Effect of Fire on Honey Mesquite

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Highlight: *Based on this research and other work that has been reported, honey mesquite is very difficult to kill with fire on the High Plains and along river bottoms in the Rolling Plains. On upland sites in the Rolling Plains, 27% of the mesquite trees were killed following single fires. Using repeated fires on upland sites at 5 to 10 year intervals, the potential exists to kill 50% of the older mesquite trees. Seedlings of honey mesquite were easy to kill with moderate fires until they reached 1.5 years of age, severely harmed at 2.5 years of age, and very tolerant of intense fires after 3.5 years of age.*

This study was undertaken to determine fire's historical role in controlling honey mesquite (*Prosopis glandulosa* var. *glandulosa*) in Texas, and its potential as a tool to control honey mesquite today. Several researchers (Bray, 1901; Cook, 1908; Sauer, 1950; Stewart, 1951; Wells, 1970) have hypothesized that fire was chiefly responsible for keeping the prairies free of woody species, with brush occurring primarily along water courses and in draws (Humphrey, 1958; Lehmann, 1965; Box, 1967). These conclusions led to the theory that honey mesquite in Texas may be a disclimax induced by grazing (Cook, 1908; Clements and Shelford, 1939).

Some researchers, however, have expressed skepticism over the ability of fires to keep honey mesquite suppressed. Young et al. (1948) suggested that overgrazing by domestic animals was chiefly responsible for the increase of honey mesquite. These researchers and Fisher (1947) noted that it is very difficult to kill honey mesquite by burning after it has reached 1 year of age. Hence, they doubted whether burning had been effective in preventing the spread of honey mesquite. Allred (1949) reported that some of the most constantly recurring fires are in the "Texas brush country" (apparently the Rolling Plains and Rio Grande Plains in Central and West Texas) where mesquite is most dense, which also suggests that fire is generally ineffective in controlling honey mesquite.

Based on journal records by Marcy (1849) and Michler (1850), who traveled in West Texas and eastern New Mexico before settlement by the white man, the range of honey mesquite was about the same then as it is today. They did not observe mesquite on the High Plains, but in the Rolling Plains it was abundant and occurred on uplands as well as along streams. From Big Spring to the junction of the Clear Fork of the main Brazos River, Marcy mapped an area of 150 miles by 50 miles as "mesquite timber" in a "peach-like orchard." Thus, historical evidence indicates that honey mesquite has always been a dominant species of the Rolling Plains (Malin, 1953). Grazing and the probable reduction of fires during the last 75 years has apparently changed honey mesquite from a "peach-like orchard" to a dense thicket in the Rolling Plains.

Journal records of the 19th Century show that prairie fires easily top-killed honey mesquite trees over large areas in the Rolling Plains. In the area described as mesquite timber by Marcy in 1848, Michler, traveling through the same area in 1850, said "the whole country was well timbered with mesquite, but most of it had been killed by prairie fires." Obviously, at the time of Michler's travels he was seeing a top-kill of mesquite. In this area, however, fire has exhibited the potential to root-kill as much as 32% of the mesquite trees after they have been top-killed with 2,4,5-T [(2,4,5-Trichlorophenoxy) acetic acid] (Stinson and Wright, 1969; Britton and Wright, 1971). Once mesquite trees have been top-killed with 2,4,5-T, fire kills large trees much more easily than small ones because they burn into the crown more deeply (Britton and Wright, 1971). This would imply that two successive fires, or a fire following a severe drouth had the potential to root-kill a portion of the most susceptible mesquite trees in the Rolling Plains.

Honey mesquite on the High Plains is difficult to root-kill (Heirman and Wright, 1973). It is very well adapted to fire and most likely has always been present, but kept near mid-grass height by a combination of frequent fires, drouths, insect and rodent damage, and competition from grasses. Protection from fire during the past 50 years or so, has enabled these trees to become obvious.

Most mesquite mortality data have been collected on velvet mesquite (*Prosopis velutina*) in Arizona. This species is relatively tolerant of fires, although some trees usually die after being burned, especially if they are young (Glendening and Paulsen, 1955; Cable, 1961). Following summer fires, Blydenstein (1957) and Glendening and Paulsen (1955) reported 52% mortality for trees less than 0.5 inches in diameter

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Fig. 1. *A specially designed propane burner was constructed from stainless steel to burn the plants individually. Heat treatments were controlled by pressure of propane gas at the nozzle in relation to time as shown in Figure 2.*

and 8 to 15% mortality for trees greater than 0.5 inches in diameter. Amount of fine fuel (less than ⅛ inch diameter) also affects mortality. Fires with fine fuel loads of 4,500 lb/acre killed three times (25%) as many mesquite trees as fires with fine fuel loads of 2,200 lb/acre (Cable, 1965). Moreover, headfires are usually more damaging to brush than backfires because more plants ignite, and subsequent combustion is higher (Willard, 1973).

In this study specific objectives were to (1) determine the potential role of various intensities of prescribed fire to kill young mesquite trees from 0.5 to 10 years of age, and (2) determine the potential of headfires to kill large mesquite trees on various sites in the Rolling Plains of Texas.

Methods

This research project was initiated as two separate studies in 1969. One study was conducted 45 miles west of San Angelo, Tex., to determine the effect of various intensities of heat on mesquite plants from 0.5 to 10 years of age. The other study was initiated 20 miles south of Colorado City, Tex., to collect mortality data following fire on mesquite trees that had been previously top-killed with 2,4,5-T in 1966.

Seedling Study

Mesquite seedlings with cotyledons were permanently marked in October, 1969, on the Hal Noelke Ranch, 45 miles west of San Angelo. The seedlings had germinated in late August in a heavily grazed stand of buffalograss (*Buchloe dactyloides*) following a hot, dry summer and early fall rains. In this area, topography is gently rolling and average annual precipitation is 19 inches. Our plot with the mesquite seedlings was 2.0 acres on a bottomland site of the Nuvalde clay loam series. The plants varied from 0.3 to 0.7 ft high during the first 2.5 years. Thereafter, they were from 1 to 2 ft high with a 0.6 to 1.2 ft crown diameter.

To burn the plants a specially designed propane burner was constructed from stainless steel (Fig. 1). Six nozzles were mounted in the base of the 3 ft diameter burner and aimed at a 10-inch circle on

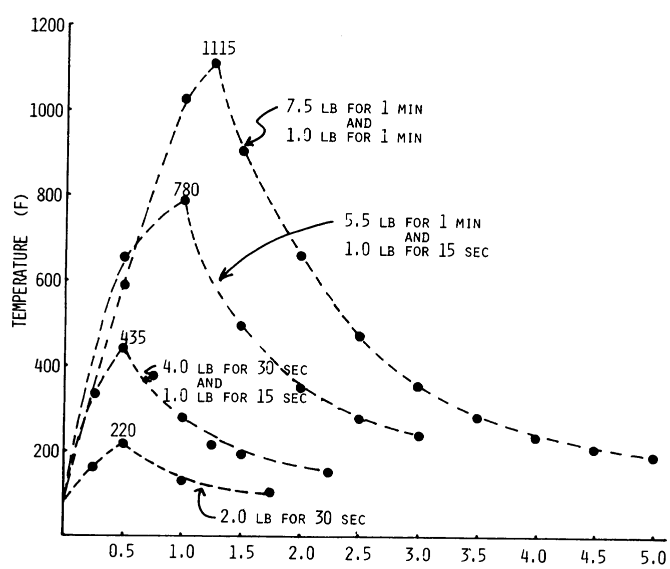

Fig. 2. *Time-temperature curves at the soil surface that were applied to mesquite seedlings.*

the soil surface in the center of the burner. Temperature sensors were placed at the edge and center of the 10-inch circle to calibrate gas pressures to obtain specific time-temperature curves (Fig. 2). The propane burner permitted the burning of plants individually and supplied a heat source completely independent of the plot variables. Weather data were taken on each day of burning, and mortality data were taken 15 months (two growing seasons) after application of treatments.

The study was conducted as a single experiment, using five heat treatments (including a control) and four ages of mesquite in a completely randomized design with 25 replications. Heat treatments, as shown in Figure 2, were applied in March 1970 through 1973 to living plants when they had reached 0.5, 1.5, 2.5, and 3.5 years of age, respectively, and to a group of plants that were estimated to be 10 years old. The time-temperature treatments simulated those found in natural grassland fires (Fig. 3) with 1,500 to 8,000 lb/acre of fine fuel (Stinson and Wright, 1969; Britton and Wright, 1971).

Natural mortality of mesquite seedlings is quite high. About 75% of all mesquite seedlings eventually died after emergence in the study area, but for the treatments, only living plants were burned.

Large Mesquite Tree Study

Mortality, following the burning of large, sprayed mesquite trees, was taken for several years on six upland Stamford clay sites and two bottomland clayey alluvium flood plain sites. All burns were conducted on the Renderbrook-Spade ranch 20 miles south of Colorado City. Vegetation consists of almost pure stands of tobosagrass (*Hilaria mutica*) with an overstory of honey mesquite. Following wet falls and winters, annual broomweed (*Xanthocephelum dracunculoides*) will also be abundant. Slopes of the upland sites vary from 0 to 3% at an elevation of 1,600 ft. All trees had been sprayed with 2,4,5-T in 1966 and had resprouts 3 to 5 ft high at the time they were burned. Height of sprayed trees varied from 7 to 12 ft with crown diameters from 6 to 10 ft.

On the upland sites, a 90-acre area was burned in 1968, 24 10-acre plots in 1969, 3,000 acres in 1970, and four 10-acre plots in 1971. On bottomland sites 300 acres were burned in 1969 and 50 acres were burned in 1974. On each individual burn, from 30 to 50 live mesquite plants with basal diameters from 2 to 6 inches were permanently marked before burning. The plots were burned with headfires (with the wind) (Wright, 1974) between March 1 and April 7, just before tobosagrass and honey mesquite began growing in the spring. Adjacent to the burns of each year, 50 control plants were also permanently marked.

At the time of burning, tobosagrass fuel, fine fuel moisture, air temperature, relative humidity, and wind speed were measured. In 1969, soil moisture was also measured. Mortality was measured for 3 to 5 years after burning except for the trees that were burned in 1974.

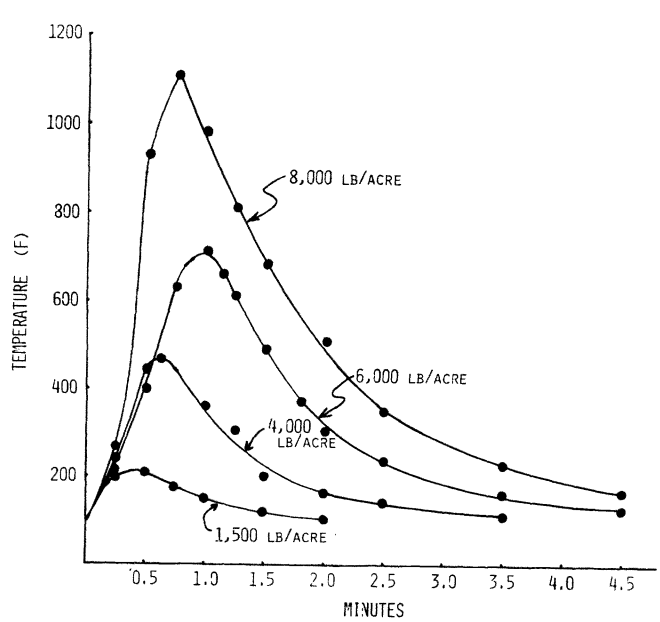

Fig. 3. *Time-temperature curves at the soil surface during prescribed grass fires for four amounts of fine fuel. At the time of burning air temperature, relative humidity, and wind were 70 to 80°F, 20 to 40 %, and 8 to 15 mph.*

Results and Discussion

Seedling Study

Young mesquite plants are very susceptible to moderate fires until they reach 1.5 years of age, moderately susceptible at 2.5 years of age, and very tolerant after 3.5 years of age (Table 1). Only the 220°F treatment during the first 3 years and the 435°F treatment during the third year differed significantly from the other heat treatments. Thus, fires in thick stands of buffalograss, midgrasses, or tobosagrass with potential maximum soil surface temperatures of approximately 350°F, 500°F, and 800°F, respectively, would be equally effective as fuel sources in killing honey mesquite trees less than 2 years old.

Table 1. Mortality (%) of young mesquite trees 15 months after burning in relation to age and maximum soil surface temperature (resulting from fire) near Mertzon, Texas.[1]

	Temperature (°F)				
Age (years)	220	435	780	1115	Control
0.5	43 b	91 a	100 a	100 a	14 c
1.5	60 b	100 a	100 a	100 a	0 c
2.5	20 c	40 a	64 a	72 a	0 d
3.5	8 a	8 a	8 a	8 a	4 a
10 (approx.)	0 a	0 a	4 a	8 a	0 a

[1]Means within a row followed by the same letter are not significantly ($P < 0.05$) different.

Since mesquite seedlings usually germinate on heavily grazed sites after a period of very warm weather and rain, the best time for fire to be effective in killing mesquite seedlings would be the second year after emergence. This would allow time for natural mortality to take its toll (Table 2) and for vegetal recovery to provide a fuel source to burn the survivors. A fire within 1.5 years after emergence of honey mesquite seedlings would kill from 43 to 100% of the survivors, whereas a fire 2.5 years after emergence would kill from 20 to 72% of the survivors.

In thick stands of grass, such as tobosagrass, seedlings undergo severe competition and die easily (Table 2). Thus, from the standpoint of management, vigorous stands of grass

Table 2. Mortality (%) of mesquite seedlings by natural death in relation to date after germination (August 20, 1969) and degree of competition near Mertzon, Texas.

	Degree of competition[1]		
Date	Bare soil	Buffalograss	Tobosagrass
10/1/69	0	0	0
6/3/70	14	26	40
9/25/70	59	61	96
6/8/71	68	70	100
6/20/72	73	78	100

[1]The buffalograss and tobosagrass stands were producing 1,800 and 1,100 lb/acre of current growth, respectively. Corresponding amounts of litter were 500 and 4,000 lb/acre.

Table 3. Mortality (%) of mesquite trees following different years of burning in relation to average weather and fuel conditions on upland sites near Colorado City, Texas.

Year of burn	Number of trees	Year after burn 1	2	3	4	5	Tobosa fuel (lb/acre)	Fuel moisture (%)	Air temp. (°F)	Relative humidity (%)	Wind speed (mph)
1968	50	32	32	32	32	32	7,000	19.8	80	25	10
1969 (a)[1]	250	8	13	18	20	22	5,000	19.2	67	45	5
(b)[2]	950	11	19	24	27	28	5,700	15.8	72	38	13
1970	50	12	12	18	–	–	4,000	15.0	70	23	12
1971 (a)[1]	60	12	15	15	–	–	4,800	19.5	60	54	5
(b)[2]	60	45	50	50	–	–	4,200	14.7	80	32	10

[1]Average wind less than 8 mph.
[2]Average wind more than 8 mph.

will minimize the chance for honey mesquite seedlings to get established. For those that do get established, however, vigorous stands of grass provide a good fuel source for fire to kill most of them within 2 years after emergence.

Where sites are heavily grazed, honey mesquite invasion is inevitable during opportune years and fire may not be a realistic tool to kill honey mesquite seedlings. In these cases, an alternative treatment such as the application of 2,4,5-T or some other herbicide might be effective in top-killing the young plants and inducing mortality before the trees reach 2 to 3 years of age.

Large Mesquite Tree Study

Large honey mesquite trees that have been top-killed with 2,4,5-T before burning can be root-killed by burning on upland sites in the Rolling Plains (Table 3), but not on bottomland sites. On the upland sites, 27% of all trees died within 3 to 5 years after burning. Following dry winters such as 1971 and burning with winds in excess of 8 mph, which are necessary to ignite and burn mesquite stems (Britton and Wright, 1971; Wright, 1972), it appears that honey mesquite mortality can be raised to 50% with one burn (Table 3). Low relative humidity and high air temperatures may also have been contributing factors to the high mortality in this set of data, but wind in excess of 8 mph is necessary for continuous burning after ignition (Britton and Wright, 1971). High mortality of honey mesquite during drouth years is attributed to the burning of stumps below the mineral soil surface, which probably kills many living buds. During wet years the tree stems burn off at the mineral soil surface (Fig. 4). Mortality, as shown in Table 3, was essentially independent of fuel amounts, within the range from 4,000 to 7,000 lb/acre, and apparently more directly related to wind speed, relative humidity, air temperature, fine fuel moisture, and moisture of mesquite stems.

Since additional honey mesquite trees continue to die after the first year, honey mesquite mortality seems to be a function of fire, insect and rodent damage, drouths, and competition from grass. All of these factors apparently interact together to enhance the kill of honey mesquite trees.

Based on preliminary reburn data and data during drouth years, it appears that 50% of the honey mesquite trees on upland sites in tobosa grasslands can be killed if burned at 5 to 10 year intervals. In the Colorado City area this may be the best that we can expect since this is part of the area mapped as "mesquite timber" by R. B. Marcy in 1849. The first burn would kill the more susceptible trees and each successive burn would kill fewer and fewer trees because only the older more resistant trees would be left, plus possibly a few new plants. The magnitude of mortality after each burn would also be dependent on the dryness of the year and weather at the time of burning.

Fig. 4. *During wet years, dead mesquite stems with living resprouts usually burn off at the soil surface (left); 15 to 30% of the trees die. However, during dry years, the stems frequently burn into the root crown, and fire kills as many as 50% of the trees (right).*

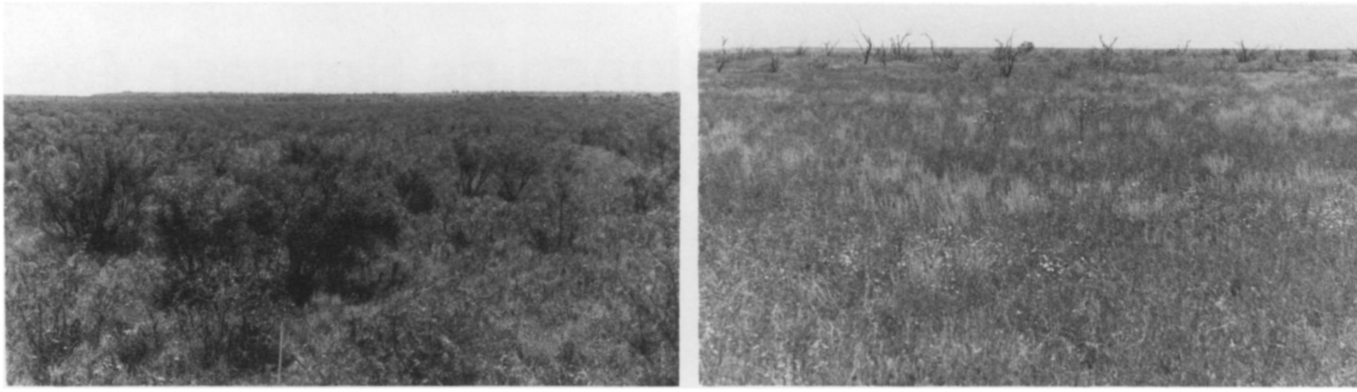

Fig. 5. *Mesquite is well adapted to fire on bottomland sites (left), but can be thinned by fire on upland sites (right).*

The above theory is further supported by the variety of responses that we get after burning honey mesquite trees. Some are killed outright, some undergo severe damage by insects and rodents and die later, and others are very healthy and vigorous after fire. With such a wide variety of genetic adaptability, many trees will always survive fires on upland sites. If fires are too frequent, they might select against the poorly adapted ecotypes and increase the proportion of fire-adapted ecotypes, as apparently happened before the white man's appearance on the High Plains.

On bottomland sites of the alluvial flood plains next to rivers (Fig. 5), honey mesquite is very tolerant to fire (4 to 8% mortality) and appears extremely well adapted to these sites. This agrees with the observations of many early travelers that mesquite was thick along the river bottoms. As one looks away from the alluvial flood plains to upland sites (Fig. 5), however, honey mesquite becomes thinner but has always been a dominant part of the general aspect of the Rolling Plains (Malin, 1953). Following fire, some areas will be almost completely void of honey mesquite while some areas will be moderately thick. Most upland sites, however, appear quite thin with honey mesquite for many years after burning because even though many trees are alive, the resprouts are usually few.

Conclusions

Honey mesquite trees up to 1.5 years of age are easily killed by fire, severely harmed at 2.5 years of age, and very tolerant of fire after 3.5 years of age. Thus, honey mesquite trees older than 3 years of age are very difficult to kill by fire unless they have been top-killed by a previous herbicide treatment. Even with a top-kill, the trees are hard to root-kill on the High Plains (Heirman and Wright, 1973) and on bottomland sites of the Rolling Plains.

On upland sites of the Rolling Plains, honey mesquite trees that have been top-killed by a previous herbicide treatment are moderately harmed by single fires in combination with drouths, rodents, insects, and competition from grass. Fires during drouth years or repeated fires during wet years, however, show the potential to kill 50% of the honey mesquite trees. If fires are too frequent, they may select against the intolerant ecotypes of honey mesquite and, in time, fire would probably have less effect on mortality of honey mesquite. Nevertheless, it seems reasonable for fire to be used as a tool in honey mesquite-tobosa communities of the Rolling Plains about every 10 years to thin mesquite to a tolerable level.

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