Changes in Vegetation and Grazing Capacity Following Honey Mesquite Control

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Abstract

Honey mesquite kill and suppression, vegetation response, and changes in grazing use and capacity were evaluated following brush control in north-central Texas. Tree grubbing was most effective for eliminating honey mesquite, but because of soil and plant damage the treatment did not increase grazing capacity or improve range condition compared to nontreated rangeland. Aerial application of 2,4,5-T + picloram was more effective in killing and defoliating honey mesquite than 2,4,5-T alone, but both treatments significantly increased forage production. The 2,4,5-T + picloram and 2,4,5-T sprays provided a 7 to 16% increase in grazing capacity over a 4-year period on light and heavy honey mesquite infested pastures, respectively.

Nearly 6 million hectares in the Rolling Plains of Texas are infested with woody plants of low forage value (Smith and Rechenthin 1969). Honey mesquite *(Prosopis glandulosa* Torr. var. *glandulosa)*[1] is the most abundant woody invader having increased in density over the past century with drought, overgrazing, and the cessation of natural fires (Fisher 1948, Bogoush 1951, Rechenthin and Smith 1967). Chemical and mechanical control of honey mesquite has been used extensively throughout the Rolling Plains with the objective of reducing the size and number of plants and to promote secondary succession (Fisher 1977, Scifres 1980).

Thirty years of experience have shown that total eradication of honey mesquite is neither practical nor feasible. Several methods for controlling honey mesquite have been developed, however, and are widely used to maintain and increase forage production. Foliar applications of herbicides, such as 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and 2,4,5-T plus 4-amino-3,5,6 trichloropicolinic acid (picloram), usually "root-kill" only 25 to 40% of the honey mesquite plants (Fisher et al. 1972). Plants not killed by the herbicides develop new stems from previously defoliated branches or from the root crown (Young et al. 1948, Scifres et al. 1974). Prolific sprouting from the root crown can result in a multi-stemmed, shrubby growth requiring retreatment in 4 to 7 years (Scifres and Hoffman 1974). Grass response following spraying is most significant under the honey mesquite canopy and over a period of years expands into interspace areas between the plants (Brock et al. 1979).

Tree grubbing with a low energy crawler tractor equipped with a sharp, U-shaped blade attached to the front can eliminate over 90% of the honey mesquite by cutting roots 15 to 30 cm below the soil surface (McDaniel et al. 1978). Grasses growing beneath the canopy are often uprooted with the grubbed honey mesquite leaving a pit of bare exposed soil. Grubbing honey mesquite usually induces a lower seral stage of succession because of the disturbance of soil under the canopy area.

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[1]Scientific names follow Gould, F.W. 1975.

Spraying honey mesquite is expected to give maximum increases in grazing capacity the first 3 years, whereas mechanical control may not yield a return until after 3 or 4 years (Workman et al. 1965, Dahl et al. 1978, Wiedeman et al. 1977). Following interviews with range trained personnel, Whitson and Scifres (1980) reported an annual rate of return from aerial applications of 2,4,5-T on honey mesquite in the Rolling Plains to be from 12.7 to 16.9% over a 20-year planning horizon. Five to 9 years are required to recover the initial investment of aerial application of 2,4,5-T on deep soils, and 12 to 13 years are required on shallow soils. Tree dozed or grubbed areas seeded to a native mixture of adapted species require nearly three times the number of years to yield a return on the original investment compared to spraying 2,4,5-T.

The choice of which method to use for honey mesquite control is more complex than the treatment's ability to kill the plant or yield the greatest economic return. Environmental and management variables enter into the decision-making process making the choice of no single specific practice uniformly superior for every situation (Whitson and Scifres 1980). A brush control method which provides a favorable vegetation response and which allows an increase in red meat production is likely to be the preferred practice. The objective of this research was to evaluate changes in vegetation and grazing capacity following several different brush control techniques on light and heavy infested honey mesquite rangeland.

Study Area

Research was conducted within two 280-ha pastures located 37 km southwest of Vernon, Texas, on the W.T. Waggoner Ranch. Elevation is about 384 m above sea level and topography is a gently sloping upland plain typical of rangeland in northcentral Texas. Tillman clay loam soil, a member of the fine, mixed thermic family of Typic Paleustolls, is the dominant soil series (Koos et al. 1962). The soil has a noncalcareous brown silty clay loam surface horizon, a thick red argillic horizon, and becomes calcareous at depths greater than 60 cm (Rogers et al. 1976). The two study pastures, about 11 km apart, occupy areas classified as deep hardland range sites.

Normal annual rainfall is 65.2 cm, with May, June, and October being months with highest rainfall (USDC 1976). January and February are the driest months. The growing season is approximately 232 days (Koos et al. 1962).

Climax vegetation is representative of the honey mesquite/ lotebush/ mixed grass association (McDaniel 1978). Dominant midgrasses present are Arizona cottontop [*Digitaria californica* (Benth.) Henr.], Texas wintergrass (*Stipa leucotricha* Trin & Rupr), and sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.]. Buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] is the dominant shortgrass species. Sand dropseed [*Sporobolus cryptandrus* (Torr.) Gray], purple threeawn (*Aristida purpurea* Nutt.), hairy tridens [*Erioneuron pilosum* (Buckl.) Nash], and tumble windmill (*Chloris verticillata* Nutt.) have increased with grazing. Broadleaf plants which vary in importance depending on available soil moisture include common broomweed [*Xanthocephalum dra-*

cunculoides (DC.) Shinners], Texas filaree (*Erodium texanum* Gray), wooly plantain (*Plantago purshii* R & S. var. *purshii),* silvery leaf nightshade (*Solanum elaenifolium* Car.), and heath aster (*Aster ericoides* L.). Lotebush [*Condalia obtusifolia* (Hook.) Weberb.], tasajillo *(Opuntia leptocaulis* DC. var *leptocaulis),* and grassland prickly pear cactus (*Opuntia macrorhiza* Engelm.) are woody and succulent plants associated with honey mesquite dominated vegetation.

Materials and Methods

Replicated brush control treatments were applied in spring 1973 in a randomized complete block design. Each treatment was applied to two blocks 503 m long by 128 m wide. Honey mesquite control treatments included: (1) no treatment (control); (2) aerial application of 0.56 kg/ha of 2,4,5-T; (3) aerial application of 0.56 kg/ha of 2,4,5-T plus picloram; (4) basal spray with a 2,4,5-T-diesel oil mixture; and (5) tree grubbing in Pasture 1, and tree grubbing followed by chaining and seeding in Pasture 2.

Honey mesquite control was determined by counting the number of plants either dead or alive three growing seasons after treatment. Live honey mesquite was noted as sprouting either from stems in the canopy or from basal buds near the soil line. Plants were counted within 6-m wide belt transects taken along six permanent sample lines, 61 m in length, established in each treated area. Canopy cover of honey mesquite was estimated from color infrared aerial photography (sc. 1:3000) taken prior to treatment in spring 1973, and each spring or fall through 1976.

Species composition by weight of herbaceous vegetation was taken 120 days after spraying the first year (October) and each successive spring (May-June) through 1976. Herbage production estimates were collected using a double sampling technique described previously by McDaniel et al. (1978). Ground cover for grasses, forbs, litter, and bare ground was estimated at the same time composition date were collected. All data were acquired from ten 0.22 m^2 permanent plots, located 6 m apart along the permanent transect lines.

Forbs and grasses were grouped into one of six ecological classes, based on their successional status and forage value. The ecological classes and one or two dominant plants in each group were: (1) warm-season decreasers—Arizona cottontop and sideoats grama; (2) warm-season increasers—buffalograss and sand dropseed; (3) warm-season invaders—purple threeawn and tumble grass [*Schedonnardus paniculatus* (Nutt.) Trel.]; (4) cool-season grasses—Texas wintergrass; (5) annual grasses—rescue grass (*Bromus unioloides* H.B.K.) and Japanese brome (*B. japonicus* Thunb.); and (6) forbs. No measurements were made on individual forb species, except for common broomweed. A special seeded grass category was added for the tree grub treatment to include sideoats grama and sorghum almum (*Sorghum almum* L.), which were aerially seeded after grubbing in Pasture 2.

Grazing capacity was determined from the forage production data. Using our best judgment, a proper use factor (PUF) was assigned to every species and multiplied by the dry weight to determine kilograms of potentially usable forage per hectare. Warm- and cool-season decreaser plants were given a 50% PUF value; the PUF for warm-season increasers ranged from 20 to 40%; and PUF's for invaders and forbs were 10 to 20%. Annual grasses were not included in the calculation. Forage intake for a 400-kg cow was estimated as 275 kg/month based on data provided by Allison and Kothmann (1979). Grazing capacity was estimated by taking the sum of the potentially usable forage, multipled by the number of hectares in a treated area, and divided by the animal intake requirement. This calculated total divided by 12 provides an estimate of animal unit months of grazing.

Actual grazing during the 4-year study was restricted to the December through March winter dormant season. Both pastures were stocked with pregnant Hereford cows at the equivalent of one animal per 6.9 ha season-long. Occular estimates of forage removed at the end of the grazing period were made using 100 randomly placed 30 $\times$ 30 cm quadrats in each treated area.

Data were analyzed using analysis of variance techniques. Following a significant *F*-Test, mean separation was made using Duncan's new multiple range test (Steel and Torrie 1960).

Results and Discussion

Honey Mesquite Control

Before the brush control treatments were applied, honey mesquite canopy cover was 8% and honey mesquite density about 247 plants/ha in Pasture 1, and 25% and 680 plants/ha in Pasture 2 (Table 1). Three growing seasons after brush control, honey mesquite canopy cover increased 1.5% on untreated areas in Pasture 1, and 5.1% on the more dense Pasture 2 site.

Tree grubbing was the most effective method of eliminating honey mesquite, with 94% of the plants killed in Pasture 1, and 87% killed in Pasture 2 (Table 1). Tree grubbing resulted in a 98% reduction in honey mesquite canopy cover at both sites after 3 years. Honey mesquite top and lateral roots not completely severed during the grubbing operation did allow some resprouting to occur from the root crown.

Basal spraying the trunk of honey mesquite with the diesel oil-2,4,5-T mixture killed 43 and 52% of the plants in Pastures 1 and 2, respectively (Table 1). Honey mesquite not killed by basal spraying resprouted primarily from crown buds, resulting in a 90% reduction in canopy cover after 3 years.

The effectiveness of aerially applied 2,4,5-T and 2,4,5-T + picloram was somewhat reduced in Pasture 2 by a partial defoliation of honey mesquite by hail approximately 1 month before spraying the herbicides. Honey mesquite growing in Pasture 1 was not damaged by the storm. The 2,4,5-T + picloram treatment killed 43.8% of the honey mesquite in Pasture 1 and 25.3% in Pasture 2 (Table 1). Fisher et al. (1972) reported the 2,4,5-T + picloram combination killed on the average about 42% of the plants compared to a long-term average of 26% mortality on honey mesquite sprayed with 2,4,5-T only. Application of 2,4,5-T in Pasture 2 killed only 9.7% of the honey mesquite, whereas the plant kill in Pasture 1 was near the reported long-term average at 26.7% (Fisher et al. 1972).

Honey mesquite was completely defoliated within aerially applied 2,4,5-T and 2,4,5-T + picloram treatments 120 days after applying the herbicides (Fig. 1). The following spring, mesquite not killed in the sprayed areas provided a 7% canopy cover in Pasture

Table 1. Field estimates of dead honey mesquite (%), plants with basal growth (%), and canopy growth (%) in the third growing season after brush control in light (Pasture 1) and dense honey mesquite (Pasture 2) infested pastures.

	Honey mesquite kill and regrowth (%)					
	Pasture 1			Pasture 2		
Treatment	Dead plants	Basal growth	Canopy growth	Dead plants	Basal growth	Canopy growth
Control	2.3 a[1]	2.3 a	95.4 d	0.5 a	20.6 c	78.9 c
2,4,5-T	26.7 b	42.4 c	30.9 b	9.7 b	45.1 d	45.1 d
2,4,5-T + picloram	43.8 c	51.7 c	4.5 a	25.3 c	61.3 d	13.4 b
Basal spray	43.2 c	32.0 b	24.8 b	52.0 d	35.9 cd	12.1 b
Tree grubbing	94.1 d	3.6 a	2.3 a	86.6 e	12.4 b	1.0 a

[1]Plant control within a pasture followed by the same letter are not significantly different according to Duncan's multiple range test ($P<0.05$).

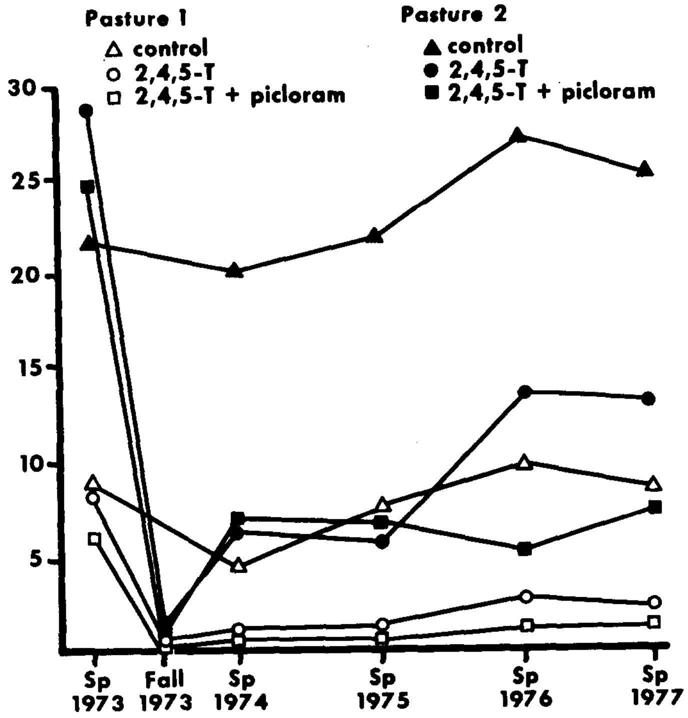

Fig. 1. *Honey mesquite canopy cover (%) from aerial photo measurements prior to treatment (1973) and in 1976 after spraying 2,4,5-T and 2,4,5-T + picloram in light (Pasture 1) and dense (Pasture 2) honey mesquite infested pastures.*

2, and less than 1% canopy cover in Pasture 1. Honey mesquite canopy cover was gradually increased in the aerial spray treatments from 1974 to 1977. The most significant regrowth occurred within the 2,4,5-T treatments, where honey mesquite canopy growth nearly doubled that found in the 2,4,5-T + picloram treatments 3 and 4 years after spraying.

Herbage Response to Brush Control

Pretreatment evaluation showed no differences (P<0.95) in grass cover or yield between areas to be treated by a particular brush control method (Fig. 2 and 3). Total herbage yield in Pasture 1 was about 2769 kg/ha and grass cover about 25%. In the more dense honey mesquite infested Pasture 2, herbage yield was significantly less than Pasture 1 at 1023 kg/ha and grass cover about 17%.

One year after brush control, grass cover increased significantly on aerial and basal spray treatments in Pasture 1 (Fig. 2). Tree grubbing followed by chaining significantly reduced grass cover and increased bare ground cover the first year in Pasture 2, and in the second year after tree grubbing in Pasture 1. There were few significant differences in ground cover parameters measured on sprayed and unsprayed rangeland after the second year. Overall, grass and litter cover was generally higher in aerial and basal spray treatments compared to the control or tree grub treatments, but these differences could not always be substantiated statistically. Conversely, forb and bare ground cover was generally greatest on nontreated and tree grubbed areas compared to sprayed rangeland.

Several ecological and environmental factors influenced the vegetation response besides simply reducing honey mesquite activity. Annual fluctuation in rainfall was a most important factor influencing vegetation growth in this study. During 2 years (1973 and 1975) when rainfall was above the annual average (Fig. 4), broadleaf forbs were very productive (Fig. 3). However, above-normal rainfall did not greatly increase the production of perennial grasses. Grass production in the 2 years (1974 and 1976) with below annual average rainfall was equal to or greater than in the wet years. Competition from annual broadleaf plants, especially common broomweed, was largely responsible for the suppressed perennial grass production in the two wet years. In 1973 and 1975 when precipitation was above the annual average (14.1 and 33.3 cm, respectively), broadleaf forbs made up more than 50% of the total composition by weight. In 1974 and 1976, with below average precipitation (–7.8 and –6.7 cm, respectively), nearly 90% of the herbage consisted of grasses. Scifres and Polk (1974), in a study on vegetation response following spraying of a light infestation of honey mesquite in northcentral Texas, reported grass production to increase 21.8 kg/ha for every centimeter of precipitation received above the annual average. They also reported treatment

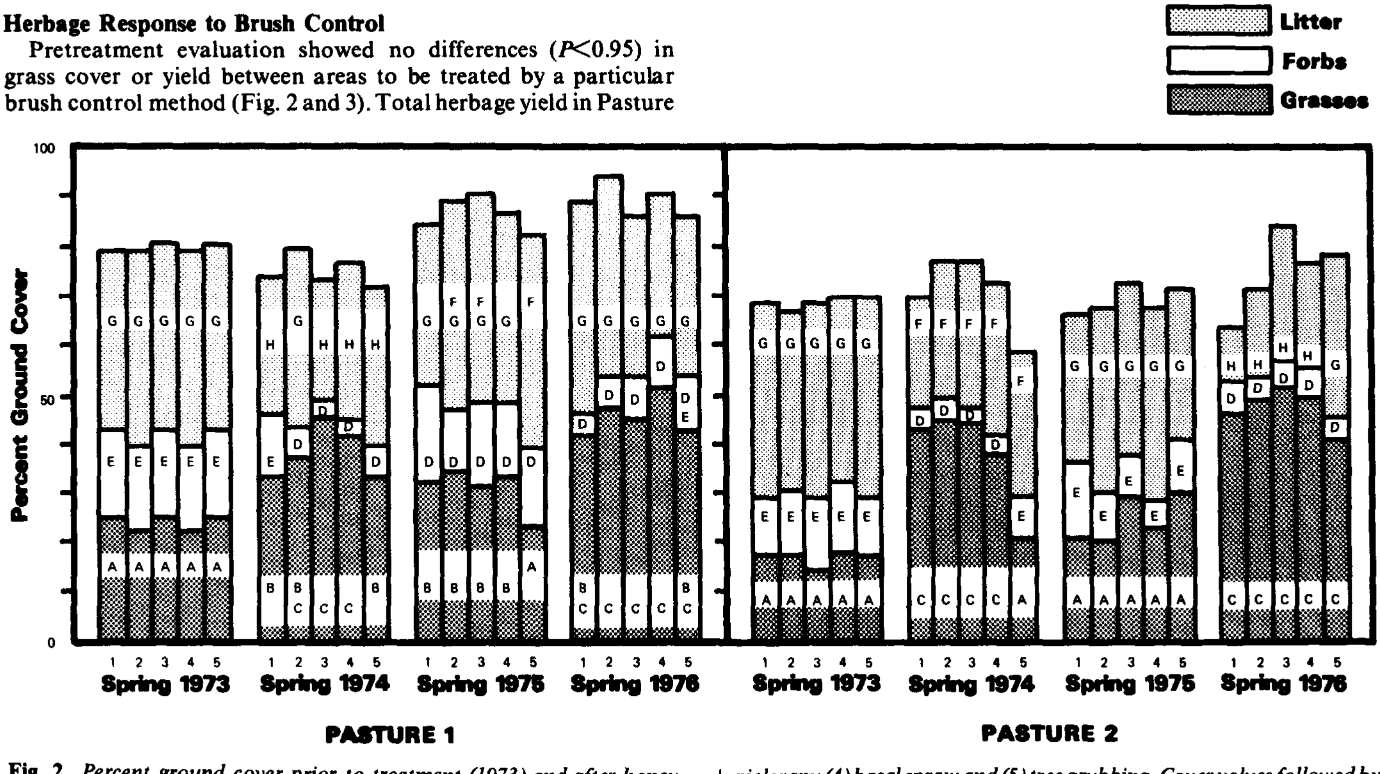

Fig. 2. *Percent ground cover prior to treatment (1973) and after honey mesquite control. Treatments include: (1) control; (2) 2,4,5-T; (3) 2,4,5-T + picloram; (4) basal spray; and (5) tree grubbing. Cover values followed by the same letter are not significantly different.*

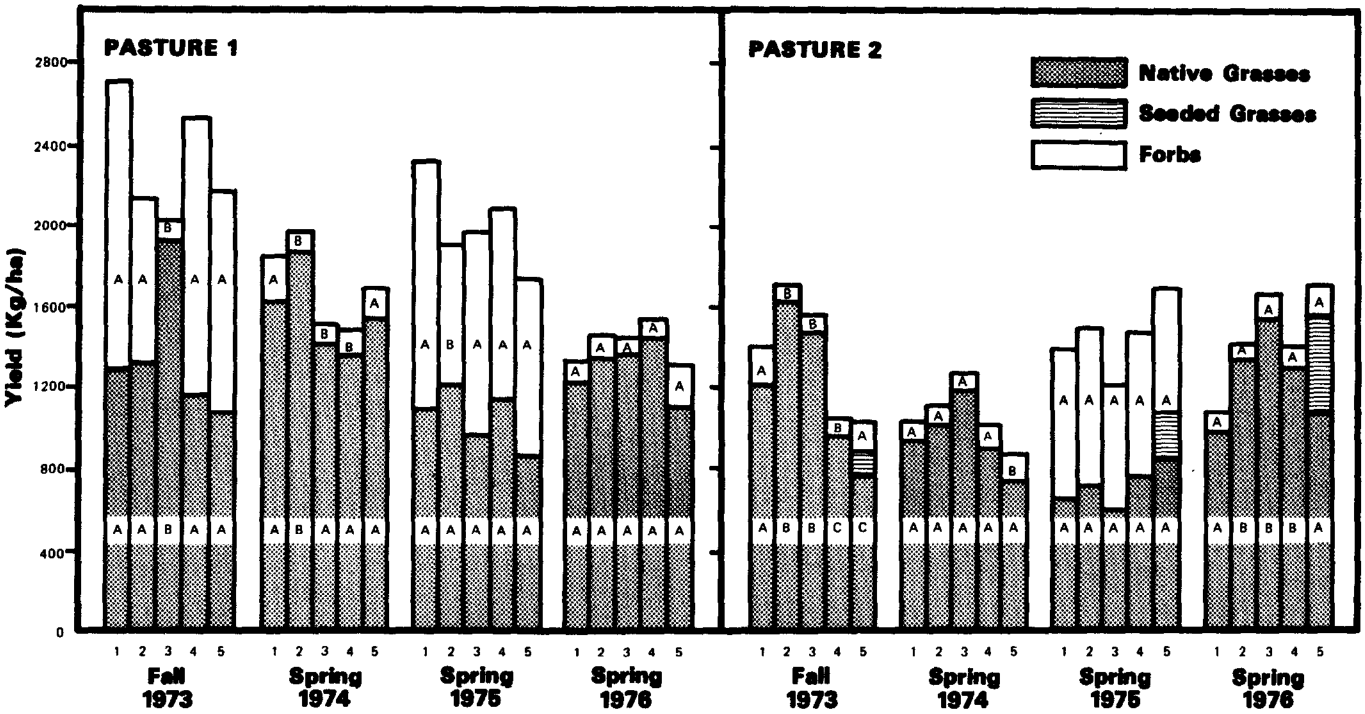

Fig. 3. *Yield of grasses and forbs (kg/ha) 120 days (fall 1973) and annually for three growing seasons after honey mesquite control. Treatments include: (1) control; (2) 2,4,5-T; (3) 2,4,5-T + picloram; (4) basal spray; and (5) tree grubbing. Yield values followed by the same letter are not significantly different.*

effects to be masked in a low rainfall and high air temperature years. In this study, grass production did not necessarily increase with additional precipitation, although total herbage production did. Further, grass yield in sprayed areas exceeded nonsprayed areas during both wet and dry years.

Herbage production differences 120 days after application of foliar herbicides were closely related to the control of broadleaf species in addition to honey mesquite. Annual forbs, especially common broomweed, were abundant in spring 1973, but were reduced by the 2,4,5-T + picloram combination in Pasture 1 resulting in a significant increase in grass production (1940 kg/ha) compared to the control (1286 kg/ha) (Fig. 3). Aerial spray treatments in Pasture 2 also had significantly fewer forbs and greater grass produced compared to the basal spray, tree grub, and control.

One year after brush control, the 2,4,5-T spray at Pasture 1 was the only treatment to exceed the control in total grass yield (Figure 3). No treatment within Pasture 1 was different from nontreated rangeland after the second or third year. In Pasture 2, grass production within 2,4,5-T and 2,4,5-T + picloram treatments exceeded the control by significant amounts 120 days and three years after spraying. Workman et al. (1965) reported maximum increases in grazing capacity to generally occur the first 2 or 3 years after spraying honey mesquite. Dahl et al. (1978) showed significant grass responses from 2,4,5-T spraying the first year in west and northcentral Texas. Our results show that a significant grass response may occur within 120 days to 3 years after spraying, but the increase may not occur over consecutive years.

Grazing Capacity and Plant Succession

The mean estimated grazing capacity from 1973 to 1976 on nontreated rangeland averaged one cow per 6.7 ha/cow/yr in Pasture 1, and 8.3 ha/cow/yr in Pasture 2 (Table 2). Grazing capacity in the control exceeded the 4-year average in 1974 in Pasture 1 (5.6 ha/cow/yr), and was below the average in Pasture 2

Table 2. Grazing capacity (ha/cow/yr) 120 days (fall 1973) and for three growing seasons after honey mesquite control on a light (Pasture 1) and dense (Pasture 2) honey mesquite infested pastures.

	Grazing capacity (ha/cow/yr)				
Treatments	1973	1974	1975	1976	x
Pasture 1					
Control	6.72 c[1]	5.63 d	7.62 bc	7.38 bc	6.69 A[2]
2,4,5-T	6.61 c	4.76 d	7.49 bc	6.66 c	6.38 A
2,4,5-T + picloram	4.47 d	6.66 c	9.32 a	6.89 c	6.84 A
Basal spray	6.66 c	6.17 cd	8.44 ab	6.37 cd	6.91 A
Tree grub	7.83 b	6.42 cd	10.01 a	7.83 b	8.02 B
Pasture 2					
Control	6.75 c	7.98 c	10.85 b	7.67 c	8.31 A
2,4,5-T	5.15 e	7.04 c	10.45 b	5.84 d	7.12 A
2,4,5-T + picloram	5.45 e	7.49 c	9.78 b	6.03 d	7.18 A
Basal spray	8.31 c	8.18 c	11.32 b	6.23 d	8.51 A
Tree grub-no seed	10.58 b	15.43 a	10.54 b	8.64 c	11.30 B
Tree grub-seed	9.32 b	13.50 a	10.25 b	6.03 d	9.77 B

[1]Means within a study pasture followed by the same letter are not significantly different at the 95% level of probabily according to Duncan's multiple range test.
[1]Four-year mean average within a study pasture followed by the same letter are not significantly different at the 95% level of probability according to Duncan's multiple range test.

(10.9 ha/cow/yr) in 1975. The estimated grazing capacity determined from the forage production data was nearly equivalent to the 6.8 and 8.4 ha/cow/yr stocking rate maintained by the W.T. Waggoner Ranch on nontreated rangeland adjacent to Pastures 1 and 2, respectively.

From fall 1973 to spring 1976, the yield of all ecological classes of grasses was greater in aerial and basal spray treatments as compared to the control, with the exception of annuals and warm-season invaders in Pasture 2 (Table 3). The especially favorable response of high producing cool- and warm-season decreasers in the 2,4,5-T and 2,4,5-T + picloram treatments provided a 7 to 16% increase in grazing capacity over the four-year period in Pastures 1 and 2, respectively (Table 2). Texas wintergrass, Arizona cottontop, and the cool-season annual, rescue grass, were abundant beneath the sprayed honey mesquite canopy making up more than 50% of the total composition by weight (Brock et al. 1978). Cattle grazing in the winter showed a strong preference for these grasses and utilized nearly twice as much grass growing beneath sprayed honey mesquite canopies as compared to the interspace area between honey mesquite plants (Table 4 and Fig. 5). Cattle grazing in the 2,4,5-T spray treatment removed two to three times more forage than from comparable untreated and tree grubbed rangeland.

Tree grubbing encouraged the production of early successional species of low forage value (Table 3). As a result, grazing capacity in tree grubbed areas was less than the other treatments throughout most of the study (Table 2). Sideoats grama and sorghum almum seeded into denuded areas did not become established until 3 years after tree grubbing when they constituted 34% of the total compo-

Table 3. Mean production differences, as a percent of the untreated control, for brush control treatments applied on a light infestation (Pasture 1) and dense infestation of honey mesquite (Pasture 2).

Brush control treatment	Cool and-warm-season decreasers	Increaser grasses	Annual and invader grasses
	Mean Percent Difference[1]		
Pasture 1			
Aerial spray	↑ 28	↑ 6	1 ↓
Basal spray	↑ 4	↑ 8	3 ↓
Tree grubbing	4 ↓	18 ↓	↑ 11
Pasture 2			
Aerial spray	↑ 30	↑ 11	↑ 26
Basal spray	↑ 29	↑ 8	↑ 11
Tree grubbing	25 ↓	44 ↓	↑ 40

[1]Mean Percent Difference = $\frac{\text{Mean treatment wt} \times \text{Mean control wt}}{\text{Mean control wt}} \times 100$

↑Indicates the percent increase in yield relative to the control.
↓Indicates the percent decrease in yield relative to the control.

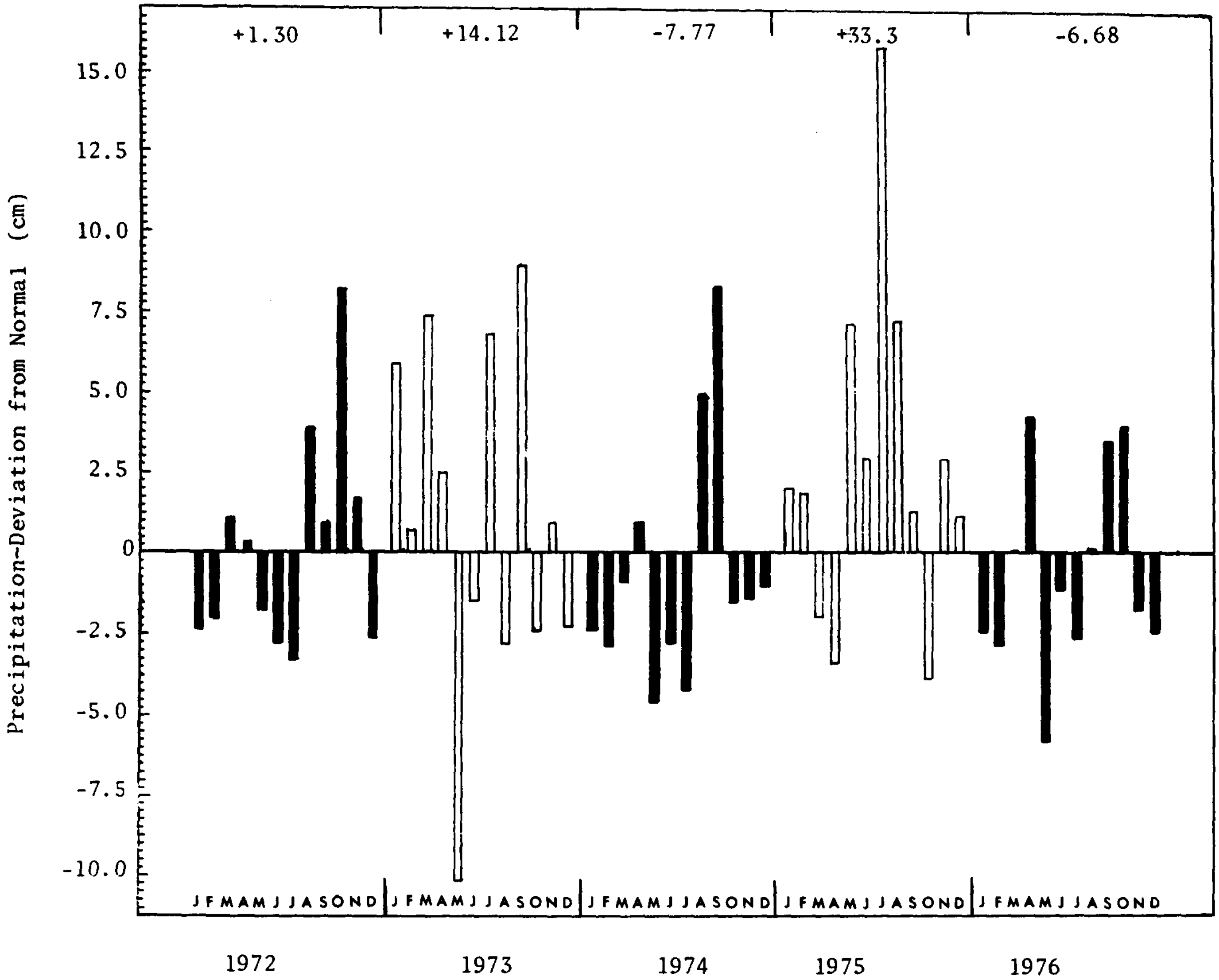

Fig. 4. *Monthly normal precipitation and deviation from normal at Vernon, Texas from 1972 to 1976. Long-time precipitation is 65.61 cm. Annual deviations from normal are shown on the top of the graph.*

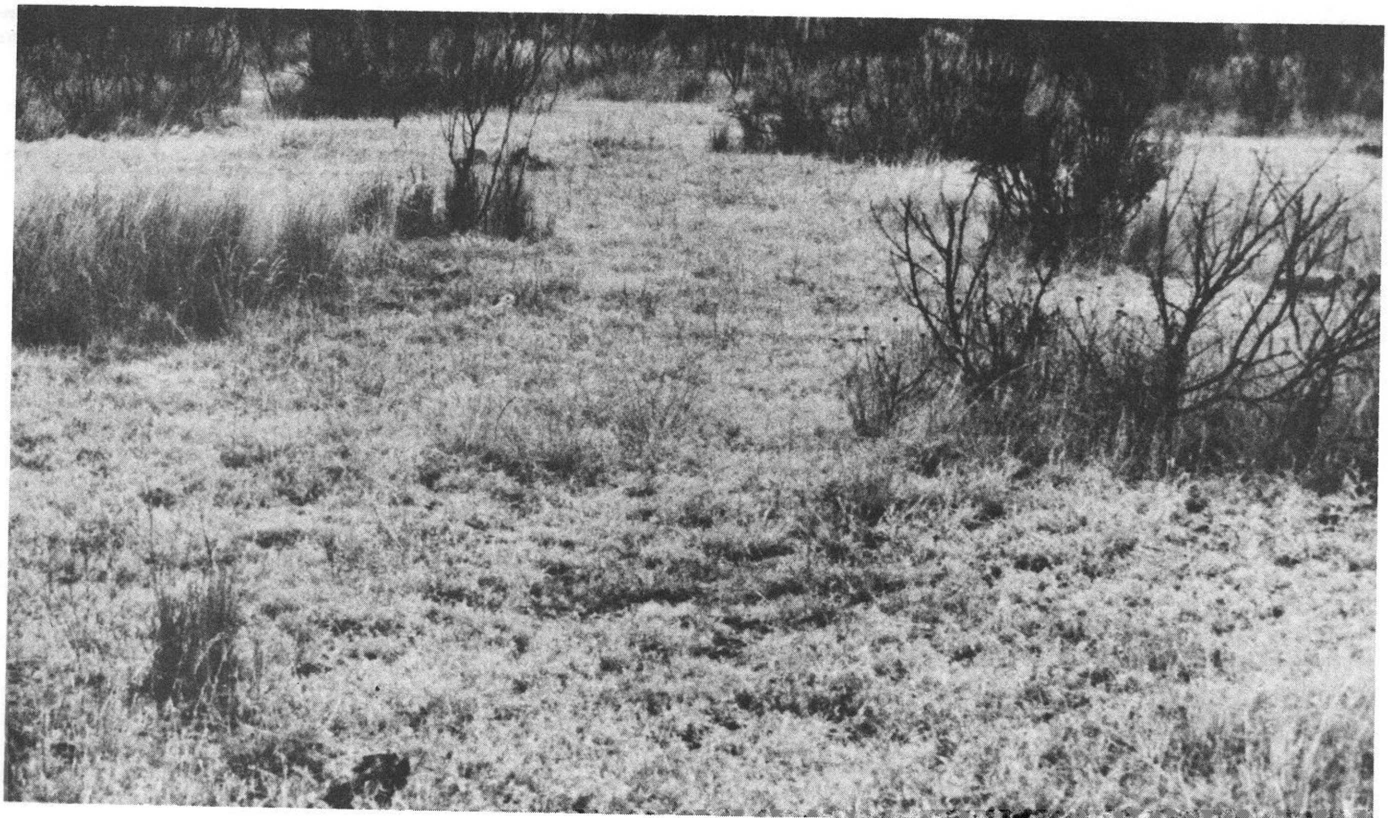

Fig. 5. *Yield of high producing cool-and warm-season decreaser grasses was significantly greater in the canopy zone of sprayed honey mesquite compared to the interspace area or the yield in untreated and tree grub rangeland. Cattle grazing in the winter preferred grasses growing in the canopy zone of sprayed honey mesquite.*

sition by weight. Without the production obtained from the seeded grasses, grazing capacity would have been 15 to 25% less than pretreatment conditions.

Conclusions and Management Implications

To a large degree, the results document what is known about the effectiveness of the different treatments for controlling honey mesquite. Tree grubbing eliminated most of the honey mesquite plants, but because of excessive grass damage and cost, this method should be confined to relatively sparse brush stands (less than 250 plants/ha). Aerial application of 2,4,5-T + picloram was more effective in killing and defoliating honey mesquite than 2,4,5-T alone, but both treatments gave similar forage responses. Individual plant treatment, such as basal spraying, yields a forage response similar to aerial spraying, but is an impractical method when the density of honey mesquite is great.

The 4-year duration of this study did not make it possible to evaluate treatment longevity. Treatment effectiveness, however, is not necessarily related to the number of honey mesquite killed but rather to the length of time that honey mesquite canopy growth is suppressed. Although it is still to be verified, it appears that when the honey mesquite canopy increases beyond 15 to 20%, there is a detectable decline in forage production. Brush control in dense stands is likely to produce the most significant increases in herbage production (Dahl et al. 1979). On the other hand, it is more difficult to measure a significant forage response related to control of honey mesquite with less than 10 to 15% canopy cover (Scifres and Polk 1974).

An increase in the production of more desirable perennial grasses is most significant beneath the canopy zone of sprayed honey mesquite rather than interspace areas (Brock et al. 1978). The canopy zone is critical for the production and "release" of cool- and warm-season decreaser grasses into interspace areas between honey mesquite plants. The canopy zone is the focal point for range improvement and is very susceptible to overgrazing if improperly managed. Deferment through the first growing season allows warm-season mid-grasses the opportunity to increase vigor and set seed prior to the initiation of grazing in the dormant season (approximately November 1 to April 1). Ending the grazing season by April 1 provides Texas wintergrass and other cool-season grasses an opportunity to reproduce.

A dormant season grazing regime following honey mesquite control should be carried out for one or more years, depending upon the range condition of treated pastures and the management goals. Growing season deferment and dormant season grazing

Table 4. Forage removed (%) after winter grazing (December-March) in brush control treatments, and within honey mesquite canopy zone and inter-space area in a dense honey mesquite infested pasture (Pasture 2).

Year	Forage removed (%) from brush control treatments			Forage removed (%) from honey mesquite zones	
	Control	2,4,5-T	Tree grub	Canopy	Interspace
1974-75	3.2	8.8	6.9	——No Data——	
1975-76	5.7	9.2	3.3	13.8	6.6
1976-77	17.3	26.1	8.4	28.4	13.6
Average	8.7	14.7	6.2	21.1	10.1

maximizes range improvement on rangeland in poor to fair condition.

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