USING FIRE FOR SCULPTING BRUSH

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Abstract: We are only beginning to understand the potential of fire to sculpt brush. This paper summarizes the current knowledge on sculpting honey mesquite (*Prosopis glandulosa*) with fire. Fire can be used to sculpt mesquite growth form. Hot, intense fires will likely topkill mesquite and stimulate resprouting. Low intensity fires kill some lower canopy foliage and stems to create what appears to be browse line. The reduced canopy foliage will increase visibility and compete less with understory grasses, yet this foliage will still exert apical dominance and prevent resprouting from tree bases. Desired fire intensity can be achieved by burning under certain fuel loads, humidities and air temperatures. Prescriptions for low intensity fires are provided. Sculpting mesquite at the landscape-level can be accomplished with fire in combination with other treatments. Fire alone will not alter mesquite densities. Information is needed which determines which growth forms, densities and mosaics of grass and mesquite patches are optimum for each multiple use management goal.

Fire is recognized as a natural part of grassland ecosystems. It is believed to limit woody plant encroachment on grasslands because grasses are better adapted than woody plants to withstand fire (Daubenmire 1968). European settlers reduced fire frequency in the southern prairie grasslands (USA) either directly by extinguishing naturally-caused fires, or indirectly through livestock overgrazing which reduced the grasses that fueled fire. It is believed that the reduction of these fires is partly (but not solely) responsible for the encroachment of woody plants on southwestern grasslands during the last century (Archer 1989).

Because of its relatively low cost of application when compared to other brush treatments, and because of its natural role in grassland ecosystems, fire has become an increasingly popular management option. Most rangeland fire research has focused on application of high intensity fires to maximize canopy reduction or mortality of woody plants (Wright and Bailey 1982). This research emphasis reflected the traditional rangeland management goal of opening up more grassland areas from woodlands for livestock (in particular, cattle) production.

In contrast, the concept of "brush sculpting" strives to develop and manage a mosaic of brush and grassland patches within a landscape to meet multiple land-use goals. In addition, brush sculpting involves altering the verticle structure or growth form of individual trees. Brush sculpting uses many of the principles outlined in Integrated Brush Management Systems (Scifres et al. 1985).

To use fire as an effective tool for brush sculpting, managers must consider (1) the potential of fire to manipulate brush, (2) conditions that produce certain types of fires and resulting brush or ecosystem responses, and (3) fire application techniques required achieve desired effects. Fire-related objectives may differ markedly from traditional goals. The viewpoint that the only "good fire" is one that "kills all the brush" must certainly change if fire is to be used for brush sculpting.

Sculpting mesquite with fire

Our research group at Vernon has been evaluating the potential of fire for sculpting honey mesquite (*Prosopis glandulosa*). We have referred to such efforts as "rangescaping" or "mesquite savanna development" (Ansley et al. 1996*a*, 1996*b*). We define a mesquite savanna as a relatively low density of large trees, but it may also refer to a mosaic of open grasslands, scattered mesquite and mesquite thickets. The Resource Conservation Glossary (SCS 1982) defines a savanna as a "grassland with scattered trees, either as individuals or clumps".

The presence of a low density of mesquite may be beneficial to the rangeland resource. In addition to providing cover for wildlife, mesquite may enhance soil fertility through nitrogen fixation and organic carbon additions (Johnson and Mayeux 1990). Herbaceous species diversity in a pasture often is enhanced because some species grow better beneath mesquite canopies than in open spaces (Brock et al. 1978). Thus, total eradication of mesquite may limit recruitment of certain grasses.

Conversely, large areas of dense mesquite thickets are usually undesirable because they negatively impact understory production, herbaceous species diversity, livestock management, and watershed yield. Poor visibility through mesquite thickets is often cited by livestock managers as a significant and costly problem. We hypothesize that a mesquite savanna will maximize the benefits and minimize negative impacts of this species. More research is needed to determine what kinds of densities and mosaics are truly beneficial.

Mesquite response to fire is highly variable, depending on fire characteristics and/or condition of the plant at the time of burning (Wright and Bailey 1982). This variation may enable managers to use fire to sculpt mesquite. Consideration must be given to *growth form* of individual trees as well as *landscape distribution*. In the following sections we will review the current knowledge related to these two areas, and finish with prescriptions for mesquite-sculpting fires.

Sculpting mesquite growth form

We have been studying effects of high and low intensity fires on mesquite growth form. Most research was conducted on clay loam soils in north-central Texas where annual precipitation ranges from 18 to 26 inches. Mesquite were 8-15 ft. tall, multi-stemmed regrowth from prior herbicide treatments. Younger, 1-3 ft. tall mesquite were scattered throughout each of the plots but were not as numerous as the adult regrowth trees.

As a rule of thumb, high intensity fires had flame heights greater than 5 ft, and a low intensity fires had flame heights less than 5 ft. Peak fire temperature usually occurred at 5 to 10 inches above ground and ranged from 1100 to 1650 °F (600 to 900 °C) in high intensity fires, and 750 to 1300 °F (400 to 700 °C) in low intensity fires (Ansley et al. 1998b). At 3 to 10 ft. above ground, temperatures of high intensity fires were 3-4 times greater than low intensity fires. We hypothesize that temperatures at these upper heights are what causes the differences in mesquite growth form response to fire.

The effect of high and low intensity fires on mesquite growth form is illustrated in Figure 1. High intensity fires will topkill mesquite and stimulate resprouting. The rate of sprout regrowth is variable, depending on site, weather, etc., and size of the original plant (Scifries and Hamilton 1993). Such regrowth will create a mesquite thicket if no post-fire maintenance practices are utilized. In this regard, fire is no better that a topkilling herbicide or mechanical treatment such as chaining or shredding. For this reason, a manager should have clear long-term goals before applying a high intensity, topkilling fire.

The effect of low intensity fires on taller mesquite (greater than 8 ft. tall) will range from little or no effect, to a partial defoliation of the tree. Almost any fire, regardless of intensity, topkills mesquite that are less than 3 ft. tall. Trees partially defoliated by low intensiy fires tend to retain foliage in the upper portions of the canopy, but lower-positioned canopy growing points are killed. Primary support stems are not killed. These trees appear to have a browse-line (Fig. 1). Because of their similarity in appearance to Acacia trees in the African savannas, we refer to mesquite that have been "sculpted" with low intensity fires as "savanna" trees.

Amount of living foliage on the tree during the growing season following a fire has direct bearing on whether the tree basal-sprouts or maintains apical dominance. Most trees which retain 30 to 40% or more of pre-burn foliage maintain apical dominance and have very few or no basal sprouts. Below this threshold foliage amount, apical dominance is lost (Fig. 2).

Mesquite topkill was greater in higher intensity fires (Table 1). Under similar fire intensities, summer fires produced greater topkill than winter fires, probably because of differences in physiological activity of mesquite at the time of burning. Low intensity fires usually topkilled less than 20% of the mesquite, and almost all of these were small trees. Foliage remaining on non-topkilled (ntk) trees ranged from 13 to 79%.

Thus far, it has been possible to maintain the "savanna" growth form on taller mesquite with repeated low intensity fires. After 3 low intensity fires in 5 years, per tree foliage was maintained near the 40% threshold level needed to maintain apical dominance (Fig. 3). These results suggest that repeated low intensity fires can maintain mesquite foliage high enough increase visibility for livestock management, while retaining some shade for livestock.

Sculpting landscape distribution

Percent root-kill (or complete mortality) of mesquite remained low in all treatments, including repeated summer fires (Table 1). These results substantiate reviews by Wright and Bailey (1982) and Scifres and Hamilton (1993) that fire will not significantly reduce mesquite density in terms of number of plants per land area. Thus, if a reduction in mesquite density is desired, sculpting must be supplemented with other treatments such as aerial spraying of herbicides, individual plant treatment (e.g., Brush Busters), or mechanical grubbing are necessary.

An example of such an area (Fig. 4) initially has a moderate stand of medium-sized (10 ft. tall) mesquite and a dense mesquite thicket on one side of the pasture (Fig. 4*a*). The plan is to preserve the thicket for wildlife and open up the rest of the area. A lane of grassland next to the thicket is desired for wildlife habitat edge effect and for creating an access lane for livestock management. On the remaining mesquite in the moderate density area, the goal is to increase visibility for livestock management by reducing mesquite foliage, while preserving an overstory sufficient to suppress resprouting.

Herbicides such as the current broadcast recommendation of a mixture of Reclaim* (clopyralid) and Remedy* herbicide (triclopyr) can be used to create the grassland lane (Fig. 4*b*). This treatment combination, at 0.25 + 0.25 lb/acre (about $22.00 per acre), usually achieves 50-70% root kill and topkills surviving plants.

Low intensity fires can then be applied to all areas except the thicket (Fig. 4*c*). To preserve the thicket, a drip torch is applied along the down-wind side of the thicket perpendicular to the direction of the wind, so that the headfire moves away from the thicket. A backfire from the torch line will creep into the thicket but will have little or no effect on the mesquite. Using these techniques, a mosaic of thickets, open grasslands and areas with "savanna"-sculpted trees can be achieved (Fig. 4*d*).

In time, resprouts from topkilled mesquite and new seedlings can be treated individually with herbicides or mechanical methods (Fig. 5). Hand-treating these mesquites will root-kill them before they become a significant problem.

Fire prescriptions for sculpting mesquite

While Wright and Bailey (1982) identified the most desirable weather and fuel conditions to produce high intensity mesquite-topkilling fires, alternate guidelines are needed if savanna is the management goal. The ideal goal for the low intensity "savanna" fire prescription is to create a fire intense enough to reduce foliage but preserve apical dominance in taller trees.

It is extremely important to monitor weather while burning, not only for safety reasons but to achieve desired effects on brush. Weather conditions during fires have a profound effect on fire behavior and subsequent response of mesquite to fire. When effects of several winter fires were compared on two north Texas ranches, the Waggoner and Y Ranch, mesquite topkill (i.e., number of plants in a stand that were topkilled) increased with increasing air temperature (Fig. 6). Topkill decreased with increasing relative humidity (RH), but this relationship was found only on the Y Ranch and not the Waggoner sites. The Y Ranch sites were dominated by warm-season grasses which were dormant at the time of burning. Fuel moisture of these grasses was subject to changes in RH. In contrast, the Waggoner plots had an abundance of cool-season grasses (Texas wintergrass, Japanese brome) which were green at the time of burning and less affected by changes in RH. As fine fuel moisture content increased, percent topkill decreased (Ansley et al. 1998*b*).

We successfully conducted low intensity fires as headfires during winter months (January-March) when mesquite was dormant. The range of conditions which produced the sculpted "savanna" trees (see Fig. 1) were as follows:

- Fine fuel 1000 to 3500 lb/acre,
- Air temperatures between 52 and 68 °F (11-20 °C),
- Relative humidities between 30 and 50%,
- Wind speed 8 to 12 mph.

Headfires were conducted in mornings (8-10:00 AM) or at night (6-9:00 PM) to take advantage of higher relative humidity (RH) and lower air temperatures. Under low fuels (1000 to 1500 lb/ac), low intensity fires were conducted in afternoons. A moderate wind speed was needed to move the flame front because fires were conducted under relatively high RH and low air temperatures. Wind speeds of 12-18 mph were used if RH was greater than 40% and air temperatures were less than 60 °F. Light and variable winds were ***undesirable*** for winter low intensity headfires.

Fuels greater than 3500 lb/ac under any RH, or RH less than 25% under most fuel amounts generated topkilling fires. Fine fuel below 1000 lb/ac often burned completely, but there was no apparent damage to mesquite foliage. Similarly, backfires produced little effect on mesquite and were not viewed as a desirable means of applying fire for mesquite sculpting.

Very little is known on the potential of low intensity summer fires to sculpt mesquite. Low intensity summer fires may have greater potential than winter fires to reduce mesquite foliage to desired levels, but the risk of topkill is greater. One possible advantage of using low intensity fires in summer rather than winter months would be if the management goal was to preserve the mesquite overstory, yet kill prickly pear cactus (*Opuntia* spp.). Prickly pear appears to be much more susceptible to summer than to winter fires (personal observation).

Achieving low intensity fires are much more difficult during summer than winter months because summer air temperatures are so much warmer. The only low intensity summer fire we have thus far attempted was conducted at 90°F air temperature, 35% RH, and winds at 8 mph. Fine fuel was low (1500 lb/ac) because the plot had been burned the previous winter. The result was suitable: topkill was 15% and foliage remaining (ntk trees) was 46%.

Summer low intensity fires may be possible if burned as headfires during the morning (7 to 9 AM) or evening (7 to 10 PM). Summer fires during midday and/or afternoons under any fuel load appear to topkill most mesquite and are unsuitable for savanna development (Ansley et al. 1998a). At this time we do not know what the desirable fine fuel, air temperature, RH and wind speed ranges are to conduct low intensity summer fires. Therefore, a fire prescription is not available. We believe that to conduct summer fires safely, wind speeds should not exceed 10 mph and RH should be greater than 35%.

Only narrow time windows of opportunity exist for low intensity fires - either early in the morning or late in the evening. This window is even less with summer fires. One cannot afford to spend a great deal of time backfiring fire guards. These must be burned out ahead of time so one can apply the prescribed low intensity headfire when air temperature and RH are correct. To burn the fireguards ahead of time, one must have parallel roads or dozer lines on at least one and preferably two downwind sides of the area to be burned (see Wright and Bailey 1982, Scifres and Hamilton 1993).

Literature Cited

Ansley, R.J., D.L. Jones, and B.A. Kramp. 1996a. Use of different intensity fires to convert *Prosopis* woodlands to grasslands or savannas. pp 13-14 In: N. West (ed.), Proceedings: 5th International Rangeland Congress, Soc. Range Manage., Salt Lake City, 23-28 July 1995.

Ansley, R.J., J.F. Cadenhead, and B.A. Kramp. 1996b. Mesquite savanna: a brush management option. Cattleman 82: 10-12 (April 1996 Issue).

Ansley, R.J., B.A. Kramp, and T.L. Moore. 1997. Development and management of mesquite savanna using low intensity prescribed fires. Proceedings, First Conf. on Fire Effects on Threatened and Endangered Species and Habitats, International Association of Wildland Fire, Coeur d'Alene, ID, 13-15 November 1995 (In Press).

Ansley, R.J., B.A. Kramp and T.R. Tunnell. 1998a. Manipulation of fire intensity to achieve mesquite management goals in north Texas. Proc. 20th Tall Timbers Fire Ecology Conference, 4-6 May 1996, Boise, ID (In Press).

Ansley, R.J., D.L. Jones, T.R. Tunnell, B.A. Kramp and P.W. Jacoby. 1998b. Honey mesquite canopy responses to single winter fires: relation to fine fuel, weather and fire temperature. International J. Wildland Fire (In Press).

Archer, S. 1989. Have Southern Texas savannas been converted to woodlands in recent history? The American Naturalist. 134: 545-561.

Brock, J.H., R.H. Haas, and J.C. Shaver. 1978. Zonation of herbaceous vegetation associated with honey mesquite in northcentral Texas. 1st International Rangeland Congr., SRM, Denver, CO. pp 187-189.

Daubenmire, R. 1968. Ecology of fire in grasslands. Adv. Ecol. Res. 5: 209-266.

Johnson, H.B. and H.S. Mayeux, Jr. 1990. *Prosopis glandulosa* and the nitrogen balance of rangelands: extent and occurrence of nodulation. Oecologia 84: 176-185.

Scifres, C.J., W.T. Hamilton, J.R. Conner, J.W. Stuth, J.M. Inglis, T.G. Welch, G.A. Rasmussen, and R.P. Smith. 1985. Integrated brush management systems for south Texas: development and implementation. Texas Agric. Exp. Sta. Bull. 1493. 71 pp.

Scifres, C.J. and W.T. Hamilton. 1993. Prescribed Burning for Brushland Management: the South Texas Example. Texas A&M Univ. Press, College Station. 246 pp.

Soil Conservation Service (SCS). 1982. Resource conservation glossary. SCSA, Ankeny, Iowa. 193 pp.

Wright, H.A. and A.W. Bailey. 1982. Fire Ecology - United States and Southern Canada. John Wiley and Sons, New York. 501 p.

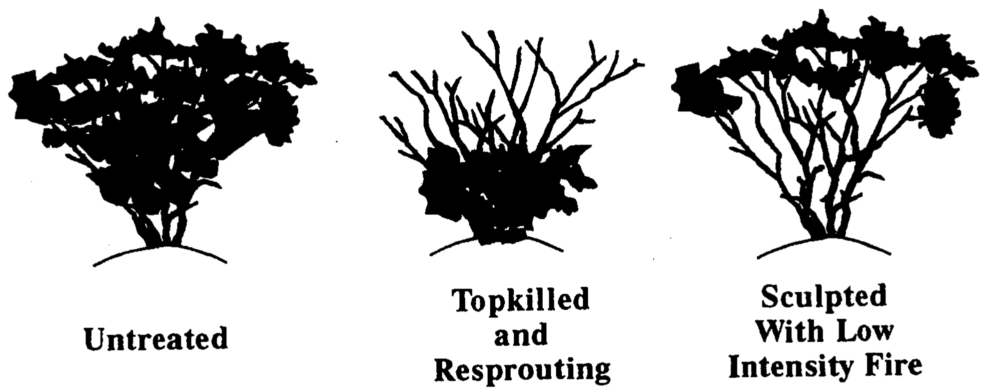

Figure 1. Illustration depicting effects of high and low intensity fires on mesquite canopy foliage and basal sprouting.

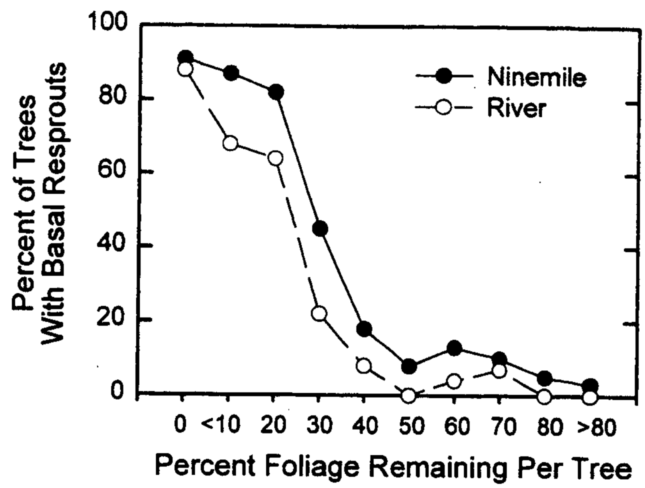

Figure 2. Relation between percent of foliage remaining on mesquite trees after low intensity fires (x axis), and percent of trees within each foliage remaining category that had basal sprouting (y axis). Data are from 6 fires at Ninemile Pasture, Waggoner Ranch and 3 fires at River pasture, Y Ranch (from Ansley et al. 1997).

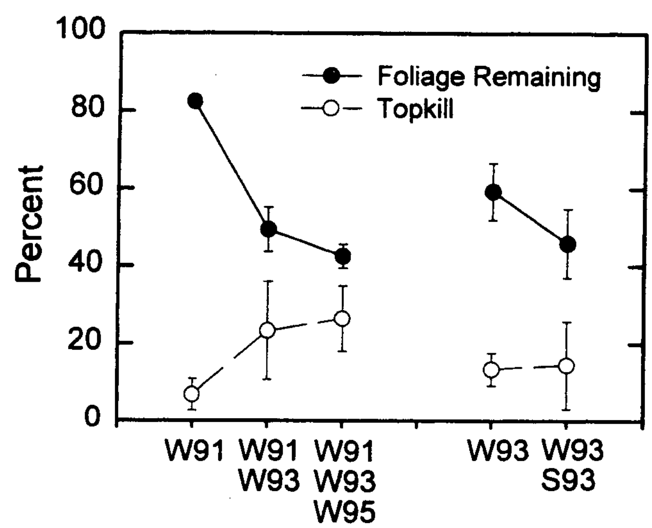

Figure 3. Effects of repeated low intensity fires on mesquite percent topkill per stand and foliage remaining on non-topkilled trees. Each point is a mean of 3 plots. W91=winter fire in 1991. Vertical bars are standard errors (from Ansley et al. 1997).

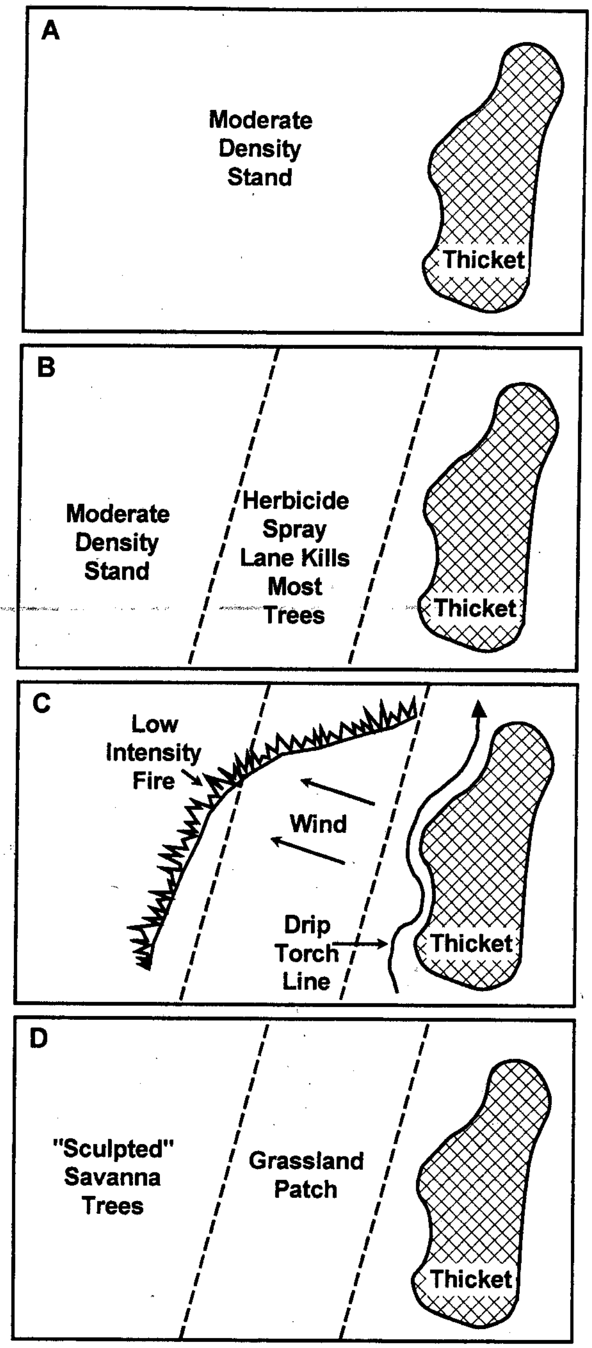

Figure 4. An example of brush sculpting a pasture to serve wildlife and livestock management goals: (a) starting conditions; (b) using aerially-applied herbicides to create a mesquite-free grass lane; (c) using low intensity fires to maintain the grass lane, sculpt savanna trees and preserve the thicket; and (d) mosiac of grassland, savanna and thicket.

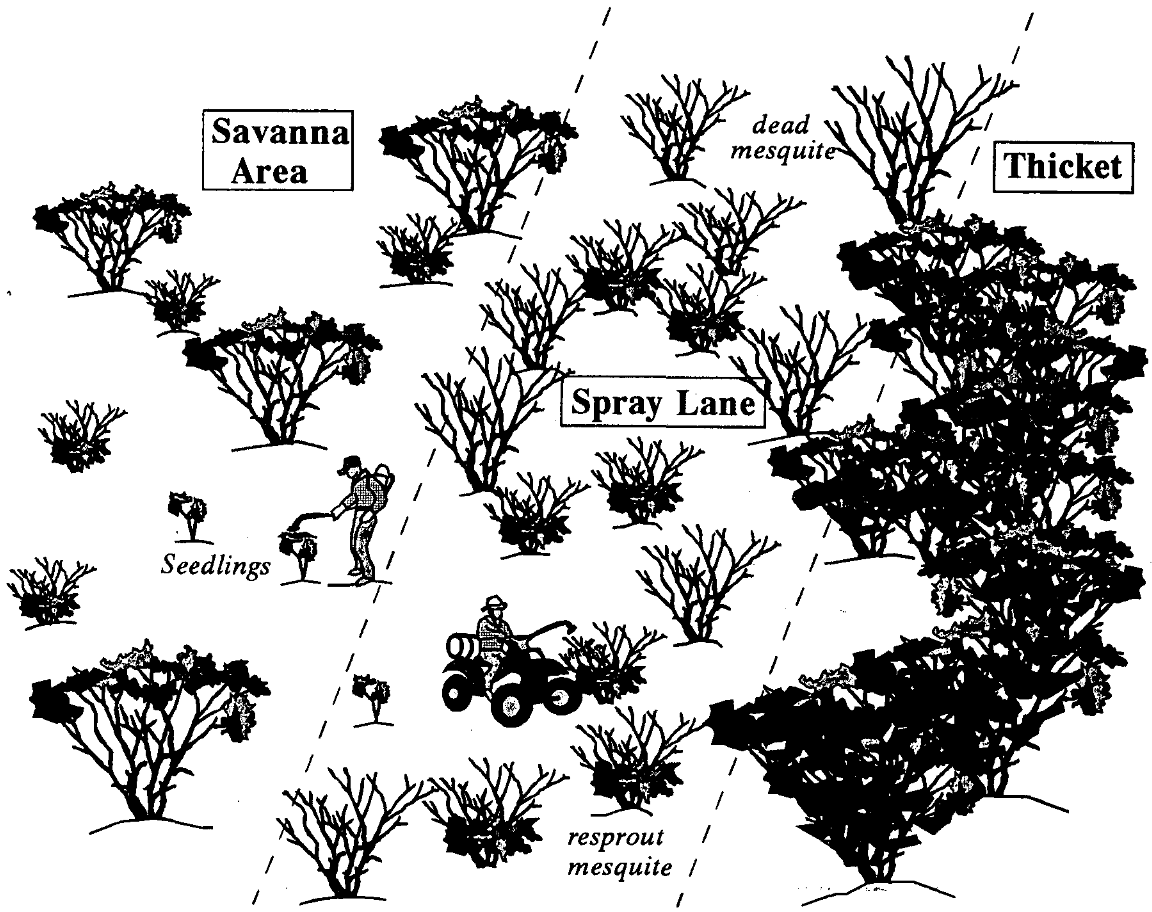

Figure 5. A more detailed view of Figure 4d showing herbicide spray lane and mesquite "sculpted" into savanna trees by low intensity fires. Individual plant treatment (Brush Busters, etc.) may be used on seedlings or resprouts in selected areas.

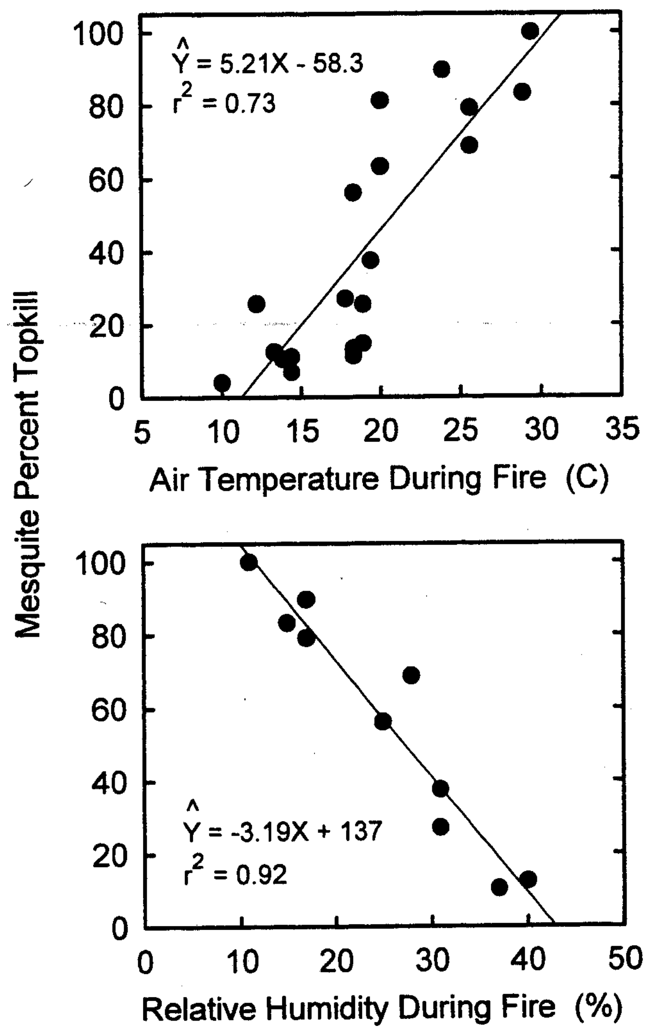

Figure 6. The relationship between air temperature or relative humidity just prior to a fire and percent of mesquite in a stand that were topkilled by the fire. Each point represents a different fire. Fine fuel loads of all fires ranged from 2000 to 3500 lb/ac. All fires were first-burn winter fires (adapted from Ansley et al. 1998b).

Table 1. Weather conditions, fine fuel, fire intensity and mesquite response to different intensity fires.

			Conditions During Fire					Mesquite Response		
Burn Season and Year	Site	Fire Goal	Air Temp (F)	RH (%)	Wind Speed (mph)	Fine Fuel (lb/ac)	Fire Intensity (Btu/ft/s)	Percent Topkill	Percent Foliage Remain. (ntk)	Percent Root Kill
Winter 93**	Y	H	85	11	16	4436	5645	100		0
Winter 93	W	H	62	30	10	3070	1005	36	39	0
Winter 95	Y	H	74	23	8	2665	358	68	24	0
Summer 92	W	H	92	27	5	2675	1076	93	27	1
Summer 94	Y	H	88	33	7	3396	1076	86	13	2
Winter 91	W	L	58	28	10	2188	62	7	79	3
Winter 93	W	L	65	24	9	1375	139	13	59	2
Winter 95	W	L	55	37	9	2854	48	16	66	1
Winter 95	Y	L	59	36	6	2308	116	17	42	0

All values are avg. of 3 plots, except (**) which was a single, unreplicated plot.

Y = Y Ranch, W=Waggoner Ranch, H=High Intensity, L=Low Intensity, ntk=non-topkilled trees.

Data are from Ansley et al. (1998a, 1998b).

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