

Mesquite savanna development using low-intensity fires and Reclaim herbicide

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Introduction

Mesquite in dense thickets reduce grass production and make livestock management more difficult. To compound the problem, treatments which top-kill mesquite, such as chaining, shredding, high-intensity fires, or herbicides such as 2,4,5-T or triclopyr (Remedy), stimulate regrowth from stem bases and increase stem number per plant and per land area (Fisher et al. 1959).

An alternative strategy may be to manage for a "mesquite savanna", or a grassland with a low density of taller trees. The mesquite savanna offers a middle ground between maximizing benefits while minimizing negative effects of this species (Jacoby and Ansley 1991). Mesquite may enhance soil fertility by nitrogen fixation. Plant species diversity often is enhanced because growth of some grasses, shrubs and forbs are better beneath mesquite canopies than in open spaces. A mesquite savanna may enhance wildlife habitat over open grassland alone and optimizes a multiple use strategy of livestock and wildlife production (Fulbright 1997). The savanna option may provide sustainable ecological and economical productivity while minimizing management and maintenance costs.

The tactical goal for savanna management would be to reduce density of thickets to some "moderate" level, yet maintain the upright growth form of remaining mesquite. Fire may accomplish such a goal if fireline intensity is low enough so as to not top-kill the larger mesquite, yet sufficient to top-kill or possibly root-kill the smaller mesquite. Another treatment which has potential for mesquite savanna development is a low rate of Reclaim (clopyralid) herbicide. Use of clopyralid alone has been observed to root-kill some mesquite, but surviving plants usually have "stem flagging" in which portions of the canopy foliage survive (Jacoby and Ansley 1991). The remaining foliage on stem-flagged mesquite may exert apical dominance and prevent sprouting from stem bases.

Our objective was to examine the potential of low-intensity fires and a low rate of clopyralid herbicide to convert mesquite thickets into savannas. Specific hypotheses were: (1) low-intensity fires or a low rate of clopyralid will achieve the thicket-to-savanna objective by achieving a moderate (i.e., 20 to 40%) level of top-kill and root-kill, and (2) repeated low-intensity fires are more effective than single low-intensity fires in achieving the thicket-to-savanna objective.

Methods and Materials

Low-intensity fires were conducted on 2 clay loam sites in north Texas: Ninemile pasture on the Waggoner Ranch south of Vernon, and River pasture on the Y Ranch west of Crowell. Mesquite at both sites were multistemmed, but plants at River pasture were shorter (1-3 m) than those at Ninemile (1-6 m tall). Primary grasses at Ninemile are Texas wintergrass (*Nassella leucotricha*), buffalograss (*Buchloe dactyloides*) and meadow dropseed (*Sporobolus asper*). Primary grasses at River pasture

are tobosagrass (*Hilaria mutica*) and buffalograss. Livestock grazing was excluded at Ninemile since 1986 and River pasture since 1994.

Effects of single low-intensity winter fires (burned mid-January to mid-March) were evaluated at Ninemile in 1991 (W91), 1993 (W93) or 1995 (W95), and at River pasture in 1995 (W95). Effects of repeated low-intensity fires in 1991 and 1993 (W91+W93) and 1991, 1993 and 1995 (W91+W93+W95) were evaluated at Ninemile. Another treatment involving alternate-season low-intensity fires in winter 1993, summer 1993 and winter 1996 (W93+S93+W96) was also tested. Each treatment had 3 replicate plots, each 1-2 ha.

Fires were conducted as headfires under high humidity, and/or low air temperature to suppress fire intensity. Herbaceous fine fuel amount (litter + standing crop), fuel moisture content, wind speed and direction, air temperature, and relative humidity (RH) were measured prior to each fire. Mesquite were evaluated in each plot for root-kill, top-kill, and foliage remaining (as a percentage of pre-burn amounts) on non-topkilled trees during the growing season following each fire. Percent top-kill was defined as the percent of trees in a stand that had complete above ground mortality and included dead trees and those with basal regrowth.

Plots of 1/4 lb/ac clopyralid were established on the Y Ranch on 08 July 1994 and in Big Kite Trap on the Waggoner Ranch on 02 July 1996. Each site had 4 replicate plots of 20 (Y Ranch) and 10 (Waggoner ranch) acres per rep. Treatments were applied by fixed-wing aircraft at 4 gallons total volume per acre. Diesel oil-to-water emulsion was 1 to 6.8 (0.5 gallons diesel per acre). No surfactant was used. Soil temperatures at 18 inches were 81 (1994) and 83 F (1996). Air temperatures ranged from 80 to 90 F during spraying. Foliage conditions were rated as good to excellent but soil moisture was dry during both dates. Evaluations of mesquite percent top-kill, root-kill and non-topkill (stem flagged trees) were conducted 2 or 3 years following treatment.

Results

Low-Intensity Fire Effects

Low-intensity winter fires were conducted at air temperatures between 13 and 23°C (55-73°F) and relative humidities between 25 and 37% (Table 1). Mean fine fuel ranged from 1540 to 4805 kg/ha at Ninemile and averaged 2585 kg/ha at River pasture. Mean wind speed ranged from 10.2 to 16.1 km/hr (6.3 to 10 mph).

Single low-intensity winter fires achieved mesquite top-kills ranging from 7 to 17% (Table 1). Top-kill increased to 23 and 26% following two (W91+W93) or three low-intensity winter fires (W91+W93+W95), respectively, but root-kill remained less than 5%. Hypothesis 1 was rejected because single low-intensity winter fires did not achieve the objective of 20 to 40% top-kill or root-kill. In the alternate-season fire

Table 1. Weather, fuel and mesquite response data from low-intensities fires at Ninemile (NM) and River (RV) pastures, in north Texas. Means of 3 treatment replicates (\pm SE).

Site	Treatment	Air Temp °C	RH %	Wind Kph	Fine Fuel kg/ha	Mesq. Top-kill %	Mesq. Foliage Remain. Ntk %
NM	W91	14.4	29	16.1	2450	7 (4)	83 (2)
NM	W91+W93	19.4	32	11.3	2339	23 (13)	49 (6)
NM	W91+W93+W95	18.1	30	11.3	2779	26 (8)	43 (3)
NM	W93	18.3	25	14.5	1540	13 (4)	59 (7)
NM	W93+S93	32.2	34	12.1	1643	15 (11)	46 (9)
NM	W93+S93+W96	23.0	35	10.5	4805	77 (3)	23 (7)
NM	W95	13.0	37	15.3	3196	16 (8)	66 (4)
RV	W95	15.0	36	10.2	2585	17 (5)	42 (4)

Ntk= non-topkilled trees. Data are from Ansley and Jacoby 1998.

treatment, two low-intensity fires in the same year (W93+S93) did not achieve 20% top-kill. The third fire (W93+S93+W96) far exceeded the 40% top-kill goal with 77% top-kill and essentially converted the stand to a basal sprout thicket. Fine fuel of 4805 kg/ha during the third fire (W96) yielded a higher fire intensity and produced a greater top-kill than was desired.

With these results, part of Hypothesis 2 was not rejected because two of the repeated low-intensity fire treatments, W91+W93 and W91+W93+W95, were more effective than single low-intensity fires in achieving a moderate (20 to 40%) level of top-kill. However, part of Hypothesis 2 was rejected because the other two repeated low-intensity fire treatments (W93+S93 and W93+S93+W96) failed to achieve the 20-40% top-kill goal. Moreover, none of the repeated low-intensity fire treatments reduced stand density.

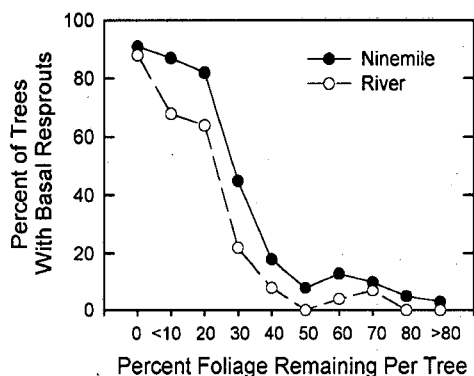


Figure 1. Percent of trees within each "foliage remaining" class (x-axis) which have substantial basal sprouting (i.e., more than 3 basal sprouts). Foliage remaining class is the amount of foliage remaining on trees following low-intensity fires as a percentage of their original pre-burn foliage (Data from Ansley and Jacoby 1998).

Average foliage remaining on non-topkilled trees ranged from 42 to 83% following single low-intensity winter fires (Table 1). Most trees that were partially defoliated by low-intensity fires retained foliage in the upper portions of the canopy, but lower-positioned canopy growing points and secondary branches were killed. Primary support stems survived; however, the appearance of the partially defoliated trees was similar to that of a browse-line created by herbivores.

Amount of foliage buds that survived each fire had direct bearing on whether the trees basal sprouted or maintained apical dominance during the growing season following the fire. A threshold in resprouting response occurred at 30-40% of foliage remaining per tree, and this was determined at both the Ninemile and River pasture sites (Figure 1). Below this threshold (i.e., if only 0 to 20% of preburn foliage amounts per tree remained intact) abundant basal sprouting was common. Above the threshold (i.e., if at least 40% of preburn foliage remained intact), over 80% of the trees had little or no sprouts.

Foliage remaining per non-topkilled tree decreased from 83 to 49 and 43% with second and third winter fires, respectively (W91+W93 and W91+W93+W95), and from 59 to 46 to 23% by a winter-summer-winter combination (W93+S93 and W93+S93+W96) (Table 1). With the exception of the W93+S93+W96 treatment (reasons explained earlier), remaining foliage of non-topkilled trees remained above the 30-40% threshold needed to maintain apical dominance.

Effects of low rates of Clopyralid

Clopyralid alone at 1/4 lb/ac produced 12 and 29% root-kill and 21 and 52% top-kill at the Y Ranch at Big Kite Trap sites, respectively. While foliage remaining on non-topkilled trees was not evaluated, percent of trees that had stem flagging and no basal sprouting was 62 and 32% at the Y Ranch and at Big Kite Trap sites, respectively. Thus, apical dominance was maintained on 70% (62/88) of surviving trees at the Y Ranch and 45% (32/71) of surviving trees at Big Kite Trap.

Discussion

Repeated low-intensity winter fires appear to be ideally suited as a first step toward conversion of mesquite thickets to savannas. These fires modified the vertical distribution of mesquite foliage by reducing foliage per tree, yet apical dominance was maintained. With less leaf mass, savanna mesquite will be less competitive with grasses compared to mesquite thickets. While the desired level of foliage remaining per non-topkilled trees was not specified at study initiation, data from Fig. 1 suggests that a range of 30 to 60% should be high enough to maintain apical dominance, yet low enough to reduce mesquite competition with grasses (to be quantified). Creating a mesquite savanna from thickets using low-intensity fires will take time and should be part of a long-term management plan. We estimate that three to four fires in a 10 to 15-year period will be needed. Repeated low-intensity fires should prevent increases in density by maintaining suppression of shorter, top-killed mesquite and killing some seedlings and seeds on the

ground. However, low-intensity fires alone did not root-kill mesquite. Use of individual plant treatment with herbicides or mechanical grubbing may be necessary to reduce stand density, but at increased cost.

Prescription for low-intensity savanna fires

Winter low-intensity fires that produced the desired "savanna" effect on mesquite were successfully conducted at the Ninemile site within fine fuel levels of 1500 to 3200 kg/ha (1350 to 2850 lb/ac), air temperatures between 13 and 20°C (55-68°F), relative humidities between 30 and 40%, and wind speeds from 10 to 16 km/hr (6 to 10 mph) (Table 1). Herbaceous fine fuels greater than 4000 kg/ha (3560 lb/ac), or RH less than 30% under most fuel amounts generated top-killing fires. Moderate wind speed was needed to move low-intensity flame fronts because fires were conducted under relatively high RH and low air temperatures. Low-intensity headfires were conducted in mornings, when air temperatures were cooler and RH

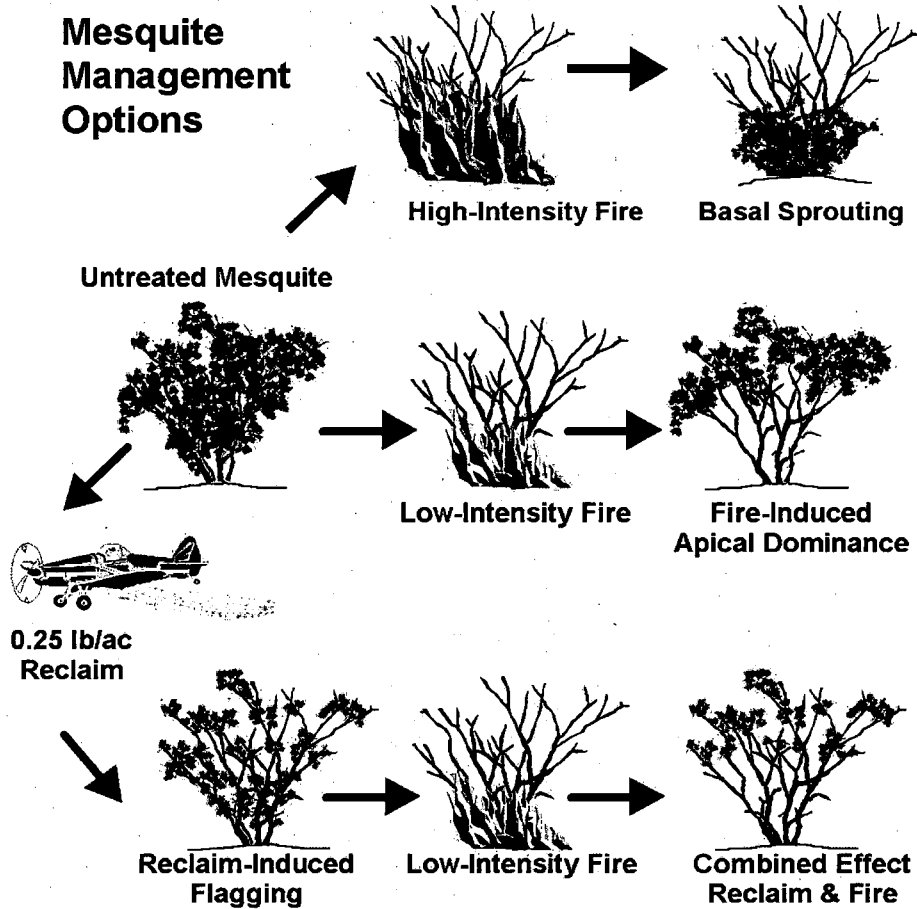


Figure 2. Illustration depicting effects of high and low-intensity fires and a low rate of Reclaim (clopyralid) followed by low-intensity fires on mesquite canopy foliage and basal sprouting.

was higher, than during afternoons. Under low fine fuels (1000-2000 kg/ha), some savanna fires were successfully conducted in afternoons, or when wind speeds were higher (12-20 km/hr). Conditions required for low-intensity headfires are very similar to those recommended by Wright and Bailey (1982) for burning perimeter fireguard areas (i.e., blacklines) prior to burning a large area, with the exception that we desired higher wind speed to move the flame front.

Clopyralid effects

The current broadcast recommendation of a mixture of clopyralid and triclopyr (Remedy) herbicide achieves adequate root-kill and surviving plants are top-killed by the triclopyr. This treatment is favored by livestock-only producers who seek to restore pastures to grassland. In time, however, surviving mesquite will become multistemmed regrowth and must be re-treated.

In contrast, stem-flagged mesquite, achieved by spraying clopyralid alone, have less leaf area and are less competitive with forage grasses than before treatment. Stem flagging also preserves apical dominance within the plant and inhibits basal resprouting. Over time, mesquite that survive clopyralid treatments will be few-stemmed, have elevated and not basal canopy foliage, and will remain less of a problem than they were before treatment.

Savanna mesquite created with low rates of clopyralid have potential for optimizing forage production for cattle and screening cover for wildlife habitat. This treatment yields moderate root-kill and surviving plants tend to be stem sprouters. Stem flagging provides some screening cover for wildlife, yet mesquite foliage is reduced enough to increase forage production for livestock. The optimum rate of clopyralid if used for such a management goal appears to be 1/4 or possibly 3/8 lb/ac as other research has found that 1/2 lb/ac achieves high root-kill and top-kill (Jacoby and Ansley 1991).

Figure 2 depicts effects of a high-intensity top-killing fire (top), a low-intensity savanna fire (middle), and a low rate of clopyralid followed by a low-intensity fire on mesquite foliage and structure (bottom). High-intensity fires will provide temporary suppression of mesquite before basal sprouting dominates. Low-intensity fires typically reduce some lower foliage but maintain apical dominance. Upper foliage is largely untouched and from the air, these trees would not appear much different than unburned trees. Thus, if round-up of livestock is performed by helicopter, low-intensity savanna fires do not offer as much of an advantage when compared to high-intensity fires. The bottom of Figure 2 illustrates the hypothesis that combining an initial low-rate of clopyralid with a subsequent low-intensity fire will thin foliage to the maximum level (30-40% of initial levels), yet still maintain apical dominance. The herbicide/fire option should accelerate mesquite savanna development over use of fire alone. Studies on the Y Ranch and Waggoner Ranch were established to test this hypothesis.

Conclusions

Low-intensity fires and Reclaim (clopyralid) at 1/4 lb/ac rate facilitated conversion of mesquite woodlands to savanna by reducing mesquite foliage and preserving apical dominance.

Behavior of low-intensity fires was predictable and primarily a function of relative humidity, air temperature and fine fuel. Unlike clopyralid, low-intensity fires did not reduce stand density. Thus, a follow-up treatment with herbicides to kill small mesquite or use of repeated low-intensity fires to maintain suppression of small mesquite is necessary.

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