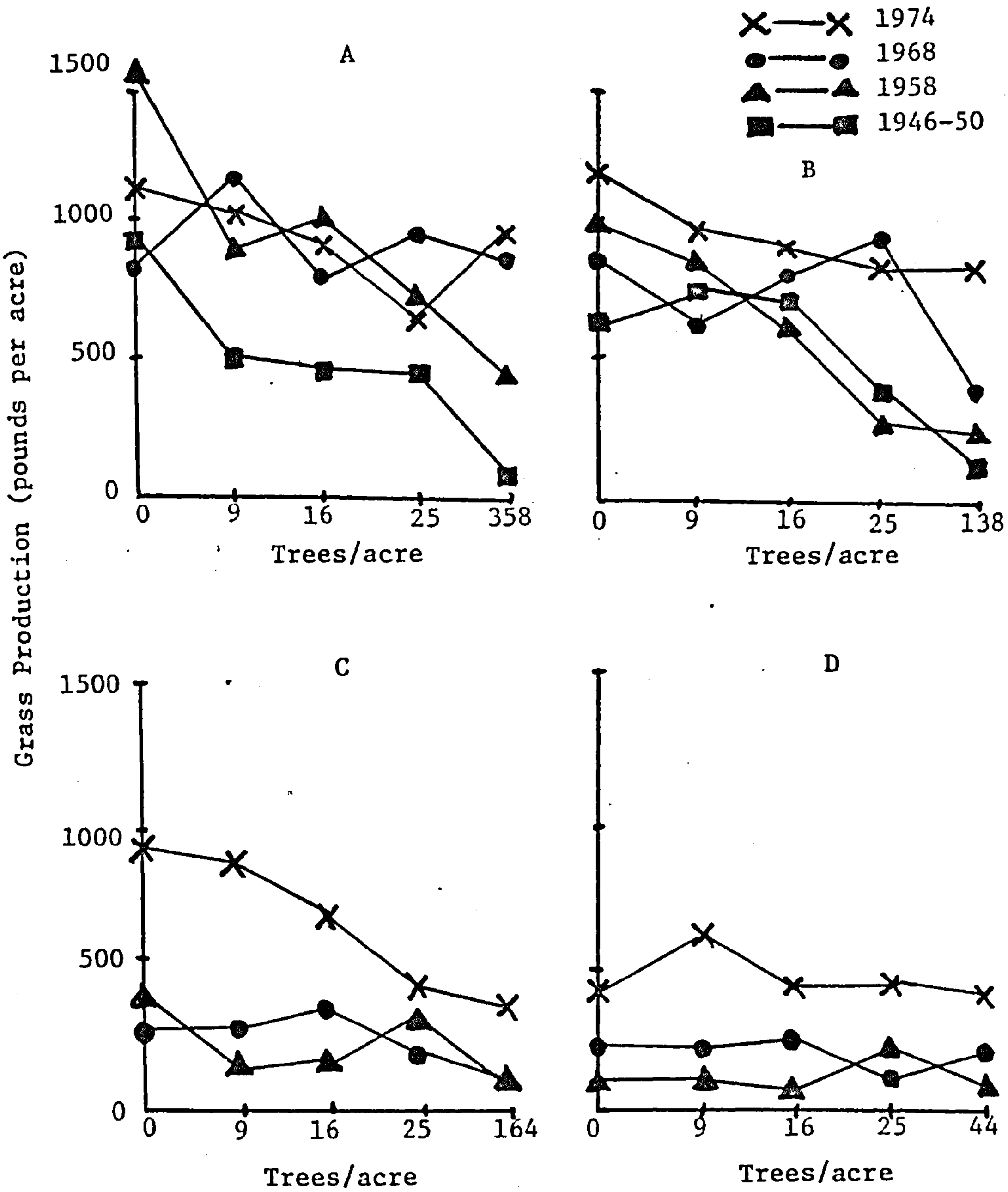

Figure 4. Grass production by thinning treatment for 1946-50, 1958, 1968, and 1974 (native perennials and Lehmann lovegrass).

Table 7. Total grass production per acre (pounds), including Lehmann lovegrass, on the mesquite thinning study in 1974.

Area	Trees Left per Acre in 1945				
	All	25	16	9	0
A	835	726	902	1096	1131
B	742	832	877	973	1127
C	310	397	632	837	845
D	355	413	421	591	452

Table 8. Native perennial grass production per acre (pounds) on the mesquite thinning study in 1974.

Area	Trees Left per Acre in 1945				
	All	25	16	9	0
A	43	80	21	168	197
B	85	0	0	0	66
C	202	303	206	198	130
D	250	157	82	262	203

concept that the less dense the mesquite stand, the higher the grass production.

Overall grass production in 1974 was clearly greater on Study Areas C and D than in previous measurements. Production in 1974 on Study Areas A and B was also high but did not so greatly exceed yields of earlier years.

CONCLUSION

This thesis has been concerned with five areas and two different treatments on the Santa Rita Experimental Range. The trees were counted to determine the numbers of mesquite that had reinvaded the treated areas. Crown cover was measured to determine the relative size of these invading trees versus the originals. Grass production was measured to determine relationships between grass production and the number and size of mesquite.

Areas mesquite controlled in 1945 were still producing increases in production in 1974. Generally speaking, the more mesquite on a site, the less grass produced; and the larger the mesquite, the less grass produced. On areas that were thinned, increases in grass production were in proportion to the amount of thinning.

After 34 years, the mesquite killed plots of the elimination study still produced 150 pounds per acre more grass than the untreated plots. This is a smaller difference than in the 1940-48 means (220 pounds). This reduction in difference is associated with increased crown cover of invading mesquite on the cleared plots.

All thinning study areas show that perennial grass yields are related negatively to mesquite density. Trends at study area D, the lowest rainfall site, were weaker than at the other three areas.

Over time, one would expect grass production to decline following a thinning treatment, but grass production in 1974 was higher on all sites than in many of the earlier measurements. Two explanations are possible: (1) Rainfall in 1974 was exceptionally favorable, and (2) Lehmann lovegrass, which has become the dominant grass on most of the plots since 1945, seems to compete much better with mesquite than do the native perennials.

Lehmann lovegrass, introduced on all sites in 1945, was an uncontrolled factor in this study. As the mesquite became reestablished, this grass was also just beginning to spread and become established. An inverse relationship exists between Lehmann lovegrass and mesquite. The more thinned an area, the more Lehmann lovegrass produced.

On Study Area D, grass production has remained more or less level in the treatments. This area receives an average 12.8 inches of precipitation a year and this isn't enough to maintain a vigorous grass stand with or without mesquite. Lehmann lovegrass doesn't do very well on this site.

How soon should a rancher retreat a mesquite-controlled area? Based on my results, it should not be necessary to retreat for at least 35 years and possibly longer. But this conclusion is based on two assumptions: (1) that cost per acre would be the same for retreating an old area as for treating a new area; and (2) that the rancher would achieve a near 100% mesquite kill on his original treatment, as was achieved on the Santa Rita Experimental Range. A commercial aerial spray job with no follow-up usually results in about 50% plant kill. On such areas, mesquite recover includes regrowth on trees that were not killed as well as invader mesquite. Grass production increases following a commercial mesquite control job therefore can be expected to diminish more rapidly than on these study areas and I would not expect the average commercial job to still show benefits 34 or even 30 years later.

APPENDIX A

IDENTIFICATION OF STUDY AREAS

Thesis Designation	Forest Service Designation
Mesquite Elimination Study Mesquite Thinning Study	Study Area 194
A	Study Area 196
B	Study Area 197
C	Study Area 198
D	Study Area 199

APPENDIX B

REGRESSION CONSTANTS USED IN FORAGE PRODUCTION ESTIMATES ON MESQUITE THINNING STUDY

Table B-1. r and b values for total grass production, mesquite thinning study.

Study Area	r	b
A	0.9438	1.2894
B	0.9089	1.7591
C	0.9181	1.5468
D	0.8552	1.4270

Table B-2. r and b values for native perennial grass production, mesquite thinning study.

Study Area	r	b
A	0.9511	1.1051
B	0.8226	0.9722
C	0.7210	1.0731
D	0.7457	1.0002

APPENDIX C

ANALYSES OF VARIANCE FOR NUMBERS OF MESQUITE, MESQUITE CROWN COVER AND GRASS PRODUCTION

Table C-1. Mesquite elimination, number of trees per acre.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	1	12,376	12,376	2.30
Samples within treatments	14	75,223	5,373	
Total	15	87,599		

Table C-2. Mesquite elimination, mesquite crown cover.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	1	5,971.5	5,971.5	49.85
Samples within treatments	14	1,676.8	119.8	
Total	15	7,648.2		

Table C-3. Mesquite elimination, total grass production.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	1	94,249	94,249	3.94
Samples within treatments	14	334,735	23,910	
Total	15	428,984		

Table C-4. Mesquite thinning, total grass production, Study Area A.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	375,554	89,389	12.77
Samples within treatments	5	35,000	7,000	
Total	9	392,554		

Table C-5. Mesquite thinning, total grass production, Study Area B.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	203,646	50,912	2.26
Samples within treatments	5	112,450	22,490	
Total	9	316,096		

Table C-6. Mesquite thinning, total grass production, Study Area C.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	482,443	120,611	2.86
Samples within treatments	5	210,874	42,175	
Total	9	693,317		

Table C-7. Mesquite thinning, total grass production, Study Area D.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	79,596	19,899	1.37
Samples within treatments	5	72,444	14,489	
Total	9	152,040		

Table C-8. Mesquite thinning, native perennial grass production, Study Area A.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	238,331	59,583	10.78
Samples within treatments	5	28,980	5,796	
Total	9	267,511		

Table C-9. Mesquite thinning, native perrenial grass production, Study Area B.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	172,633	43,159	2.05
Samples within treatments	5	105,201	21,040	
Total	9	277,834		

Table C-10. Mesquite thinning, native perennial grass production, Study Area C.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	484,521	121,130	2.98
Samples within treatments	5	204,738	40,948	
Total	9	689,259		

Table C-11. Mesquite thinning, native perennial grass production, Study Area D.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Among treatments	4	61,941	15,485	2.07
Samples within treatments	5	37,424	7,485	
Total	9	99,365		

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