The Survival of Velvet Mesquite
(Prosopis juliflora var. velutina)

After Fire

by

John Blydenstein

A thesis

submitted to the Faculty of the

Department of Agronomy and Range Management

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in the Graduate College, University of Arizona

1957

Approved:

Erwin M. Schmitz
Director of Thesis

Date:

May 15, 1957

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ACKNOWLEDGEMENTS

The author of this paper wishes to express his sincere thanks to Mr. E. M. Schmutz for his assistance during this study and to Dr. R. R. Humphrey for his guidance and help in editing the manuscript.

Special thanks are also extended to the staff of the Department of Agronomy and Range Management for their assistance in locating the study areas and to my wife, Mrs. R. N. Blydenstein, for her help in collecting the data.

INTRODUCTION

Fire can affect plant distribution through the differential effect it has on the various species and life-forms found in a plant community. Many ecologists have concluded on this basis that natural wildfires were formerly a major factor in controlling brush species and preventing their spread over the grasslands they have invaded in so many places in recent times. Various opinions exist, however, on the importance of fire as a factor in the control of the original range of mesquite within the desert grassland.

In recent times, broadcast burning has been developed as a valuable tool in controlling many noxious plants on the range. But here again little is definitely known concerning the effect of fire on mesquite or the possible value of fire as a tool in clearing mesquite-infested grasslands.

The velvet mesquite of southern Arizona, with which this study is concerned, is classified taxonomically as Prosopis juliflora (Schwartz) D.C. var. velutina (Woot.) Sarg. by Benson (1941) in his study of the mesquites and screwbeans of the United States. Prosopis velutina Woot. is cited as a synonym. Burkart (1940), however, in a study of the whole genus Prosopis L. classifies the mesquite of southern Arizona as Prosopis articulata Wats. and limits the range of Prosopis juliflora to northern Mexico; he mentions that more study is needed to classify all species and variations of Prosopis in the northern hemisphere correctly.

LITERATURE REVIEW

Much research has been done on the physiology and growth habits of mesquite in order to arrive at satisfactory methods to control the rapid spread of this species over the grazing lands of the Southwest. Many of the publications on mesquite research are discussed by Glendening and Martin (1948) and Bogush (1950) in literature reviews.

The range of mesquite has been delineated by several authors. Bray (1904a) was one of the first to map the extent of the area occupied by mesquite in Texas. Foster et al. (1917) made a general survey of Texas woodlands and studied the commercial possibilities of mesquite. Shantz (1924) in his map of the natural vegetation zones in the United States indicates the limits of the range of mesquite for the entire Southwest and mentions temperature as the ecologic factor preventing the spread of mesquite further north. Tharp (1939) in a study of the vegetation of Texas noted the extent of mesquite in that state and Bell and Dyksterhuis (1943) published a map of the range of mesquite in Texas in an article on the control of mesquite and cedar on Texas ranges. For the entire Southwest Benson and Darrow (1944) note the range of mesquite in their Manual of Southwestern Desert Trees and Shrubs. A map composed from several of these data presented above and showing the range of mesquite in Arizona, New Mexico and Texas is shown in Figure 1.

An indication of the rapid spread of mesquite is given by Paulsen (1950) who studied the mortality of mesquite seedlings. Even though cattle and rodent grazing eliminated many seedlings, his studies in-

licated that up to eight seedlings per acre might become established every year. Brown (1950) studied the increase of mesquite over an 18-year period on an Arizona desert grassland range which was protected from fire. He recorded a 55% increase under open grazing versus a 24% increase under only rodent grazing and a 30% increase under exclusion of both livestock and rodents. This study indicates the role played by domestic livestock in the dissemination of mesquite seeds.

The role of fire in restricting mesquite to its original range along the drainages within the desert grassland has been discussed by many authors. As early as the beginning of the last century Michaux (1803), based on his experience from travels in the Midwest, mentions the possibility of wildfires as the cause of the treeless grass prairies of New Mexico. Thornber (1907) in a study of a burned-over area in southern Arizona reported:

. . . all the plants in the area burned over, even those partly charred, were killed outright: including such other shrubs as the catclaw, creosote bush, Brigham's tea, mesquite and Zizyphus.

Cook (1908) in a study of changes in the vegetation of southern Texas prairies concluded that fires had kept mesquite from spreading over the grassland. Another early worker in Texas, Bray (1904b, 1906), although recognizing the value of fire in eradicating many woody species such as white brush (Aloysia ligustrina) and prickly pear (Opuntia engelmannii), also mentions:

If the grass had been burned off regularly, this bottomland (Rio Grande Plain) would still be beautiful mesquite-dotted pasture.

Apparently this indicates at least partial survival of mesquite after

natural fires. Thornber (1910), noting the increase of mesquite in southern Arizona on the large Range Reserve Tract fenced seven years earlier, mentions the removal of the control afforded by occasional fires and close grazing as some of the reasons for this increase. Griffiths (1910) in a study on the Santa Rita Experimental Range in south-central Arizona also concluded that fire was a controlling factor which prevented the spread of mesquite over that area. Foster (1915) describes the invasion of mesquite on the Edwards Plateau of Texas as a gradual orchard-like spreading of the trees over the area until consequent reduction of grass cover and lack of competition allowed a heavy establishment of mesquite and other brush seedlings; he mentions lack of fires on the area as an additional factor aiding the spread of mesquite. A comprehensive study of the history of the desert grassland and the role of fire in preventing brush invasion was carried out recently by Humphrey (1957).

Some authors disregard natural fires as an important factor which limited the spread of mesquite over the desert grassland. Leopold (1924) rated fires as a factor in controlling junipers at the higher elevations but mentions reports by early settlers that indicate inadequate fuel to carry extensive fires in the lower elevations affected by mesquite invasion. Lack of evidence of old fires in that region led him to the conclusion that the encroachment of brush on these areas should be attributed entirely to the reduction of the competing grass cover. Clements et al. (1932) state that shrubs in southern Texas owe their victory over grasses due to their ability to sprout from roots after fire; this fact, coupled with the reduced grass

competition and the spread of mesquite seeds by grazing animals, led to the invasion of former grasslands by mesquite. Allred (1949) agrees with this opinion and mentions that some of the most constantly recurring fires in Texas today occur where mesquite is densest.

The use of fire as a tool in the eradication of mesquite on infested ranges is no longer mentioned in most of the recent publications (Fisher 1950, 1952; Fisher et al. 1951; Glendening 1952; Parker 1945) which advocate either mechanical or hand methods or the use of chemicals for the control of mesquite. Humphrey (1949, 1952), however, suggests fire as a means of controlling mesquite and cites mortality rates between 10 and 50 percent in various experimental fires. Other experimental burns to determine the mortality of mesquite after fire were carried out by Fisher (1947) and Glendening and Paulsen (1955). Glendening and Paulsen burned a desert grassland area in the spring and measured the mortality of mesquite in various size-classes; of the individuals with a basal diameter of 1/2 inch or less 52% died, trees larger than this had a mortality rate of 8 to 15 percent. Fisher in a similar experiment with honey mesquite (Prosopis juliflora var. glandulosa) in Texas burned an area for two years successively in February. Thirty-one percent of the mesquite seedlings on the area were destroyed by the fires but no mortality was found among the older plants.

DESCRIPTION OF THE STUDY AREAS

Two separate areas were sampled in order to evaluate the effect of fires during two different seasons. A fire during the dormant winter season was located at the Page-Trowbridge Experimental Ranch of the University of Arizona near Oracle, Pinal County, Arizona. The exact location is T 9 S, R 14 E, S 1/2 section 27, at an elevation of 3,800 feet. The topography of the study area is only slightly dissected with a very gentle slope to the west. The climate of the area is typical of moderate elevations in southern Arizona; two rainy seasons, during July-September and December-March, yield an average of 16 inches of precipitation per year, almost none of which falls as snow. The vegetation as described by Haskell (1945) is dominated by perennial grasses with Aristida hamulosa, Aristida longiseta and Bouteloua rothrockii as dominants. Of the shrubby species Prosopis juliflora, Haplopappus tenuisectus and Eriogonum wrightii are the most important. In the scattered low areas with a slightly more moist habitat, Andropogon barbinodis becomes dominant. The area has only been lightly grazed at intermittent intervals since the University of Arizona obtained the ranch for experimental purposes in 1928 and a dense ground cover has built up. On an unburned area adjacent to the study area, total ground cover was measured at 85%, of which litter constituted 55%. A portion of the area was broadcast burned on December 23, 1955 to evaluate the effect of a burn during that season on mesquite. The area was sampled in March 1957, during the second growing season after the fire. For a view of the area, see Fig. 2

Figure 2, Page-Trowbridge Study Area

To evaluate the effect of a summer burn an area was located south of Patagonia, Santa Cruz County, Arizona, within T 22 S, R 15 E at an elevation of about 4,500 feet. The topography of the study area is rough with shallow rocky soils and deep drainages cutting into sloping hillsides. The climate on this area is similar to the Page-Trowbridge Ranch. The vegetation differs somewhat, being classified as desert grassland with Hilaria belangeri as the dominant perennial grass. Grazing pressure has modified the grass cover and allowed the invasion of many herbaceous weeds and shrubby species. Invading shrubs include Prosopis juliflora, Calliandra eriophylla and Mimosa biuncifera. Ground cover on a nearby unburned area was measured at 40%, of which 9% was litter. An accidental fire burned the area in June, 1956 after the foliage of mesquite was fully developed and flowering was complete. Sampling was done in April, 1957, less than one complete season after the fire. In comparison with the Page-Trowbridge Ranch, the smaller amount of natural fuel would indicate a less hot fire in this area.

METHODS AND SCOPE OF THE INVESTIGATION

The present study was designed to evaluate the damage to various sizes of mesquite caused by a single fire. Fires during two different seasons were considered, one occurring in December during the dormant winter season and the other in June when the plants were in full leaf and flowering was complete.

Size-classification on a uniform area was considered to be the nearest equivalent to age groups as mesquite shows no definite annual growth rings to permit more accurate dating. Six size-classes were recognized based on basal diameter of the main stem: 0 - 1/2 inch, 1/2 - 1 inch, 1 - 2 inch, 2 - 3 inch, 3 - 4 inch, and over 4 inches. Most of the trees in the last class did not measure over 5 inches. Under natural conditions it takes mesquite from 5 to 10 years to develop to 1 - inch size.

Severity of damage was based on a combination of crown damage and sprouting from adventitious buds at the root crown. Six damage-classes were recognized: class 1 included all trees which showed no crown damage and no sprouting, class 2 showed no sprouting but some crown damage, class 3 showed sprouting from the root crown but little evidence of crown damage, class 4 showed both sprouting and extensive crown damage, class 5 included all trees with complete topkill but surviving through sprouts from the root crown, class 6 showed complete topkill and no evident sprouting from the base, the plants were apparently completely dead. See Figs. 3 and 4.

On the Page-Trowbridge Ranch area, the trees were counted in plots of 66 x 200 feet laid out in a random pattern over the burned

Figure 3, Topkill in big mesquite which survived through basal sprouting

Figure 4, Small mesquite surviving through basal sprouts

area. Statistical evaluation showed that eight such plots were sufficient to provide an adequate sample of the area with additional plots not causing any differentiation beyond the effects of the random distribution of the trees in the vegetation. The area south of Patagonia did not lend itself to this kind of treatment due to the irregularity of the terrain. Here several irregular shaped plots were laid out at random over the burned area and all trees within these plots were counted until it was estimated that a representative sample had been obtained based on the experience from the Page-Trowbridge Ranch.

RESULTS

Winter burn. The sample taken on the Page-Trowbridge Ranch included 206 trees of various sizes. Only two completely dead individuals were encountered for an overall mortality rate of 1%. Mortality was restricted to individuals under 1 inch basal diameter; within this classification the mortality rate was 2%. The possibility exists, however, that some dead individuals were overlooked due to the nature of the cause of death; fire will completely consume the topgrowth of the smaller trees and where no sprouting occurs little is left above ground.

The results are tabulated in Table 1, where the six size-classes are compared with the six damage-classes. The linear regression and correlation coefficients, b and r respectively, were computed from the data according to standard statistical procedure. The linear correlation coefficient r equals -0.824 , indicating a strong inverse relationship between the two variables plotted; the larger size-classes are associated with the lighter damage, a fact which can be readily noted from the Table. The fact that r^2 equals 0.679 indicates that more than $2/3$ of the variability between plants and damage is associated with size. The linear regression coefficient b equals 0.84 , indicating that for each increase in size an almost equivalent decrease in damage is recorded. As both size-classes and damage-classes were chosen arbitrarily the significance of this figure is not as great as the significance of the linear correlation coefficient.

Table 1. EFFECT OF FIRE ON MESQUITE

Data from Winter Burn on Page-Trowbridge Ranch

Damage- classes	Size-classes, basal diameter						Totals
	0-1/2"	1/2-1"	1-2"	2-3"	3-4"	over 4"	
no topkill, no sprouting	0	4	19	10	13	17	63
part topkill, no sprouting	0	0	0	1	3	1	5
no topkill, sprouting	1	1	5	3	3	3	16
part topkill, sprouting	2	4	9	10	1	0	26
total topkill, sprouting	60	20	9	3	1	1	94
dead	1	1	0	0	0	0	2
Totals	64	30	42	27	21	22	206

$$r = -0.824$$

$$r^2 = 0.679$$

$$b = 0.84$$

Summer burn. The sample taken on the study area south of Patagonia included 171 trees. A total of 9 completely dead individuals was found for an overall mortality rate of 5%. All dead plants had a basal diameter of 1 inch or less, with the majority in the 0 - 1/2 inch size-class, within this classification mortality amounted to 8%. The same difficulty in locating the remains of completely dead plants was encountered on this area.

The results are tabulated in Table 2 in the same way as for the Page-Trowbridge Ranch study. The linear correlation coefficient r was calculated at -0.816, with r^2 equal to 0.666. The linear regression coefficient b equals 0.89.

Table 2. EFFECT OF FIRE ON MESQUITE

Data from summer burn on area south of Patagonia

Damage- classes	Size-classes, basal diameter						Totals
	0-1/2"	1/2-1"	1-2"	2-3"	3-4"	Over 4"	
No topkill, no sprouting	1	4	5	7	8	12	37
part topkill, no sprouting	3	2	7	1	0	1	14
no topkill, sprouting	0	0	0	0	0	0	0
part topkill, sprouting	13	12	1	0	0	0	26
total topkill, sprouting	73	11	1	0	0	0	85
dead	8	1	0	0	0	0	9
Totals	98	30	14	8	8	13	171

$$r = -0.816$$

$$r^2 = 0.666$$

$$b = 0.88$$

Figure 5, Mesquite hidden in vigorous grass stand

DISCUSSION AND CONCLUSIONS

In comparing the results of the two phases of this study, it is important to keep in mind the lesser amount of fuel available for the summer burn as compared with the winter burn where there was an abundant understory of grasses and litter. This can be presumed to indicate a hotter fire on the winter burn.

Mortality after both burns was restricted to trees with a basal diameter under 1 inch with the majority of dead trees less than 1/2 inch in diameter. In this respect, it is important to note the large percentage of trees which survived only through basal sprouting after a complete topkill by the fire. This has the effect of increasing the number of individuals with basal stem diameters under 1/2 inch and indicates the possibility of higher mortality rates after recurrent fires on the same area. Comparison of the effect of burning during two different seasons shows a slightly higher mortality rate of mesquite after the summer burn.

A high degree of correlation between size of tree and amount of fire damage is indicated by the linear regression and correlation coefficients b and r . The least damage was recorded in the larger size-classes with more than half of the trees over 1 inch in basal diameter showing no damage. Of the plants with a basal diameter under 1 inch over two-thirds showed total topkill but survived through basal sprouting. Fire can be expected to be more efficient in controlling young, invading stands of small mesquite than in eradicating old, established stands where the majority of trees will be able to survive with a minimum of damage. Differences in the amount of natural fuel

under both types of growth will also have an effect here. A comparison of the values for b and r on both areas shows the same correlation exists for either season of burning.

In review, two important conclusions have been reached: 1) a single fire does not cause a high mortality of mesquite but it does reduce the size of many of the larger trees that survive through basal sprouting only, and 2) a high degree of correlation exists between the amount of fire damage and size of tree, showing that fire is more efficient in controlling young stands of small mesquite.

The results seem to support the theory that fire was one of the factors preventing the spread of mesquite over the grassland before the suppression of recurrent natural burns by the white settlers. Recurrent fires could prevent the mesquite seedlings that did get established on the grasslands from developing to more than sprout size, the dimension most susceptible to fire mortality. These small plants would also be less apparent in a well developed grass stand (Fig. 5), a casual traveller could easily overlook them when describing an area as open grass prairie. The small percentage of individuals that would survive to grow to bigger size and become resistant to fire damage could create a mesquite-dotted pasture, but dissemination and establishment of mesquite would never develop to the extent we know today on the range grazed by livestock.

Fire as a tool in the eradication of mesquite on the range could be successful and economically possible in young invading stands; in older stands the need for recurrent fires and adequate herbaceous fuel would appear to make the practice too expensive in lost grazing values to be generally applicable.

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