Height Replacement of Selected Woody Plants Following Burning or Shredding

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SUMMARY

Woody plant reinvasion of tame pastures and native rangeland is a severe problem on the South Texas Plains. Shredding and/or prescribed burning may be employed as low-cost methods for suppressing woody plants, and rate of topgrowth replacement indicates how often these maintenance practices must be repeated. Honey mesquite and twisted acacia attain their pretreatment heights within the first year after shredding or burning. Blackbrush acacia regrowth attains pretreatment height by midway through the second growing season following burning. Whitebrush, lotebush, spiny hackberry, and Carolina wolfberry attain half their pretreatment heights in 10 months or less after shredding. Most other species, including blackbrush acacia, catclaw acacia, and guayacan, attain pretreatment heights within two growing seasons after shredding. Based on these regrowth rates, forage responses to the treatments, and long-term weather patterns on the South Texas Plains, it appears that burning or shredding regrowth of mixed-brush stands should be scheduled at intervals of 3 to 5 years.

INTRODUCTION

Woody species such as honey mesquite (*Prosopis glandulosa* var. *glandulosa*), blackbrush acacia (*Acacia rigidula*), and twisted acacia (*Acacia tortuosa*) aggressively reinfest rangeland and pastures in the South Texas Plains following initial brush control practices (Scifres 1980). These woody plants are commonly suppressed by shredding, treatment of individual plants with herbicides, and power grubbing. Of particular concern to livestock producers are infestations of woody plant regrowth following rootplowing and establishment of buffelgrass (*Cenchrus ciliaris*) or Coastal bermudagrass (*Cynodon dactylon*) pastures.

The potential of fire to suppress woody plants is reported by numerous authors (Sauer 1950, Humphrey 1958, Box et al. 1967, Daubenmire 1968, Scifres 1980) and has received recent attention because of rising costs of fuel, labor, and equipment associated with mechanical practices, and rising costs of herbicides and their application (Scifres 1978). Cool-season prescribed burns hold promise for effectively suppressing woody plants to levels which allow improved forage responses from pastures. Although few woody plants are killed by cool-season burns, the live topgrowth is usually reduced to near ground level and forage production is temporarily increased (Hamilton and Scifres 1981).

Because most brush species resprout from dormant basal buds following burning or shredding, optimal forage production and brush suppression can be maintained only by periodic retreatment (Scifres 1980). For example, Scifres and Haas (1974) reported about 12 sprouts per stump at 1 year after removal of post oak (*Quercus stellata*) tops. Sprouts averaged 94 centimeters (cm) in height and were about 4 cm in diameter at the base. They also noted differences in regrowth potential of various woody species of the Post Oak Savannah, but concluded that unless maintenance brush control is practiced, the brush stands can be expected to recover from mechanical top removal within 5 to 7 years following initial treatment.

Mutz et al. (1978) conclude that shredding or roller chopping must be repeated at 3- to 5-year intervals for satisfactory improvement of rangeland infested with mixed brush on the Coastal Prairie. They suggest prescribed burning to maintain initial brush suppression from shredding or roller chopping. Huisache

(*Acacia farnesiana*) had increased in canopy cover by 25 and 11 percent on shredded and on roller chopped plots, respectively, in 14 years after treatment compared to an increase of only 4 percent on untreated areas. This was attributed to the rapid regrowth of huisache, which may attain half its pretreatment height within 5 months after top removal (Powell et al. 1972).

Although shredding is widely practiced on the South Texas Plains and prescribed burning is gaining in popularity, no research has reported regrowth rates of woody plants subjected to these treatments. The objectives of this study are to (1) document and compare times required for height replacement of selected woody plants following burning or shredding, and (2) compare height increase following burning to that of unburned plants of the same species.

DESCRIPTION OF STUDY SITES

Burned Site

The experiment was conducted approximately 14 kilometers (km) south of Encinal, Texas, on an area typical of the west-central South Texas plains. Average annual precipitation at the study site is about 50 cm, with peaks occurring in May and September. The growing season is about 270 days long, with mild winters and hot summers.

Soils of the study area are of the Copita series (Ustollic calciorthid). The fine, loamy soil is moderately deep, moderately permeable, calcareous, and underlain by sandstone (Stevens and Arriaga 1977). The topography is gently rolling with slopes generally less than 3 percent. The Copita soil is included in a Gray Sandy Loam range site.

The experimental area was rootplowed, raked, and broadcast-seeded to common buffelgrass in about 1967. At initiation of this research in 1977, woody plant regrowth on the study area was primarily honey mesquite, blackbrush acacia, and twisted acacia. These species averaged 1, 1.2, and 1.6 meters (m) tall, respectively, and collectively accounted for more than 95 percent of the woody plant canopy cover. Other woody species present in the area included desert yaupon (*Schaefferia cunefolia*), leatherstem (*Jatropha dioica*), whitebrush (*Aloysia lycioides*), lotebush (*Zizyphus obtusifolia*), Berlandier wolfberry (*Lycium berlandieri*), spiny hackberry (*Celtis pallida*), guayacan (*Porlieria angustifolia*), and tasajillo (*Opuntia leptocaulis*). Woody plant canopy cover on the area averaged 8 percent prior to the burn.

Shredded Site

The shredding experiment was conducted near Campbellton, Texas, about 80 km south of San Antonio. The site supported a heavy cover of mixed brush and was composed of roughly equal proportions of Claypan Prairie, Rolling Blackland, and Shallow range sites. Kitchen et al. (1980) presented detailed soil descriptions by site.

The Claypan Prairie range site is typified by Laparita soils on nearly level to gently sloping uplands in close proximity to small drainages. Slopes are usually less than 1 percent but occasionally increase to 3 percent. Soils are sandy clay loams overlying clay loam subsoils which gradually increase in clay content with increasing depth (Kitchen et al. 1980). The soils are acidic on the surface and slightly acidic at lower depths.

The Rolling Blackland range site is characterized by Monteola clay soils on gently undulating slopes ranging from 0 to 8 percent. Monteola soils are deep and homogeneous. Soil texture is 49 percent clay in the surface 3 cm and increases to 56 percent at 46 cm. Soil reaction is neutral to slightly basic, becoming more alkaline at lower depths (Kitchen et al. 1980).

Fashing clay soils with sandy clay loam surface soils overlying clay subsoils 13 to 50 cm thick typify the Shallow range site on the upland portions of the study area. These soils are on gently sloping to sloping convex surfaces having gradients of 1 to 5 percent. Solum thickness ranges from 25 to 50 cm and the range in thickness is common within a horizontal distance of less than 6 m. The soil texture throughout the soil profile is a clay loam or clay. The soil is mildly alkaline to moderately alkaline and calcareous (Kitchen et al. 1980).

All sites on the study area appear to have a claypan at a depth of 30 to 46 cm. This claypan is most prominent on the Claypan Prairie site.

MATERIALS AND METHODS

Burning Study

The study area was burned February 7, 1977, with a maintenance fire for suppression of woody plants and minimum risk of damage to common buffelgrass, the primary herbaceous species present. Grazing use of the plots by livestock was deferred for 60 days following the burn. The area was then grazed at a stocking rate of approximately 1 animal unit/8 hectares (ha) for 17 months. Grazing was again deferred for 10 months and the area was then grazed at the same stocking rate until termination of the study. Rainfall was recorded as the amount accumulated in a rain gauge between sampling periods.

The experiment was designed as a randomized complete block design with two replications. The fire plan employed a headfire following backfiring of the lee sides of the plots (Scifres 1980). Four permanently-marked belt transects, 3.7 by 61 m, were established prior to the burn in each 1.8 ha plot. Woody plant height was measured in each belt prior to burning and at approximately 4, 6, 10, 17, 23, 27, and 33 months following the fire. Plant height was measured

as the distance from soil surface to the uppermost, live growing tip on each plant in the belts. A similar method for measuring height of huisache to estimate growth rate was used by Powell et al. (1972). At the same times heights were measured, canopy diameters at the point of maximum spread were recorded by species, and the number of live plants of each species was recorded.

In most studies, canopy diameter is used to assess the impact of woody plant regrowth on the range plant community. The validity of using height to express the influence of woody plants is evaluated in this study. The relationship between plant height and canopy diameter by species is evaluted based on the functional relationship, $Y = a+bX$ where Y = canopy diameter as a percentage of preburn diameter, and X = plant height as a percentage of preburn height. Height replacement following burning was best represented by the functional relationship $Y = a+b(\log X)$, where Y = height as a percentage of preburn height and X = time (months) after burning. Differences in b-values (slope) between equations from the burned and unburned areas were evaluted with a t-test at the 5 percent level of probability (Steel and Torrie 1962).

Height replacement comparisons among species were based on the predicted time required for regrowth to attain half the pretreatment height (Ht_{50}) and total pretreatment height (Ht_{100}). Height increases between burned and unburned plants were compared by testing differences in slopes of the regrowth response curves.

Shredding Study

Eight permanent, circular plots (15.6 m diameter) were established on each range site, and the plots were shredded with a drag-type shredder in February 1976. At 4, 6, 8, 18, and 24 months after shredding, heights of woody plant regrowth were recorded by species as described for the burning study. Numbers of individuals measured varied from as few as three (lotebush, Rolling Blacklands) to 38 (spiny hackberry, Claypan Prairie) with 15 as the average. The heights as percentage of heights before shredding were regressed against time (months) as the independent variable with the functional relationship, $Y = a+b(\log X)$. Comparisons of height replacement among species were based on predicted time required for replacement of half the pretreatment height (Ht_{50}).

Rainfall on the study area was monitored with a rain gauge. The study site was deferred from grazing for 6 months following shredding. Thereafter for the duration of the study, the pasture was stocked with cows, or cows and calves, at 1 animal unit/9 hectares.

RESULTS AND DISCUSSION

Height Replacement Following Burning

Height replacement is considered a valid comparative index of the relative influence of brush regrowth on the range plant community. More than 96 percent of the variation in canopy diameters of honey mesquite, blackbrush acacia and twisted acacia could be accounted for by measurements of height change. Therefore, only

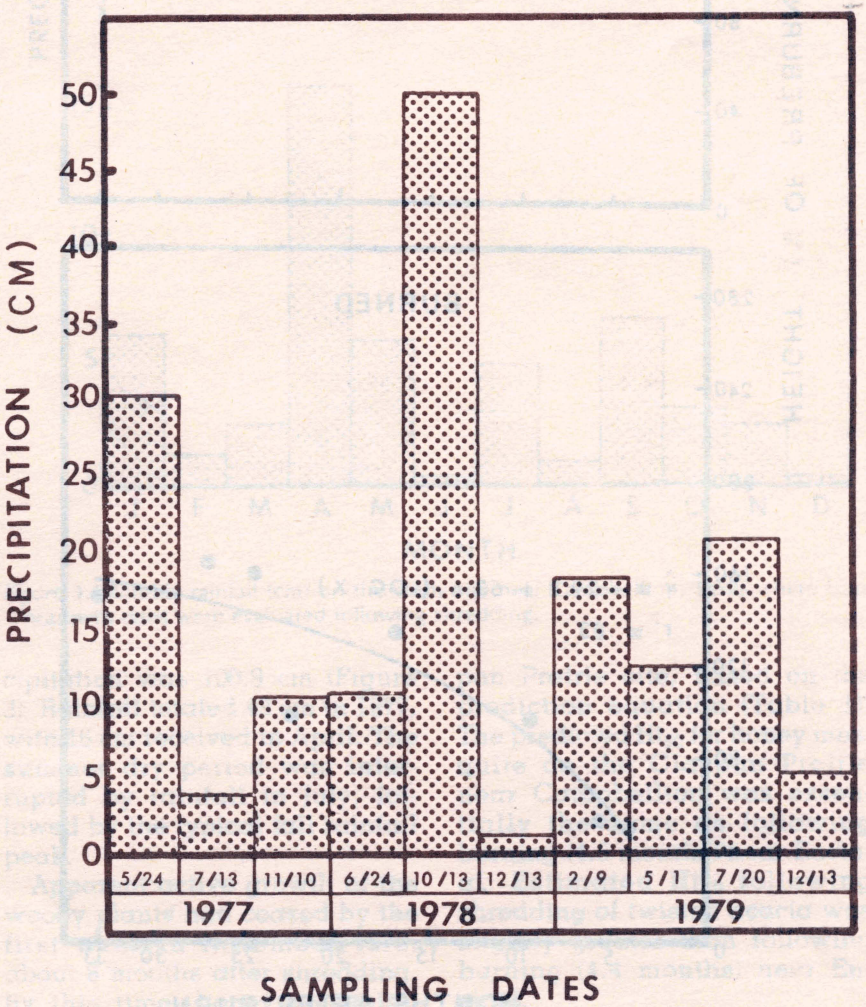

Figure 1. Rainfall (cm) accumulated for the sampling periods following burning of brush-infested buffelgrass stands near Encinal, Texas in February 1977.

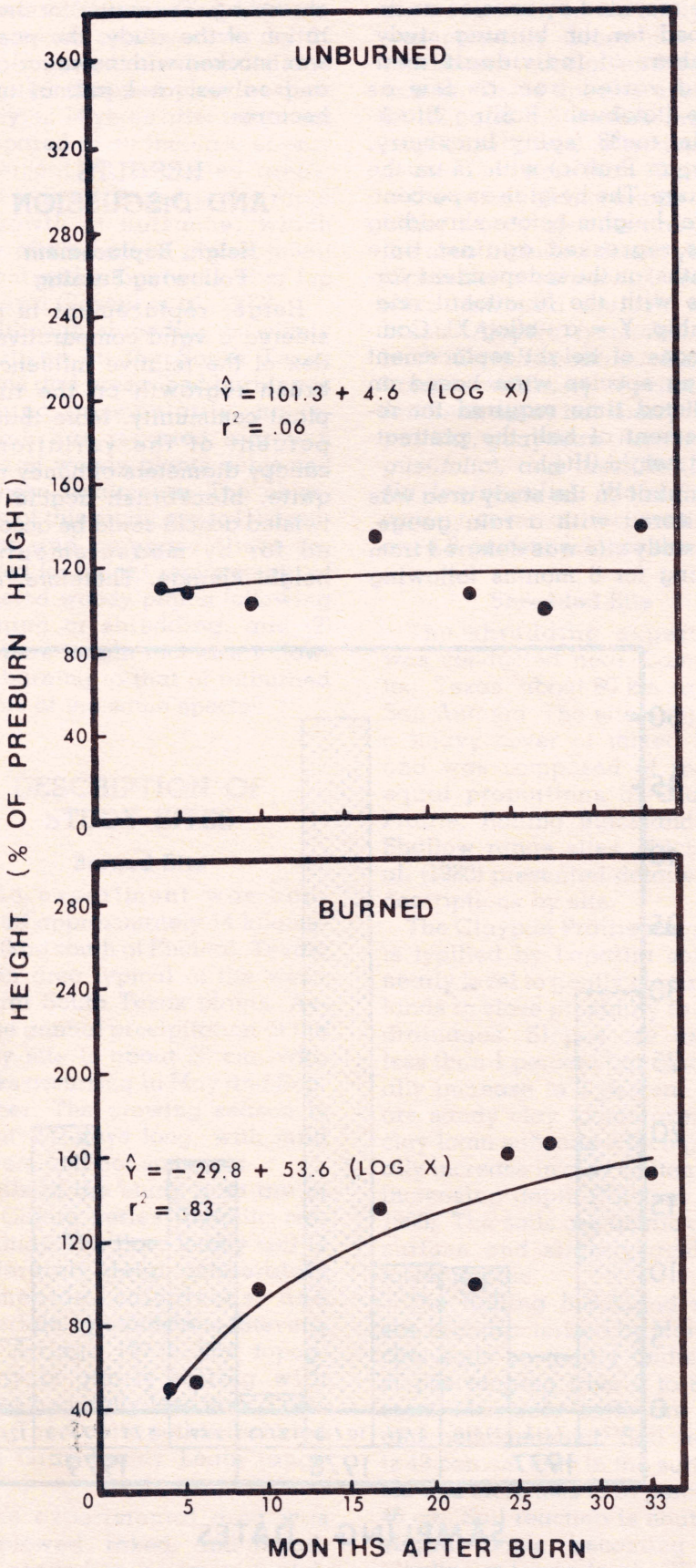

Figure 2. Change in height (as a percentage of initial height) of twisted acacia following burning in February 1977 near Encinal, Texas.

height replacement data are reported.

These data do not reflect absolute rate of growth of woody plants on the burned plots but indicate a rate of height replacement based on total pretreatment heights. There were a few plants of each species in the belt transects that were not top killed by the fire. Since cool-season burns will typically leave some woody plants unaffected, the time required for brush populations to return to total pretreatment height is the most practical measurement.

Marginal conditions at the time of the burn, including low fine fuel load (1,140 kilograms per hectare [kg/ha]), low wind velocity (8 to 13 kilometers per hour [km/hr]), high relative humidity (89 percent), high fine fuel water content (23 percent), and poor fine fuel continuity, resulted in a relatively "cool" fire. Fine fuel discontinuities were most prevalent adjacent to the older, larger woody plants. However, an estimated 80 percent of the surface area within the plots was blackened by the burns, and a high percentage of woody plants suffered visible fire damage. Average maximum temperature at 15 cm above soil surface during the burns was 225 degrees centigrade (°C) (Hamilton and Scifres 1981).

Rainfall distribution during 1977 and 1978 of the study period was typical for the area, with peaks during the spring and fall and relatively dry summer and winter seasons (Figure 1). Total amount of rainfall during the study period was near the 20-year average for the area. However, practically all the 1979 rainfall occurred in the first 6 months of the year.

Predicted times required for honey mesquite to attain half its pretreatment height (Ht_{50}) and to replace its full pretreatment height (Ht_{100}) following burning were 4.5 months and 7.8 months, respectively. The prediction equations accounted for 82 and 92 percent of the variation in

height change as related to time of measurement for the unburned and burned honey mesquite, respectively. According to a t-test ($P \leq .05$), burning did not affect honey mesquite height increase for the time of evaluation in this study.

The predicted Ht_{50} following burning of blackbrush acacia was 7.8 months, and the Ht_{100} was 19.3 months. As with honey mesquite, the prediction equations accounted for 87 pecent of the variation in height change of blackbrush acacia. Burning did not affect height increase based on comparison with unburned blackbrush acacia. Blackbrush acacia height replacement was slower than that of honey mesquite, regardless of treatment.

The predicted Ht_{50} for burned twisted acacia was 4.4 months, while Ht_{100} was 11.3 months. Although 83 percent of the variation in rate of twisted acacia height change could be explained by time of measurement on burned plots, only 6 percent of the variation was attributed to the relationship on unburned areas (Figure 2). The low coefficient of determination and insignificant slope on the unburned plots indicate that height of twisted acacia had stabilized on the site. Scifres (1980) describes twisted acacia as a low growing shrub, usually less than 1.8 m tall. The twisted acacia plants in the study area averaged 1.6 m in height prior to the burn, additional evidence that twisted acacia on the unburned plots had stabilized in height in the time since root plowing. This would explain why height increase on burned and unburned plots was significantly different ($P \leq .05$).

Height Replacement Following Shredding

Average annual precipitation near Campbellton is about 51 cm. The year of shredding, 1976, was characterized by a relatively dry winter, but rainfall from April through October totaled 79 cm, and the annual precipitation was 100.9 cm (Figure 3). Rainfall totaled 49 cm in 1977, with 16 cm received in April. The summer dry period was interrupted by rainfall in July, followed by the typical fall rainfall peak.

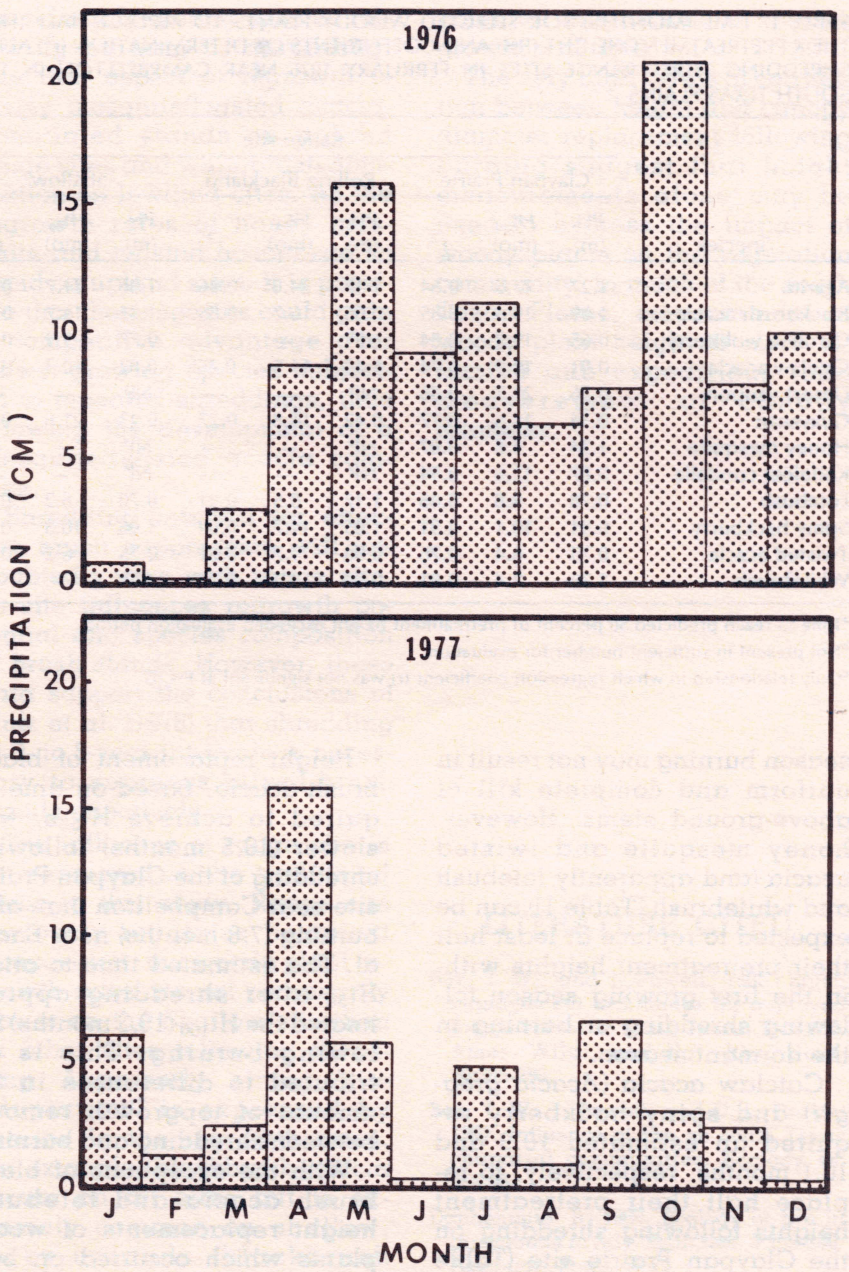

Figure 3. Monthly rainfall (cm) on the study site near Campbellton, Texas where brush regrowth rates were evaluated following shredding.

Apparent active growth of the woody plants had ceased by the first week in November 1976, about 8 months after shredding. By this time, honey mesquite, lotebush, twisted acacia, and whitebrush had regrown to half their initial height on the Claypan Prairie site, based on the prediction equation (Table 1). The predicted Ht_{50} for honey mesquite on the Claypan Prairie near Campbellton was essentially the same as following burning (4.5 months) near Encinal. Estimated Ht_{50} following shredding of twisted acacia was slightly greater than following burning (4.4 months) near Encinal.

Whereas shredding uniformly removes the aerial portions of the twisted acacia plants, cool-

TABLE 1. TIME (MONTHS) FOR SELECTED WOODY PLANTS TO REPLACE HALF (Ht_{50}) THEIR PRETREATMENT HEIGHT (PH) AND COEFFICIENTS OF DETERMINATION (r^2) AFTER SHREDDING THREE RANGE SITES IN FEBRUARY 1976 NEAR CAMPBELLTON IN THE SOUTH TEXAS PLAINS

	Range site								
	Claypan Prairie			Rolling Blackland			Shallow		
Species	PH (m)	Ht_{50} (mo)	r^2	PH (m)	Ht_{50} (mo)	r^2	PH (m)	Ht_{50} (mo)	r^2
Agarito	1.27	17.0	0.84	1.17	24.0[a]	0.86	1.06	21.7	0.84
Blackbrush acacia	1.09	19.5	0.85	0.06	16.7	0.88	1.12	14.7	0.62
Carolina wolfberry	0.65	19.8	0.84	NP[b]	—	—	0.77	9.3	0.94
Catclaw acacia	0.91	10.9	0.74	1.15	14.5	0.45[c]	0.82	10.3	0.69
Desert yaupon	0.26	21.7	0.86	NP	—	—	NP	—	—
Guayacan	0.34	14.6	0.77	0.42	14.8	0.77	0.43	21.6	0.72
Honey mesquite	1.34	4.8	0.87	NP	—	—	NP	—	—
Knifeleaf condalia	0.87	12.6	0.94	NP	—	—	NP	—	—
Lotebush	0.78	9.8	0.86	1.17	8.5	0.81	0.70	6.2	0.76
Spiny hackberry	0.91	10.1	0.91	1.05	14.7	0.89	1.06	10.3	0.84
Twisted acacia	0.73	6.4	0.76	0.98	9.7	0.81	0.75	6.2	0.79
Whitebrush	1.30	7.4	0.81	0.99	8.1	0.77	NP	—	—

[a]Time to reach predicted 50 percent of pretreatment height exceeded evaluation period.

[b]Not present in sufficient number for evaluation.

[c]Only relationship in which regression coefficient (r) was not significant at $P \leq .05$.

season burning may not result in uniform and complete kill of above-ground stems. However, honey mesquite and twisted acacia (and apparently lotebush and whitebrush [Table 1]) can be expected to replace at least half their pretreatment heights within the first growing season following shredding or burning in the dormant season.

Catclaw acacia (*Acacia greggii*) and spiny hackberry required an estimated 10.9 and 10.1 months, respectively, to replace half their pretreatment heights following shredding on the Claypan Prairie site (Table 1). Although the estimated time for achieving the Ht_{50} occurred in late fall, these species should probably also be considered in that group of woody plants with potential to regrow to half their initial height in the first growing season. Predicted Ht_{50}s for the remaining species evaluated on the Claypan Prairie site, agarito (*Berberis trifoliolata*), blackbrush acacia, Carolina wolfberry (*Lycium carolinianum*), desert yaupon, guayacan, and knifeleaf condalia (*Condalia spathulata*) occurred during the second growing season after shredding.

Height replacement of blackbrush acacia, based on time required to achieve Ht_{50}s, was slower (19.5 months) following shredding of the Claypan Prairie site near Campbellton than after burning (7.8 months) near Encinal. The estimated time to attain Ht_{50} after shredding approximated the Ht_{100} (19.3 months) following burning. This is attributed to differences in the amount of topgrowth removal between shredding and burning.

With the exceptions of blackbrush acacia and lotebush, height replacements of woody plants which occurred on both sites tended to be slower on the Rolling Blackland than on the Claypan Prairie site. Most rapid growth on both sites occurred with lotebush, twisted acacia, and whitebrush, with slower growth rates for blackbrush acacia, catclaw acacia, and guayacan (Table 1).

Agarito replaced its height the most slowly of plants evaluated on the Rolling Blackland site (Table 1). Agarito regrows from a discrete crown following top removal, and the regrowth may be heavily browsed by white-tailed deer (*Odocoileus virginianus*) (Scifres 1980). Browsing pressure could have been confounded with shredding effects in the evaluation of regrowth rates this study.

Scifres et al. (1974) reported honey mesquite regrowth in North Texas developed more slowly on Rocky Hill (shallow) sites than on Deep Upland range sites. That relationship did not hold true with other species in the study near Campbellton. Regrowth of twisted acacia, lotebush, catclaw acacia, Carolina wolfberry, and blackbrush acacia developed as rapidly or more rapidly on Shallow sites than on Claypan Prairie (deeper soil) sites. Moreover, regrowth of most of the woody species was replaced more rapidly on the Shallow than on the Rolling Blackland range site. The only exception was guayacan, which was predicted to replace half its initial height on Claypan Prairie and Rolling Blackland sites by 14.6 and 14.8 months, respectively, after shredding, compared to an estimated 21.6 months for the Shallow site.

Management and Ecological Implications

Cool-season burns of brush-infested range or pastures will commonly result in some areas either not covered by the fire or affected by the fire to varying degrees of intensity. Movement of a fire through such areas is dependent on a number of variables. Inadequate fine fuel load in patches of heavy brush cover, for example, prevents the flame from reaching the woody plants. Poor fuel continuity, the influence of which is usually magnified by low wind velocity, can also leave unburned areas in spaces between brush plants or cause reduced fire temperatures in such spots. This variation associated with range burns is often desirable relative to quality wildlife habitat since it results in a vegetation "mosaic" (Scifres 1980).

Because of the behavioral characteristics of fire, woody

plant stands on burned areas may appear to recover more rapidly than on those areas treated with shredding or "scalping," which removes woody plant topgrowth to a uniform stubble height. The live, aboveground tissues of undamaged or mildly-damaged plants become an immediate part of postburn stands. Even after the second burning of an area, the accumulation of adequate fine fuel load and continuity, and selection of the optimal combination of environmental factors (wind velocity, relative humidity, fuel moisture content) will be critical for uniform suppression of woody plants. Managers are often concerned with the need to save "motts" of woody plants or unburned herbaceous material on range areas as a part of suitable habitat for game animals and birds (Box and Powell 1965). Thus, burning may be looked upon as an effective way to suppress woody plants while minimizing damage to wildlife habitat, and may be preferred over complete top-removal by such means as shredding.

These data indicate total preburn heights of species such as honey mesquite and twisted acacia were regained within one growing season after the fire, and others, such as blackbrush acacia, required less than two growing seasons. Planning frequency of burning treatment based on total height replacement would lead to intervals of burns between 1 and 2 years. This frequency is not reasonable in many parts of south Texas because of the low rainfall and extended periods of low forage production. A more practical approach to determining burn interval would be to use herbaceous forage production as an indicator. Hamilton and Scifres (1981) have shown that benefits of a single, cool-season burn may extend into the third growing season following the fire, depending upon soil water contents.

Height replacement varies considerably among species following burning or shredding. The first aspect of regrowth is honey mesquite/twisted acacia-dominated stands on upland range sites and whitebrush domination on lowland sites. As the regrowth rates of honey mesquite and twisted acacia are so rapid on upland sites, it is possible that these species could gain a competitive advantage over slower-growing species subjected to repeated shreddings, thus allowing the development of a mesquite/twisted acacia complex.

Shredding interval for effective brush suppression will undoubtedly vary with range site, as site influences regrowth potential and species composition of brush stands. However, these data support the conclusions of Mutz et al. (1978) that shredding at 3- to 5-year intervals is necessary to suppress mixed-brush stands effectively.

The influence of range site is not expressed in the traditional sense in this study. Range site obviously regulates botanical composition, but woody plant regrowth rates are not necessarily slower on the Shallow site than on other sites following shredding. Apparently, strong "site adaptation" is expressed by species in the regrowth rates. For example, blackbrush acacia occurs on all sites but is extremely common on shallow, rocky uplands (blackbrush acacia-guajillo ridges) in south Texas (Scifres 1980). Height replacement tends to be more rapid with blackbrush acacia on the Shallow than on the deeper sites. The same trend is apparent with Carolina wolfberry and lotebush. Other species such as guayacan exhibit the "typical" response, with regrowth being slower on the shallow sites than on the deeper site. Still other species such as catclaw acacia and spiny hackberry exhibit no apparent difference in height replacement among sites. These results indicate the need for more research to elucidate the potential interactions of species growth with site.

The very high levels of correlation between height and canopy diameter replacement following burning suggest that height measurements alone may be used to express the impact of woody plants on the vegetation community. In much of the south Texas Plains, measurement of woody plant height is more effective and expeditious than measurement of canopy diameter.

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Metric Units — English Equivalents

Metric Unit	English Equivalent
Centimeter	0.394 inch
Hectare	2.47 acres
Kilogram	2.205 pounds
Kilogram per hectare	0.893 pound per acre
Kilometer	0.62 statute mile
Kilometer per hour	0.62 mile per hour
Liter	0.264 gallon
Meter	3.28 feet
Square meter	10.758 square feet
(Degrees centigrade × 1.8 + 32	Degrees fahrenheit

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