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Control of Mesquite on Grazing Lands

TEXAS AGRICULTURAL EXPERIMENT STATION

R. D. LEWIS, [illegible] STATION, TEXAS

IN COOPERATION WITH THE U. S. DEPARTMENT OF AGRICULTURE

SUMMARY

Mesquite is an aggressive, deep-rooted, undesirable woody, sprouting shrub that occurs on approximately 55 million acres of grazing lands in Texas.

Economical control of mesquite on grazing lands depends largely on the selection of methods that will provide the greatest sustained benefits for the money expanded. Where mesquite thrives, no single method or practice will give effective and economical control under widely varying conditions. Good range and livestock management are essential to obtain maximum benefits from the control of mesquite. The chief value of controlling mesquite is to increase the density, vigor and production of palatable range forage species.

Some of the factors that influence the effectiveness and cost of controlling individual plants, in thin, open stands by hand or power grubbing, oiling with kerosene and diesel fuel and basal application of 2,4,5-T and soil application of monuron are discussed in this bulletin.

Factors that influence the effectiveness and cost of controlling moderate to dense stands by chaining and cabling, use of heavy-duty brush cutters, root plowing and aerial application of 2,4,5-T are enumerated.

The benefits of mesquite control include include increased carrying capacity of the grazing lands, reduced cost of handling livestock and more efficient use of other range improvement practices.

Reinfestation of grazing lands by mesquite is aided by the dissemination of large numbers of viable seed by cattle, horses, sheep and rodents, the apparent lack of palatability of mesquite foliage to most grazing animals and the failure to maintain a heavy competitive cover of perennial grasses because of overgrazing, drouth and other factors.

The values of mesquite are limited largely to utilization of the beans by grazing animals. Some use also is made of the wood for fuel, fence posts and a source of roughage for feeding livestock. Additional uses include gum, preparation of charcoal and other special products.

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Figure 1. Dense stands of mesquite interfere seriously with the handling of livestock, production of grass and use of efficient grazing, and livestock-management practices.

Control of Mesquite on Grazing Lands

C. E. Fisher, C. H. Meadors, R. Behrens, E. D. Robinson, P. T. Marion and H. L. Morton*

THE INVASION OF MESQUITE, a thorny, sprouting, woody tree or shrub, has been underway for many years on extensive areas of range and pasturelands in the Southwest. Under most conditions, mesquite is considered to be undesirable on grazing lands. It is extremely aggressive, forming dense jungles of brush on productive grassland sites, which reduce the carrying capacity of the land. It also seriously hinders the management of livestock and the use of desirable range-improvement practices (Figure 1).

In 1896, Smith (24)[1], an agrostologist, stationed at Abilene, Texas, called attention to the hardy, aggressive nature of mesquite and predicted the problem that ranchmen face today. Similar observations were made somewhat later in Texas by Bray 1904 (5), Cook 1908 (7), and by Griffiths 1904 (18) and Thronber 1910 (25) in Arizona. Within recent years, Allred (2) estimated from surveys made by the Soil Conservation Service that approximately 55 million acres of rangeland in Texas were infested by mesquite. About 15 to 20 million acres of rangelands are infested in New Mexico and Arizona. More than half of the total infestation in Texas is moderate to dense stands of brush that seriously affect the production of forage and livestock. On the remainder, mesquite now occurs in sparse to thin stands that may develop into a serious problem in the future. Mesquite also often is a noxious pest on abandoned croplands, on perennial seeded pastures, on rights-of-ways. along fence rows and around watering facilities.

DESCRIPTION AND DISTRIBUTION

Mesquite (*Prosopis juliflora*) belongs to the Mimosa family (*Mimosaceae*) and is distributed in warm, mostly dry, hot areas of United States, Central America, West Indies, Peru, Chile, Argentine, Iran, India, Hawaiian Islands and other countries of similar climate, Dayton (9). Three varieties occur in the United States, according to Benson and Darrow (4): honey mesquite (*P. juliflora* var. ***glandulosa***), velvet mesquite (*P. juliflora* var. ***velutina***) and western honey mesquite (*P. juliflora* var. ***torreyana***). Honey mesquite occurs for the most part east and northeast of the Rio Grande in New Mexico and throughout South and West Texas and extends to the northern portion of Oklahoma on the north and Louisiana on the east. Velvet mesquite predominates in Arizona, extreme western New Mexico, Lower California and Mexico. Western mesquite is found in California, southern Nevada, Utah, western Arizona, southern New Mexico and parts of Texas (Figure 2).

The three varieties of mesquite may be distinguished by the size, shape and hairiness of the leaflets. The leaflets of honey mesquite are long, linear, glabrous and widely spaced; those of velvet mesquite are short, hairy and closely spaced; western mesquite is intermediate between the two extremes. From one to as many as four crops of flowers or blooms may occur in succession from late April to August. The "bean," or seed pod, contains 5 to 20 seed. Production varies widely from season to season.

All three varieties vary in growth forms from large single-trunk trees, 20 to 40 feet tall, to small, few to many-stemmed shrubs, depending on environmental factors of soil, water, temperature and disturbance by grazing animals and man. Mesquite grows up to elevations of 4,500 feet, where the average annual minimum temperature is above –5 degree F. and the frost-free growing season is 200 days or more. It thrives along drainage ways in the desert, where the annual rainfall is less than 6 inches, and persists on neutral and alkaline soils in areas where the annual rainfall is more than 30 inches.

Mesquite typically has a tap root with an extensive lateral root system that enables it to withstand drouths, severe competition from perennial grasses and adverse conditions due to prolonged overgrazing of rangelands (26). The roots of well-established plants may penetrate vertically to depth of 15 to 40 feet and often extend laterally as much as 50 feet from the base of the plant (Figure 3). Nevertheless, McGinnis and Arnold (20) found in southern Arizona that mesquite is an inefficient user of soil moisture. They determined that velvet mesquite during the summer required four times as much water as perennial grasses to produce 1 pound of dry matter. Parker and Martin (22) found in field studies that elimination of velvet mesquite doubled the yield of perennial grasses and increased the yield of animal grasses five fold.

The spread of mesquite on native grassland within the past 40 to 100 years has taken place so rapidly that it has become common knowledge among

*Respectively, formerly Superintendent of Substation No. 7, Spur, Texas, now superintendent of Substation No. 8, Lubbock, Texas; technician, Substation No. 7, Spur, Texas; plant physiologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture; assistant agronomist, Substation No. 7, Spur, Texas; associate animal husbandman and now superintendent of Substation No. 7, Spur, Texas; and research agronomist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

[1]Numbers in parentheses refer to Literature Cited.

people of the Southwest. Introduction of plants along the water courses is thought to have been made first by roving herds of buffalo, later by the Spanish horses and finally by the extensive movement of cattle during the trail drives. Subsequent invasion from these localized areas more than likely was accelerated by fencing and watering, heavier grazing, lack of repeated burning of grass, rapid transportation of animals with large numbers of viable seed in their digestive tracts, extended drouths, and livestock-management practices (12) (Figure 4).

GOOD RANGE MANAGEMENT IS ESSENTIAL

The chief value of controlling mesquite on grazing lands depends largely on increasing the density, vigor and production of palatable perennial forage species. To obtain maximum benefits, treated or cleared grassland preferably should be deferred during the summer for 6 months or longer to permit native or seeded grasses to become firmly established. Parker and Martin, after careful study in southern Arizona, stated that no practical management plan that will completely eliminate the need for direct control measures is known. Nevertheless, any management plan that includes seeding, summer deferment, water spreading, conservative stocking or other practices that encourage and hasten the development of a good competitive grass cover likely will help reduce the survival of mesquite seedlings.

Following extended drouth when the grass cover is greatly weakened and serously thinned, timely application of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) will help reduce the survival and establishment of mesquite seedlings and undesirable range weeds. During the early stages of development, mesquite seedlings and most range weeds are highly susceptible to 2,4,5-T. Failure to control these undesirable plants when they are most vulnerable may later require the use of far more costly measures.

For full realization of the benefits from a mesquite-control program, consideration needs to be given to selection of sites capable of sustaining a good cover of palatable range grasses and the management of grazing on these sites to obtain maximum production. Failure to manage grazing properly on treated or cleared areas may result in little or no improvement. In fact, under poor grazing management, the removal of mesquite may lead to the destruction of the few remaining grass plants that were not accessible easily to grazing animals. The adage: "It takes grass to make grass," should be kept in mind at all times.

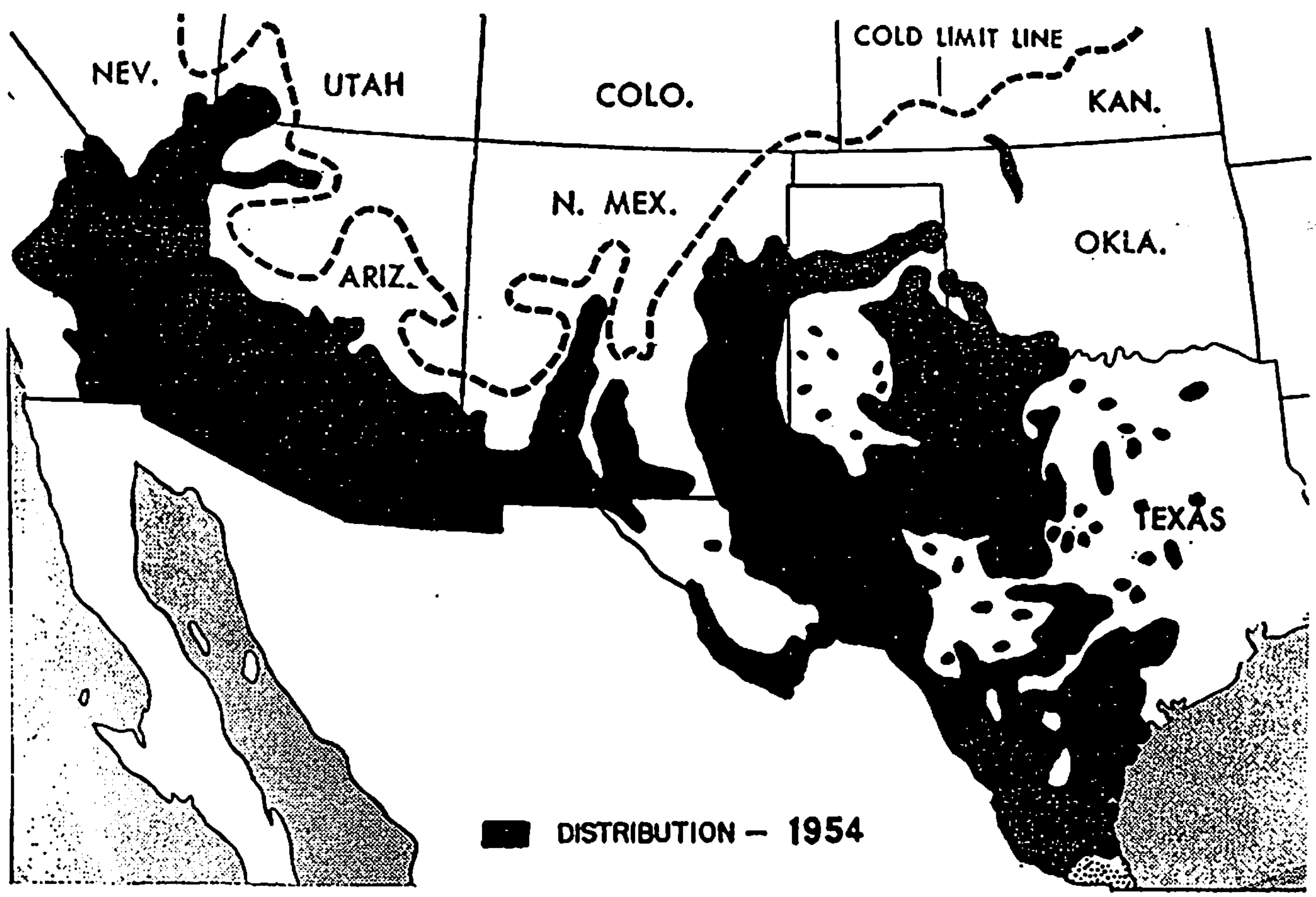


Figure 2. Generalized map showing the distribution of mesquite in the Southwest. The northern limit of mesquite appears to follow closely the average annual minimum temperature isotherm of —5 degree F.

METHODS OF CONTROL

The chief problem facing ranchmen is the selection of brush-control measures that will provide the greatest sustained benefits for the money expended. No single method that will give effective and economical control of mesquite under all conditions has been developed. In the early stages of infestation, hand or power grubbing may be used to eliminate isolated plants and sparse stands at low cost. But, after extensive areas become heavily infested with well-established stands and large numbers of seedlings with seed in the soil, repeated use of control measures usually is necessary for the greatest sustained benefits.

Since mesquite is able to persist under an extremely wide range of conditions, some of the more important factors that should be given consideration in selecting a method of control are: (1) density of stands; (2) stage and rate of infestation; (3) growth forms, whether trees are many-stemmed or single-trunked; (4) benefits that may be realized in view of the soils, moisture conditions and potential productivity of land; (5) size of the area to be treated and the capital available; (6) the presence of other undesirable woody plants; and (7) the likelihood of hazards of the control measures to livestock, grass cover and nearby crops (Figure 5).

Research has shown that mesquite trees and shrubs may be killed by mechanical or chemical methods which destroy the top and all the dormant sprout buds on the root crown and underground stem (13). These buds are small, wart-like structures under the bark that produce new growth if the top growth is killed (Figure 6). The bud zone of mesquite may extend from less than 2 inches below the soil surface to depths of 12 inches or more on old, large trees. Usually the depth of these buds is greatest on bottomlands and on sites where soils tend to accumulate around the base of the plants. Repeated removal of the topwood usually increases the difficulty of killing mesquite since it greatly increases the root crown area and the number of dormant buds and basal stems per plant, Fisher (11).

The methods of control reported in this bulletin are based on experimental results obtained by the Texas Agricultural Experiment Station at Spur during 1939-56 and at 39 off-station locations in cooperation with ranchmen (Figure 7). Research work during 1948-56 was conducted in cooperation with the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

Thin to Open Stands

Mesquite trees, shrubs and seedlings in widely scattered stands may be controlled effectively and economically by the treatment of individual plants during the early stages of infestation. Some of the methods used successfully to control stands of 50 to 125 plants per acre are described in this bulletin.

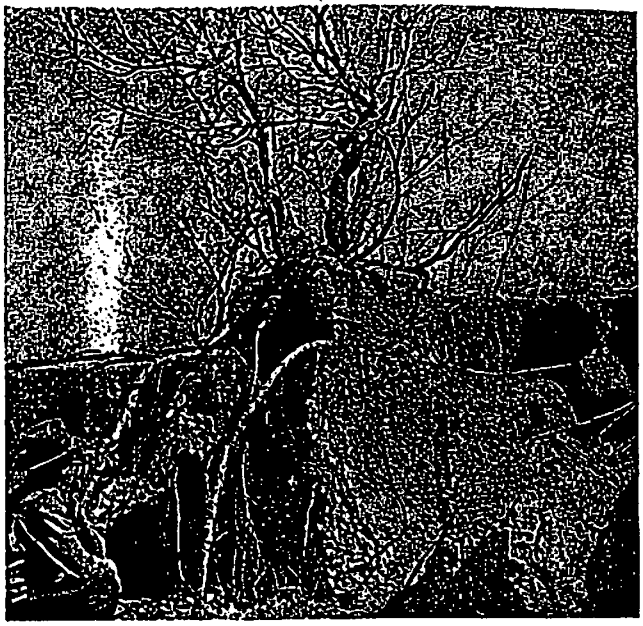


Figure 3. Root system of mesquite showing long lateral roots extending 20 to 50 feet from the base of the plant.

Hand or Power Grubbing

Control of invading stands of mesquite seedlings may be obtained at relatively low cost by hand grubbing. The sprout buds on seedlings are shallow and plants can be destroyed by grubbing below the lowest sprout buds, usually 3 to 4 inches below ground level.

For the control of extensive areas of thin, open stands of mesquite trees and shrubs, power-grubbing equipment offers an effective and economical means

Figure 4. The large mesquite tree in the foreground typifies the initial infestation of native grassland prior to the advent of the grazing industry. The secondary stage of infestation became noticeable soon after the land was fenced and watered and utilization of grass was intensified.

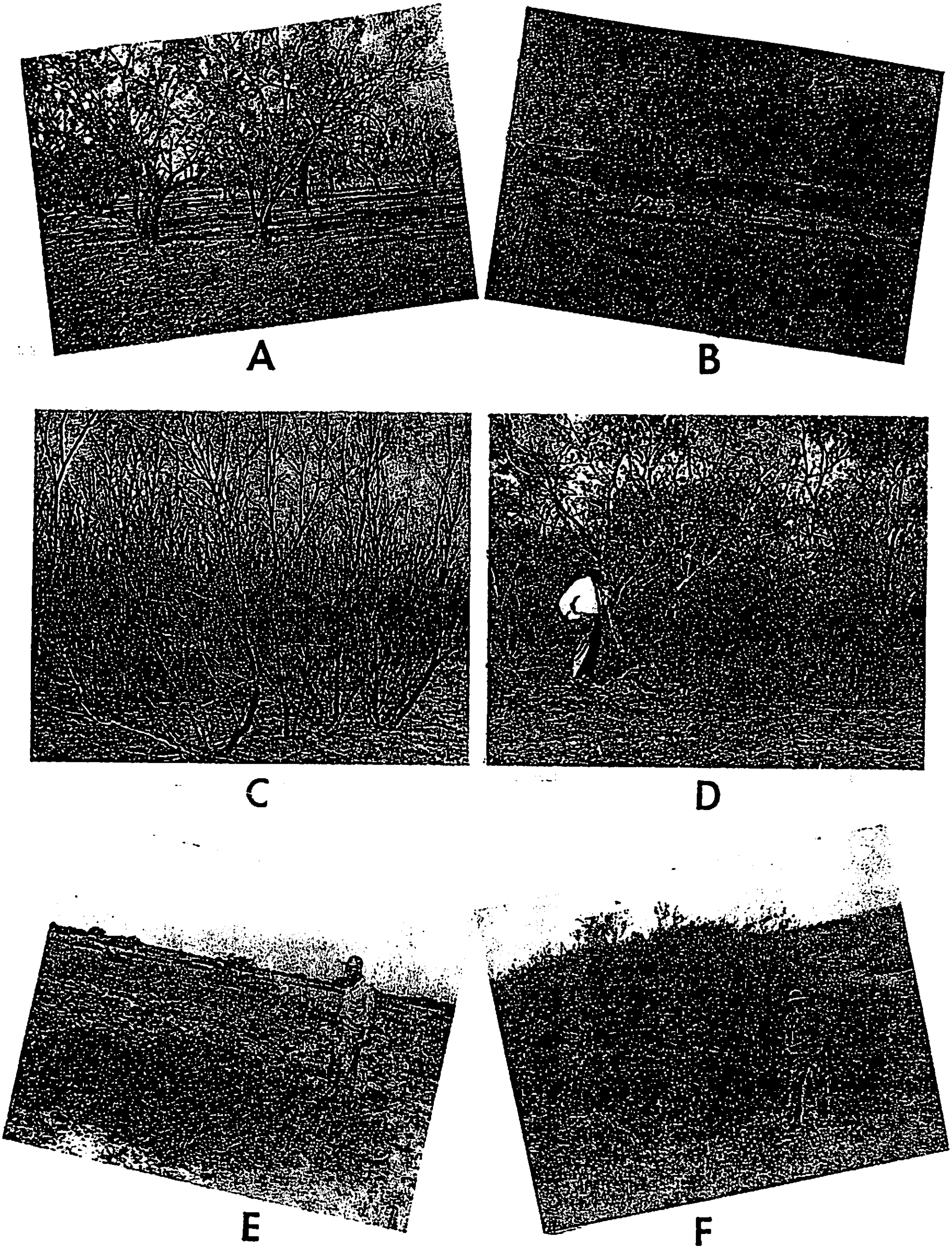


Figure 5. Six typical growth forms of mesquite. The growth forms vary with moisture conditions, soil type, low temperatures in the northern areas and man's activities that influence the above-ground growth. (A) Trees in open stands. (B) Shrub-type invading grassland. (C) Many-stemmed shrubs in dense stands. (D) Trees intermingled with mixed brush. (E) Running mesquite growing on a deep, sandy soil. (F) Many-stemmed shrubs on a sand dune site.

to uproot the plants well below the lowest dormant sprout buds. A crawler-type tractor with a front-mounted "stinger" blade will do a satisfactory job at costs of $3.00 to $7.50 per acre on stands up to 75 trees per acre (Figure 8). The cost of power grubbing may be minimized by using the equipment for building roads, tanks, spreader dams and clearing land for cultivation. Other factors that will influence the cost of grubbing include the type of soil, such as heavy clay, mixed land or sand, the moisture content of the soil and the type of growth.

The chief advantages of grubbing are that the plants are actually uprooted, leaving small soil basins and dead brush on the land to aid the establishment of grass seedlings. For dense stands, grubbing costs usually are prohibitive, many small plants are missed and a high percentage of the grass cover is destroyed. The serious disturbance of the soil often encourages heavy growth of undesirable weeds that may persist for several years until a good cover of grass becomes reestablished.

Kerosene, Diesel Fuel and Other Oils

Thin stands of single to few-stemmed trees growing on porous, gravelly and rocky soils may be killed at relatively low cost throughout the year when the surface soil is dry by pouring 1 pint to 2 quarts of kerosene or diesel fuel around the base of the tree (Table 1). The killing action of the oils depends on its movement through the bark and making physical contact with the sprout buds around the base of the tree (Figure 9). Therefore, enough oil should be used to wet the bark and soil thoroughly to the lowest sprout buds on the underground stem. Repeated studies have shown that more oil is needed to obtain effective kills of mesquite growing on wet, impervious clays, when the shrubs are many-stemmed, and on lowlands or other sites where soil has accumulated around the base of the plants. For the control of moderate to dense stands, the cost of this method usually is prohibitive.

The kill of brushy mesquite may be improved greatly with a considerable saving of oil if the topwood and lateral stems are cut back to the stump prior to oiling. The percentage kill obtained by oiling will range from 60 to 90, depending on the thoroughness of application. Usually retreatment will be necessary within 3 to 5 years to control sprout growth of plants that were missed or not treated properly.

Kerosene and diesel fuel, whichever is cheapest and most readily available, may be used interchangeably. For control of a few trees and shrubs along fence rows, use of a mixture containing 50 percent diesel fuel or kerosene and used crank case oil may reduce the cost of treatment. The total cost of oiling mesquite usually is 4 to 6 cents per tree. The chief advantages of oiling are the readily available supply of oils and the minimum amount of equipment required.

Figure 6. Sections of mesquite cut at ground level and below the lowest dormant buds. These buds must be destroyed to prevent sprout growth. The tree on the right grew on upland and its lowest dormant buds were 6 inches below ground level. The tree on the left grew on bottomland, where silting occurred, and the lowest dormant buds were 12 inches below ground level.

Basal Application of 2,4,5-T

Under conditions where oil alone is too expensive and the use of other methods is not feasible, good control of heavier stands, 50 to 125 trees and shrubs per acre, may be obtained by basal applications of 2,4,5-T. (Figure 10). The addition of 2,4,5-T ester

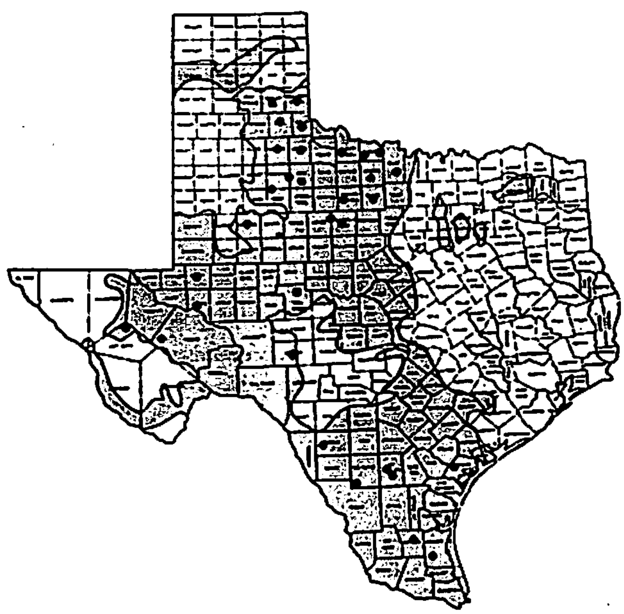


Figure 7. Generalized map showing the distribution of mesquite in Texas and the location of cooperative ranch tests for the evaluation of control practices.

Figure 8. Above—Thin open stands of large mesquite trees may be controlled on extensive areas by power grubbing with a "stinger" attachment at moderate cost. Below—Recovery of grass in soil basins after the removal of mesquite. For dense stands, the cost is prohibitive and the soil disturbance results in heavy reinfestation of undesirable weeds.

to light oils, such as kerosene or diesel, improves the percentage top kill of mesquite when limited amounts of oils are used. The lower 8 to 12 inches of the basal stems and root crown area should be sprayed thoroughly until runoff is heavy with an oil solution containing 8 pounds acid of 2,4,5-T ester or 2 gallons of 2,4,5-T, 4-pound acid formulation, per 100 gallons of diesel fuel or kerosene. One gallon of this solution will treat 10 to 15 moderate-size trees at a cost of 2 to 3 cents per tree for material. Similar

Figure 9. The application of kerosene or diesel fuel should be made around the base of the plant in sufficient amounts to wet the bark to the depth of the lowest dormant buds. This method of control has been used effectively to treat open stands of single-stemmed trees growing on porous, rocky or gravelly soils.

treatment of stumps also has been effective. A 3 to 5-gallon knapsack sprayer fitted with a nozzle that delivers a coarse spray is suitable for basal application.

This treatment will give excellent kills of top growth and root kills of 20 to 80 percent, depending on the size of trees, growth forms, nature of the soils and thoroughness of application. Usually the percentage of root kill obtained may be improved by using larger amounts of spray solution around the base of the plants. Increasing the amount of 2,4,5-T acid above 8 pounds per 100 gallons seldom improves kills. Applications are almost equally effective at any season of the year; however, retreatment will be needed at intervals of 3 to 5 years to control seedlings and sprout growth.

Basal Application of Monuron and Fenuron

Highly effective kills of mesquite also may be obtained by spraying a narrow band of soil around the base of trees and shrubs with a suspension containing 1 pound of monuron, (3-(P-dichlorophonyl)-1, 1 dimethylurea), in 10 gallons of water. Ten to 15 trees of average size may be treated at a cost of 2 to 4 cents per tree with 1 gallon of the suspension. Since monuron will not dissolve in water, the suspension must be agitated frequently to keep the chemical from settling to the bottom of the spray can. Since the killing action of monuron is due to

TABLE 1. EFFECT OF BASAL APPLICATIONS OF CHEMICALS AND OILS ON PERCENTAGE KILL OF MESQUITE AND COST OF MATERIALS

Chemical	Amount used per 100 gallons	Diluent	Percent kill	Per 100 trees	
				Volume used, gallons	Cost of material
Monuron	10 lb.	Water	42	10	$3.75
Monuron	20 lb.	Water	64	10	$7.50
Fenuron	10 lb.	Water	16	10	$3.75
Fenuron	20 lb.	Water	38	10	$7.50
Diesel fuel			73	27	$3.50
1% 2,4,5-T	2 gal.	Diesel fuel	40	10	$3.00

Figure 10. Above—Basal application of 2,4,5-T in diesel fuel is effective when the lower 6 to 12 inches of the trunk and all basal plant parts are saturated thoroughly. Below—Basal application of 2,4,5-T or oils is not highly practical for the control of brushy, many-stemmed mesquite.

absorption of the herbicide by the roots of mesquite, rainfall, soil texture and organic matter influence the results obtained. It may take 2 or more years for the trees to die after treatment. This chemical should not be used to treat mesquite if roots of ornamental shrubs or other valuable plants are in the soil. Pelleted formulations of monuron containing 25 percent active ingredient also have given good control when the material was applied around the base of each plant at rates of 20 to 30 grams, or approximately 2 to 3 tablespoons, per tree. Fenuron, a substituted urea closely similar to monuron, was not as effective for the control of mesquite in these studies.

Foliage Sprays with Ground Equipment

Small trees, sprout growth and seedlings often may be controlled effectively by application of drenching sprays of herbicides to leaves, stems and basal plant parts with power sprayers. A suitable spray solution consists of 1 pound of 2,4,5-T acid equivalent or silvex (2-(2,4,5-trichlorophenoxy) propionic acid) of a low volatile ester in 50 gallons of water. The spray solution should be applied in coarse droplets at low pressure to wet the leaves and stems of plants thoroughly. Some agitation usually is needed to prevent the herbicide from settling out. For most effective results the application should be made 40 to 90 days after the first leaves appear in the spring. The amount of spray solution required, 20 to 125 gallons per acre, depends largely on the number and size of plants and the density of foliage. Retreatment usually will be necessary within 3 to 5 years.

The use of boom-type sprayers to control mesquite generally has not been very effective. However, the application of 1 pound of 2,4,5-T acid

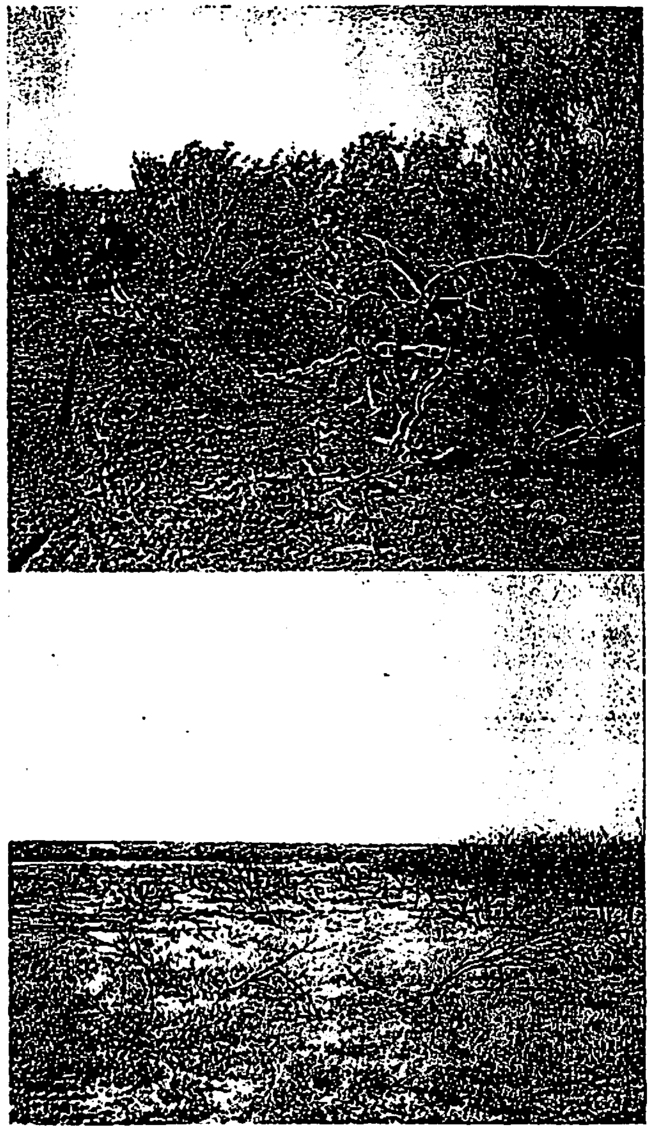


Figure 11. Above—Chaining offers a cheap means of knocking down and thinning out heavy stands of mesquite. It is most effective for the control of large, single-stemmed trees. Below—1 year after the area was double chained. Less than 5 percent of the plants were destroyed. Within 3 to 5 years, more effective measures will be required to control sprout growth.

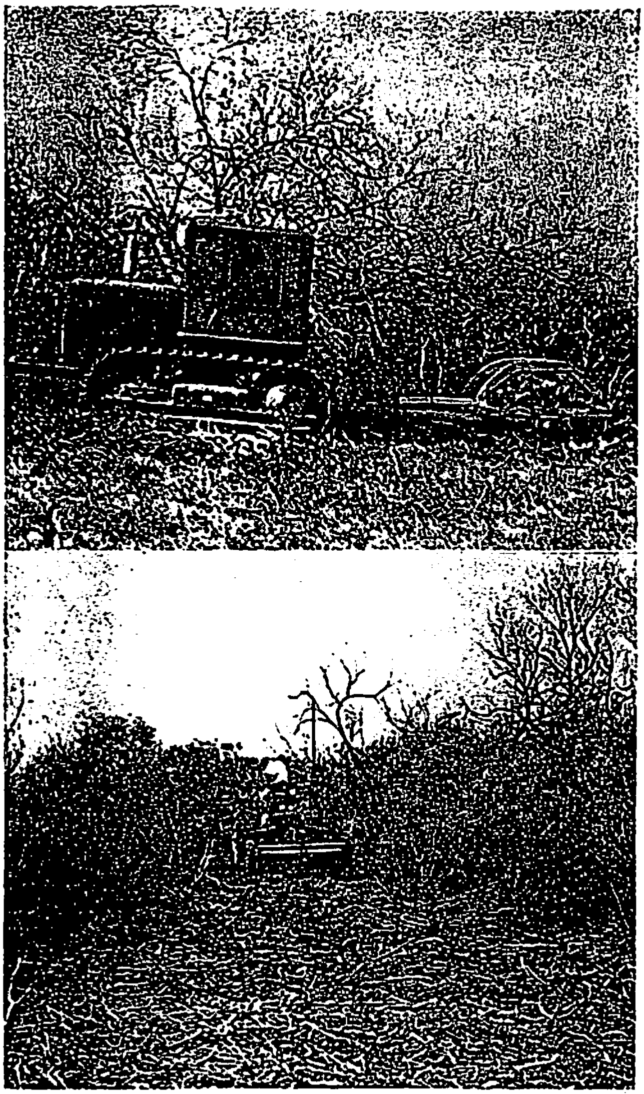


Figure 12. Above—Heavy-duty brush cutter weighing 14,000 pounds used to crush and chop mixed brush. Below—Rotary shredder used to cut underbrush. Chemicals are not effective for the control of mixed brush. Courtesy E. L. Caldwell Manufacturing Co., Corpus Christi, Texas.

equivalent in 10 to 15 gallons of water per acre for the control of undesirable weeds also will suppress mesquite seedlings and small sprout growth. Precautions should be taken to avoid spray drift to susceptible crops.

Moderate to Dense Stands

Experience has shown that extensive areas of moderate to dense stands of mesquite on range and pasture-land may be brought under control profitably by the use of large-scale treatments. Chaining, aerial application of chemicals, root plowing and chopping with heavy-duty brush cutters are methods that have been developed to control brush and improve the productivity of rangeland under a wide range of plant and soil conditions. Some of the factors that influence the general effectiveness, lasting benefits and overall cost of these large-scale treatments are discussed in this bulletin.

Chaining and Cabling

This treatment consists of dragging a heavy-duty anchor chain or cable 300 to 400 feet long in a loop behind two large crawler-type tractors (Figure 11). In most instances, a chain is preferred to a cable because it is more flexible and hugs the ground better owing to the rolling motion that tends to free the chain of uprooted trees and brush.

The greatest value of chaining is the low initial cost of knocking down and thinning out heavy stands of mesquite trees to increase grass production and to reduce the cost of working livestock. "Double chaining," covering the area twice in opposite directions, will break off nearly all the above-ground growth of brushy mesquite and may uproot 10 to 30 percent of the large trees when the moisture content of the soils is relatively high.

Chaining generally offers only temporary benefits for 3 to 5 years, the period depending on the thoroughness of the treatment, potential productivity

TABLE 2. EFFECT OF ROOT PLOWING ON CONTROL OF MESQUITE AND NATIVE GRASS COVER AT SEVEN LOCATIONS NEAR SPUR

Location	Treatment	Grassland type	Number mesquite plants per acre, 1956	Percent grass cover			Bare soil, 1956
				Buffalo	Tobosa	Others	
Spur	Plowed 1947	Tobosa-Buffalo	261	10	60	5	25
	None	Tobosa-Buffalo	500	25	60	5	10
Guthrie	Plowed 1948	Tobosa-Buffalo	508	10	10	10	70
	None	Tobosa-Buffalo	1200	30	10	10	50
Kalgary	Plowed 1948	Tobosa-Buffalo	857	30	5	T	65
	None	Tobosa-Buffalo	1089	25	5	T	70
Clairemont	Plowed 1948	Tobosa-Buffalo	290	15	5	T	80
	None	Tobosa-Buffalo	500	15	70	T	15
Gilpin	Plowed 1950	Buffalo-Aristida	363	5	T	20	75
	None	Buffalo-Aristida	1000	15	T	20	65
Spur	Plowed 1950	Tobosa-Buffalo	116	10	30	T	60
	None	Tobosa-Buffalo	1423	30	35	T	35
Crosbyton	Plowed 1952	Buffalo-Aristida	131	15	T	5	80
	None	Buffalo-Aristida	248	5	T	5	90
Average	Plowed		361	14	16	6	68
	None		851	21	26	6	48

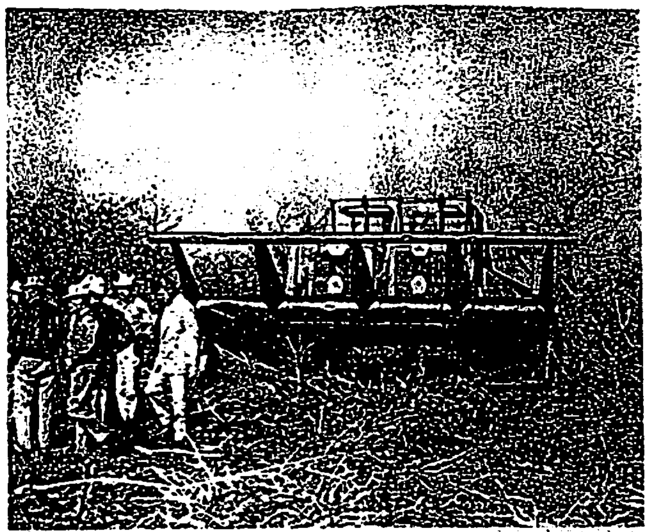
of the site and moisture conditions. Follow-up treatments, such as aerial applications of chemicals, root plowing or power grubbing, will be necessary to control sprout growth from plants that were broken off at ground level and seedling mesquite. The contract cost of chaining varies from $1.50 to $5.00 per acre, depending on the type of growth and density of brush, size of the area to be treated and the topography of the land. Properly used chaining, in combination with other methods, may provide maximum benefits for the money expended on large areas of land with low to moderate potential productivity.

Heavy-duty Brush Cutters

Various types of equipment, including large cutters, weighing 2,000 to 14,000 pounds, have been developed to chop and crush brush and trees of moderate size (Figure 12). Brush cutters have been used successfully to treat areas where mesquite is intermingled with other brush species which cannot be controlled by chaining or chemicals, or where other methods of control are not feasible. In much of the mixed-brush area of South Texas, on land with low to moderate potential productivity, heavy-duty cutters have been used effectively for controlling brush. The initial cost of the treatment is $5 to $10 per acre. Retreatment usually will be necessary at intervals of 5 to 10 years, depending on the productivity of the land and the rainfall. For control of sprout growth on farm pastures, annual cutting with a light-weight rolling cutter or shredder has considerable merit.

Root Plowing

The brush plow, or root cutter, was developed originally for clearing brush-infested land for crop production. More recently it also has been used effectively to control dense stands of mesquite and mixed brush on rangeland. Experience has shown that root plowing has been most successful and profitable on badly depleted range sites that have deep, fertile soils with ample moisture to justify the cost



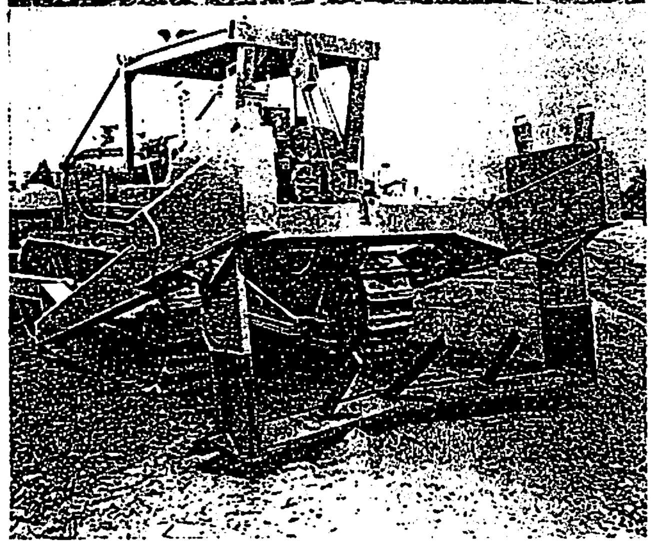


Figure 13. Above—Heavy-duty brush plow with fins on the cutting blade that help lift roots of underbrush out of the soil. Below—Giant heavyduty brushplow used on the King Ranch. These plows are equipped with seeders that utilize the exhaust to plant grass seed at the time of plowing. Courtesy of the Holt Manufacturing Company, San Antonio, Texas, and the King Ranch, Kingsville, Texas.

Figure 14. An area of mixed brush land in South Texas that has been root-plowed and seeded with a mixture of buffel and blue panic grasses. The grazing capacity of the brush land under favorable conditions has been increased 2 to 4 fold. Courtesy of the Soil Conservation Service.

Figure 15. Left—Aerial application of 2,4,5-T in 1950. This method has been used to control mesquite on approximately 2,500,000 acres of grazing land in Texas. Right—The same area in 1954.

of plowing and establishing highly productive native and introduced grasses.

The cost of root plowing and seeding varies from $8 to $25 per acre or higher, depending on the extent of the operation, type and size of brush, nature of the soil and the kind and amount of grass seed used and the success in establishing stands. Generally, this operation is too expensive to control brush on extensive areas of rangeland of low to moderate potential productivity. This is especially true where the establishment of desirable range grasses by seeding has not been successful.

The root plow commonly used is mounted on a heavy-duty, crawler-type tractor which pulls an 8 to 10-foot V-shaped cutting blade 10 to 18 inches below the soil surface. By cutting mesquite below the bud zone and severing the roots of other woody plants, sprouting is prevented, except where lateral roots of the smaller plants are not broken loose from the soil. The use of 3 to 5 fins, 20 to 30 inches long mounted at a 28-degree angle on the cutting blade helps break up the surface soil and destroys many of the plants that might otherwise survive.

On the Rolling Plains, experimental brush-control studies conducted by the Spur station, in cooperation with ranchmen, since 1947, on tobosa-buffalo type grassland have shown that root plowing without fins on the cutting blades destroyed 80 to 95 percent of moderate to dense stands of mesquite. However, extremely heavy stands of sunflower (*Helianthus annus*), Russian thistle (*Salsola kali* var. *tenufolia*) and other undesirable weeds developed on the root-plowed areas soon after treatment and persisted on the land for several years. Results obtained at seven locations indicated that root plowing alone without seeding had not materially improved the

Figure 16. Working cattle in mesquite that had been sprayed by airplane with 2,4,5-T during the preceding year. To be most beneficial, this method should be repeated at intervals of 5 to 7 years to control sprout growth and seedling reinfestation.

productivity of the rangeland because of heavy damage to existing grass cover and rapid reinfestation by mesquite sprouts and seedlings (Table 2).

Further studies were undertaken in 1953 to determine the value of root plowing and seeding promising native and introduced range grasses on moderately productive tobosa-buffalo type grassland. Turkestan bluestem (*Andropogon ischaemum*), Caucasian bluestem (*Andropogon intermedius,* variety *caucasius*), several strains of sideoats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*), buffalograss (*Buchloe dactyloidos*) and weeping lovegrass (*Eragrostic curvula*) were seeded on root-plowed land that was then disced to destroy a heavy turf of tobosa (*Hilaria mutica*). Good stands of all grasses were obtained with both methods of seedbed preparation; however, 3 years later stands of seeded grasses were at a serious disadvantage where the tobosa grass was not destroyed after root-plowing. Results of grazing trials on both seeded and comparable unseeded pastures are reported under "Benefits of Control" in this bulletin.

On the Rio Grande Plain of South Texas, a combination of root plowing and seeding buffelgrass (*Pennisetum cilaric*) and blue panic (*Panicum antidotale*) holds excellent promise of greatly increasing the productivity of badly depleted rangelands heavily infested by mixed brush, (1, 6). The principal woody species besides mesquite are blackbrush (*Acacia amentacea*), huisache (*Acacia farnesiana*), granjeno (*Celtis pallida*), whitebrush (*Lippia ligustriana*), guaycan (*Porleria angustifolia*), lote (*Condalia obtusifolia*), cactus (*Opuntia* spp.), cenizo (*Leucophyllum frutescens*) and paloverdes (*Cercidium* spp.).

Early work on the King Ranch and other ranches in South Texas showed that root plowing alone usually was unsatisfactory because of relatively poor kills of white brush, lote and other understory brush plants; failure of native grasses to become reestablished; and rapid reinfestation by brush seedlings. Within recent years, however, experience by ranchmen and range technicians of the Soil Conservation Service in extensive trials indicates that most of the undesirable features of root plowing may be overcome. The use of fins on the cutting blade of the root plow was effective in destroying a very high percentage of undesirable, shallow-rooted woody

TABLE 3. SUMMARY OF RANCH TESTS, 1949-56

Ranch and location	Date treated	Soil type	Type of growth	Plant condition	Moisture condition	Percent kill Top	Percent kill Root[1]	Nature of regrowth	Weed control	Date re-treatment needed
Emery, Spur	5/29/49	Clay loam	Small trees	Good	Good	98	45	Sparse	Exc.	1956
	5/24/50	Clay loam	Small trees	Good	Fair	98	19	M. rapid	Good	1954
	6/2/51	Clay loam	Small trees	Good	Fair	98	18	Moderate	Good	1955
	5/27/52	Clay loam	Small trees	Fair	Fair	98	10	Moderate	Fair	1956
	5/27/53	Clay loam	Small trees	Good	Dry	98	18	Moderate	Fair	1957
	5/29/54	Clay loam	Small trees	Good	Fair	98	36	Sparse	Good	1958
	5/31/55	Clay loam	Small trees	Good	Fair	98	69	Sparse	Good	1962
	5/24/56	Clay loam	Small trees	Fair	Dry	98	17	Moderate	Fair	1960
Pitchfork, Guthrie	5/22/50	Sandy loam	Small trees	Good	Fair	96	31	Sparse	Good	1956
	6/14/51	Sandy loam	Small trees	Good	Fair	98	26	Sparse	Good	1957
	6/12/52	Sandy loam	Small trees	Fair	Fair	98	20	Sparse	Good	1958
	6/12/53	Sandy loam	Small trees	Good	Dry	95	27	Sparse	Fair	1960
	5/7/54	Sandy loam	Small trees	Good	Fair	98	49	Sparse	Fair	1962
	6/7/55	Sandy loam	Small trees	Good	Fair	98	23	Sparse	Fair	1962
	6/16/56	Sandy loam	Small trees	Fair	Dry	98	31	Sparse	Fair	1963
Callaghan, Encinal	3/31/50	Sandy loam	Med. trees	Fair	Dry	75	30	Moderate	Good	1954
	6/12/51	Sandy loam	Small trees	Good	Fair	98	40	Sparse	Fair	1956
Rust, San Angelo	5/11/50	Clay loam	Med. trees	Good	Fair	98	37	Sparse	Fair	1954
Slator, Odessa	5/13/50	Clay loam	Small trees	Good	Good	98	45	Sparse	Good	1958
Elliott, Albany	5/15/50	Clay loam	Large trees	Good	Fair	95	5	Moderate	Good	1954
Clayton, Gail	5/18/50	Clay loam	Small trees	Fair	Fair	85	5	M. rapid	Good	1954
Triangle, Paducah	5/29/50	Clay loam	Med. trees	Fair	Fair	98	5	M. rapid	Good	1954
Waggoner, Vernon	5/31/50	Clay loam	Med. trees	Good	Good	98	21	Moderate	Good	1955
McClellan, Dean	6/31/50	Sandy loam	Small trees	Good	Good	98	65	Sparse	Exc.	1956
Scaling, Henrietta	6/5/50	Clay loam	Large trees	Good	Good	98	11	Moderate	Good	1955
"	6/5/50	Clay loam	Small trees	Good	Good	98	86	Sparse	Good	1956
JA, Clarendon	6/8/50	Clay loam	Med. trees	Good	Fair	98	17	Moderate	Good	1954
King, Encino	5/7/51	Fine sand	Med. trees	Good	Good	98	90	Sparse	Exc.	1958
King, Norias	5/8/51	Fine sand	Large trees	Good	Good	98	45	Sparse	Good	1956
King, Norias	5/8/51	Fine sand	Sprouts	Good	Good	98	95	Sparse	Exc.	1960
Horton, Tilden	6/8/51	Clay loam	Med. trees	Good	Good	98	40	Sparse	Good	1958
Lyles, La Pryor	6/11/51	Clay loam	Med. trees	Good	Fair	98	15	Moderate	Fair	1956
Jones, Marfa	6/22/51	Clay loam	Small trees	Fair	Fair	98	10	Moderate	Fair	1956
Halbert, Sonora	7/10/51	Clay loam	Med. trees	Fair	v.dry	98	5	M. rapid	Fair	1954
6666, Guthrie	5/27/50	Clay loam	Med. trees	Good	Good	98	23	Moderate	Exc.	1954
6666, Guthrie	5/27/51	Clay loam	Small trees	Good	Fair	98	10	Moderate	Exc.	1954
6666, Guthrie	5/27/53	Clay loam	Med. trees	Good	Fair	98	20	Rapid Sparse	Good	1958
6666, Guthrie	6/8/54	Clay loam	Sprouts	Fair	Fair	90	10	M. rapid	Good	1958
6666, Guthrie	6/7/56	Clay loam	Med. trees	Good	Fair	98	31	Sparse	Good	1962

[1]Percentage kill 15 months after treatment.

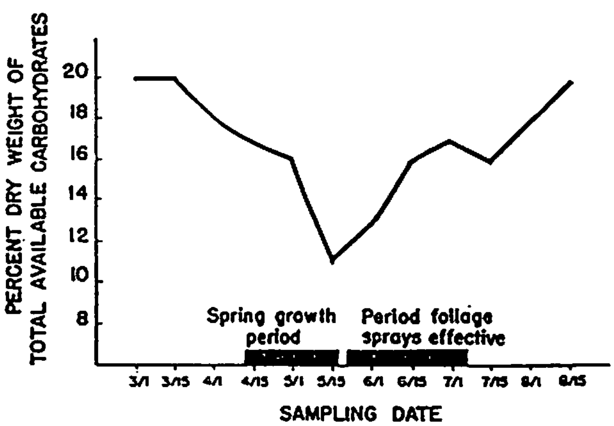


Figure 17. Average total available carbohydrate content of mesquite root tissues at biweekly intervals during 1953-56. Aerial application of 2,4,5-T has been most effective from May 20 to July 15, when the carbohydrate content of the roots is being replenished rapidly.

plants (Figure 13). By seeding 1 to 2 pounds each of buffelgrass and blue panicum with special equipment mounted on the root plow, a quick competitive cover helped to prevent rapid reinfestation by brush seedlings (Figure 14). It has been estimated conservatively that the carrying capacity of the badly depleted brushland was increased 2 to 4 fold or more during the first few years after the root plowing and seeding operations were completed.

Some control of brush seedlings likely will be necessary, depending on the early establishment of a vigorous grass cover, management of the treated area and seasonal rainfall. The chief advantage of the root plowing and seeding operation is the rather complete destruction of nearly all existing undesirable kinds of brush and the resultant greatly increased carrying capacity of badly depleted rangeland. It is an excellent practice where the establishment of grass cover is successful and the potential productivity of the land is sufficiently great to sustain heavy production of grass forage.

The high initial cost of the operation, the lack of knowledge of productivity and longevity of buffelgrass and blue panic stands under a wide range of conditions and the degree of success in obtaining satisfactory stands are factors that should be considered in choosing this method of control. Failure to obtain stands of grasses because of unfavorable rainfall, poor soil conditions and other causes following the initial seeding often results in a serious weed problem that may persist on the land for many years. This is not a serious consideration on land that is suitable for crop production. On marginal croplands, however, failure to obtain stands of perennial vegetation may bring about serious wind and water erosion and noxious weed infestation that have little or no grazing value. Once established, weeds greatly increase the difficulty of establishing a cover of grasses on the land. In most instances, the control of weed infestations soon after emergence will increase the chances of obtaining satisfactory stands of seeded grasses.

TABLE 4. SUMMARY OF OBSERVATION ON THE EFFECT OF SOIL MOISTURE AND FOLIAGE COVER ON PERCENTAGE KILL OF MESQUITE

Soil moisture		Foliage cover	Percent kill	
Prior to leafing out	Following leafing out		Tops	Roots
Deficient	Deficient	Sparse	50-90	Trace
Deficient	Intermittent	Variable	70-98	Tr. to 15
Deficient	Adequate	Normal	90-98	20 to 40
Adequate	Normal	Heavy	95-98	40 to 98
Adequate	Below normal	Normal	95-98	60 to 98

Aerial Application of Chemicals

Extensive trials since 1949 have shown that good control of moderate to dense stands of mesquite may be obtained at low cost by aerial application of 2,4,5-T (16). This method lends itself to treatment of extensive areas of grassland with low to moderate productivity where it is desirable to obtain maximum amount of brush control for the money expended (Figure 15, 16). Repeated applications at intervals of 5 to 7 years will be needed under most conditions to control mesquite effectively (Table 3). Aerial application of herbicides also provides an effective and economical means of controlling sprout growth, seedlings and undesirable weeds following the use of mechanical treatments. Herbicides have not been effective for the control of mixed brush.

The chemicals used to control mesquite are not toxic to livestock and grass plants, but are hazardous to use near fields of cotton and other susceptible broadleaf crops. The effectiveness of the chemical treatment is governed largely by the environmental factors that influence the growth of mesquite (15). Some of the factors that should be considered in the chemical treatment of mesquite are discussed following.

Effective Chemicals. Experimental studies conducted cooperatively with ranchmen at various locations throughout the mesquite area of Texas have shown that low-volatile esters of 2,4,5-T are more effective for the control of mesquite under a wide range of conditions and are much less hazardous to use than 2,4-D (2,4-dichlorophenoxyacetic acid) and combinations of 2,4-D and 2,4,5-T. Other chemicals tested were special formulations of 2,4,5-T, including water and oil soluble amines, (2 (2,4-dichlorophenoxy) propionic acid), MCPA (2 methyl-4-chlorophenoxy acetic acid), MCPB (4-(2-methyl-4-chlorophenoxy) butryic acid), amitrol (3 amino-1,2,4 triazole), 2,3,6 TBA (2,3,6 trichloro benzoic acid) and many other closely related systemic chemicals.

Aerial application of monuron and fenuron as spray solutions and in pellet forms at rates up to 7½ pounds of active ingredient per acre in 1955-56 failed to give effective control of mesquite. These materials

TABLE 5. HERBICIDAL SOLUTIONS FOR THE CONTROL OF NORMAL GROWTH OF MESQUITE WITH 1/3 POUND ACID EQUIVALENT APPLIED AT A 3-GALLON RATE PER ACRE

Acreage to be treated	Gallons			
	Amount of herbicides (4 lb. acid equiv. per gal.)	Diesel fuel	Water	Total
1	2/3 pt.	.5	2.50	3
2	1-1/3 pt.	1.0	5.00	6
3	1 qt.	1.5	7.25	9
4	1 qt. 2/3 pt.	2.0	9.75	12
5	1 qt. 1-1/3 pt	2.5	12.25	15
6	2 qt.	3.0	14.50	18
7	2 qt. 2/3 pt.	3.5	17.00	21
8	2 qt. 1-1/3 pt.	4.0	19.50	24
9	3 qt.	4.5	21.75	27
10	3 qt. 2/3 pt.	5.0	24.25	30
20	1 gal. 2 qt. 1-1/3 pt.	10.0	48.50	60
30	2 gal. 2 qt.	15.0	72.50	90
40	3 gal. 1 qt. 2/3 pt.	20.0	96.75	120
50	4 gal. 1-1/3 pt.	25.0	121.00	150
60	5 gal.	30.0	145.00	180

have been effective for mesquite only when applied in basal applications.

The low-volatile ester formulations of 2,4,5-T have been more satisfactory than amine salt or suspended acid formulations. The following esters appeared to be approximately equal in effectiveness in field tests: butoxy ethanol ester, propylene glycol butyether ester, iso-octyl ester and butoxy ethoxy propanol ester. The use of high-volatile esters is considered unsafe because of the possibilities of herbicidal drift of vapors from the treated areas that might injure sensitive crops.

Season of Treatment. The stage of growth of mesquite is one of the most important factors influencing the effectiveness of growth regulators applied to the foliage. Experimental applications at 15-day intervals from early spring to late fall, together with field trials, have shown that most effective kills

TABLE 6. CALIBRATION TABLE FOR THE CONTROL OF NORMAL GROWTH OF MESQUITE USING SWATH WIDTH OF 60 FEET

Length of swath, miles	Length of swath, feet	Square feet in swath	Acres in swath	Gallons of solution per swath (at 3 gal. per acre)
.1	528	31,680	.727	2.18
.2	1,056	63,360	1.454	4.36
.3	1,584	95,040	2.181	6.54
.4	2,112	126,720	2.909	8.73
.5	2,640	158,400	3.636	10.91
.6	3,168	190,080	4.363	13.09
.7	3,696	221,760	5.090	15.27
.8	4,224	253,440	5.818	17.45
.9	4,752	285,120	6.545	19.64
1.0	5,280	316,800	7.272	21.82
2.0	10,560	633,600	14.545	43.64
3.0	15,840	950,400	21.818	65.45

have been obtained 50 to 80 days after the first leaves appeared in the spring. Good results may be obtained during unusually early warm seasons by spraying mesquite 10 to 15 days after the leaves are fully formed and start turning from the characteristic light green to dark green. The optimum date for treatment of mequite at Spur has been approximately 65 days after the first leaves appear. Applications before the leaves have developed in the spring or during summer and fall after mesquite has ceased active growth usually give only partial kills of above-ground stems and twigs.

Since it is known that maximum transport of 2,4-D and 2,4,5-T takes place when the plants are actively growing and storing food (8), studies were undertaken in 1950 to determine when the root reserves reached a low point and the approximate time a rapid buildup of reserves might occur. Analyses of root samples collected at monthly and later at bi-weekly intervals during 1950-56 showed that the low point of root reserves occurs when mesquite is

Figure 18. Left—Bottomland pastures at the Spur station that was heavily infested with mesquite prior to treatment in 1947. Right—The same area after mesquite had been brought under control, runoff water utilized by means of water spreaders and stocking rate adjusted to utilize 50 percent of the forage production. A combination of these practices conservatively increased the grazing capacity two to four fold by 1954.

TABLE 7. CALIBRATION TABLE FOR THE CONTROL OF DENSE REGROWTH OF MESQUITE AND HEAVY WEED INFESTATION USING A SWATH WIDTH OF 42 FEET

Length of swath, miles	Length of swath, feet	Square feet in swath	Acres in swath	Gallons of solution per swath (at 4 gal. per acre)
.1	528	22,176	.509	2.04
.2	1,056	44,352	1.018	4.07
.3	1,584	66,528	1.527	6.11
.4	2,112	88,704	2.036	8.14
.5	2,640	110,880	2.545	10.18
.6	3,168	133,056	3.055	12.22
.7	3,696	155,232	3.564	14.26
.8	4,224	177,408	4.073	16.29
.9	4,752	199,584	4.582	18.33
1.0	5,280	221,760	5.091	20.36
2.0	10,560	443,520	10.182	40.73
3.0	15,840	665,280	15.273	61.09

leafing out and completing early-spring growth (Figure 17). Thereafter rapid replenishment of root reserves follows, provided soil moisture and other environmental factors are favorable. At this stage of growth, aerial applications of 2,4,5-T have been most effective.

Moisture and Growing Conditions. During the spray season, the effectiveness of 2,4,5-T and other growth regulator chemicals depends largely on factors that influence the growth of mesquite. Experience shows that good control of mesquite has been obtained generally when moisture was adequate to support normal development of foliage in the spring (Table 4).

The influence of soil moisture and plant condition on percentage root kill of mesquite is indicated strongly from results obtained in 33 ranch tests during 1949-56. In nine cases when soil moisture conditions were considered to be good at the time of aerial application of 2,4,5-T, the root kill of mesquite varied from 11 to 95 percent and averaged 60 percent. Under less favorable conditions in 18 cases when soil moisture was considered to be fair, the percentage root kill varied from 5 to 69 percent for an average of 24 percent. When the soil was considered dry at the time of application in six cases, the root kill varied from 5 to 31 percent for an average of 21 percent. When plant condition was considered to be good at the time of application, an average root kill of 39 percent was obtained in 25 cases. When plant condition was considered to be fair, the average root kill was only 15 percent in nine cases.

TABLE 8. HERBICIDAL SOLUTIONS FOR THE CONTROL OF DENSE REGROWTH OF MESQUITE AND HEAVY WEED INFESTATIONS USING ½-POUND ACID EQUIVALENT APPLIED AT A 4-GALLON RATE PER ACRE

Acreage to be treated	Gallons			
	Amount of herbicides (4 lb. acid equiv. per gal.)	Diesel fuel	Water	Total
1	1 pt.	1	2.88	4
2	1 qt.	2	5.75	8
3	1 qt. 1 pt.	3	8.63	12
4	2 qt.	4	11.5	16
5	2 qt. 1 pt.	5	14.38	20
6	3 qt.	6	18.25	24
7	3 qt. 1 pt.	7	20.13	28
8	1 gal.	8	23.00	32
9	1 gal. 1 pt.	9	25.88	36
10	1 gal. 1 qt.	10	28.75	40
20	2 gal. 2 qt.	20	57.50	80
30	3 gal. 3 qt.	30	86.25	120
40	5 gal.	40	115.00	160
50	6 gal. 1 qt.	50	143.75	200
60	7 gal. 2 qt.	60	172.50	240

If the growth and development of foliage are affected seriously by drouth or leaf insects, or if intermittent showers stimulate new growth, spraying should be delayed until moisture conditions become more favorable in later years. Unusually good control of mesquite has been obtained at several locations by spray treatments applied in wet years following drouth years.

Rate and Volume of Application. The amount of chemical used in extensive aerial tests ranged from 1/6 to 2-2/3 pounds acid of a low-volatile ester of 2,4,5-T per acre on different growth forms of mesquite. These varying rates of chemical were applied in 2, 4, 8 and in a few instances, 12 gallons of oil-water emulsions and diesel fuel per acre. Other carriers tested included water alone, oil-water emulsions containing in proportions of 1:8, 1:6, 1:4 and 1:1 diesel oil, naptha, kerosene, low and high phytotoxic oils and many other materials.

Results of these studies show that the original or natural growth of mesquite was controlled most effectively and economically by the application of 1/3 pound acid in 3 gallons of 1:6 diesel fuel-water emulsion per acre (Tables 5, 6). Increasing the amount of chemical or the volume of the spray material did not improve the effectiveness of the treatment under a wide range of conditions.

Sprout growth of mesquite was controlled effectively with chemicals when the above-ground growth reached a height of 3 to 4 feet or more (Figure 18). In most instances, best results were obtained by the use of ½ pound acid of a low-volatile ester of 2,4,5-T or silvex in 4 gallons of a 1:3 diesel fuel-water emulsion per acre (Tables 7, 8). Treatment of small sprout growth less than 3 feet tall usually was much less effective because of an apparent lack of balance between the above-ground growth and that of a well-established root system. Control of running mesquite, a decumbent growth form, appeared unsatisfactory in limited trials.

Swath Width. Tests were conducted at six locations during 1954-56 to determine the influence of swath width on the effectiveness of chemical treatment of mesquite. A Stearman biplane equipped with a 27-foot boom and 14 low-pressure nozzles was used to apply 1/3, 1/2 and 1 pound acid of 2,4,5-T in 30, 42, 54, 67 and 84-foot swaths. The results obtained show that, for natural or original growth of mesquite, swath widths of 60 to 84 feet gave just as good control as the 30 to 42-foot swaths (Table 9).

For treatment of dense sprout growth 3 to 4 feet tall, the 42-foot swath width appeared to be somewhat more effective than the 60 and 80-foot swaths, but further study is needed. In these tests, applications were made with cross winds of 3 to 7 miles per hour. Under downwind or no wind conditions, experience has shown that a swath width of 42 feet usually tends to give more uniform control.

Type of Growth. Extensive trials have been conducted on various growth forms of mesquite. Small plants and seedlings have been destroyed effectively by chemical treatment. Good to excellent control of mesquite brush with stems up to 4 inches in diameter also has been obtained when moisture and plant conditions were reasonably favorable. For control of large trees with trunks 6 to 18 inches in diameter, good top kills with some root kills have been obtained only under the most favorable conditions. Under average soil and plant conditions, especially when the trees lacked vigor and had considerable dead top wood, chemical treatments usually give fair top kills but little or no root kill. A combination of mechanical methods that will destroy a high percentage of the old trees followed several years later by chemical treatment of sprout growth in many instances have given good control at low cost.

Range Site and Soil Type. Throughout nearly all of the test areas, noticeably more effective control of mesquite has been obtained on light sandy soils on upland sites. In cooperative ranch tests in 26 cases, the average percentage root kill of mesquite growing on clay and clay loam soils was 24 percent. But, in 13 cases where mesquite occurred on fine sandy loams and fine sands, an average root kill of 44 percent was obtained. In most instances on bottomland sites with moderate to heavy clays, top kills were satisfactory; however, heavy regrowth usually developed at the base of the plant, indicating little or no movement of chemical below the soil line. Generally, it is thought that mesquite is more difficult to kill on bottomlands because the trees tend to be larger and the dormant buds are buried deeper below the soil line. A swath width of less than 42 feet or heavier rates of chemical did not improve the effectiveness of the treatment.

Weed Control and Grazing Habits. Under favorable growing conditions, seedlings and young plants of annual broomweed (*Gutierrezia dracun culoides*), cockleburs (*Xanthium* spp.), sunflowers (*Helianthus annus*), Russian thistle (*Salsola kali* var. *tenuifola*), lambs quarters (*Chenopodiom alba*), annual croton (*Croton* spp.) and many other annual broadleaf plants are controlled satisfactorily by aerial treatment of mesquite with 1/3 to 1/2 pound acid of 2,4,5-T per acre. The chemical treatment becomes less effective as weeds approach maturity.

The grasses on land that has been sprayed with 2,4,5-T to control mesquite, almost without exception, are heavily utilized by livestock even though there may be large areas of untreated land available to the grazing animals. It is thought that the greater amount of sunlight and moisture made available to the grasses following treatment of mesquite is primarily responsible for this grazing preference. Some chemical changes probably occur in the composition of the grass plants, but no definite information has been obtained on this subject.

To obtain greatest benefit from the use of chemicals for the control of mesquite and undesirable weeds, careful consideration should be given to the selection of seasons and sites. Following extended drouths, the grass cover usually becomes thin and, therefore, mesquite seedlings and other undesirable plants can gain a foothold. Timing the chemical treatments when rainfall becomes favorable to help eliminate these invading plants will greatly speed up the recovery of native grasses on the range.

Spraying Equipment. Research work on the effect of droplet size of the spray solution delivered by aerial equipment has been conducted under field and laboratory conditions. These tests showed that equipment which delivered a major portion of the droplets within a range of 100 to 400 microns is most satisfactory for the control of mesquite. The use of droplets of less than 100 microns increased the danger of

TABLE 9. EFFECT OF AERIAL SWATH WIDTH AND VARIOUS RATES OF 2,4,5-T ON PERCENTAGE KILL OF MESQUITE AT SIX LOCATIONS, 1954-57

Swath width, feet	Pounds of 2,4,5-T acid per acre	Volume, gal. 1:3 emulsion per acre	Percent root kill[1]
30	¼	5.59	31
30	½	5.59	34
30	¾	5.59	30
30	1	5.59	34
42	¼	4.00	33
42	½	4.00	31
42	¾	4.00	34
42	1	4.00	32
54	¼	3.10	31
54	½	3.10	35
54	¾	3.10	33
54	1	3.10	29
67	¼	2.54	31
67	½	2.54	31
67	¾	2.54	31
67	1	2.54	33
84	¼	2.00	33
84	½	2.00	40
84	¾	2.00	31
84	1	2.00	33

[1]Percentage root kill 15 months or longer after treatment.

spray drift, whereas droplets above 400 microns tended to give inadequate coverage of the foliage.

For best results, only experienced operators with approved equipment should be employed to apply these chemicals. The height of flight, nearness of susceptible crops, wind direction and velocity, condition of the plants to be treated and many other related factors must be taken into consideration by the operator for the greatest benefit and safety to the landowner.

The cost of aerial chemical treatment of mesquite varies from $2 to $3 per acre depending on such factors as the amount of chemical applied, swath width used, the size of the area to be treated and the distance to the landing field.

Effects of Repeated Aerial Applications. Early experimental tests with 2,4,5-T under a wide range of climatic and environmental conditions showed that in nearly all instances excellent top kills were obtained, but that root kills varied from 5 to 95 percent. Even though root kills, in many cases, were low because of unfavorable plant conditions and other factors, in every instance there was insufficient sprout growth to permit retreatment within a period of less than 3 years after the initial treatment. In cases where root kills of 30 to 50 percent were obtained, sprout growth rarely was large enough to permit retreatment within 4 to 7 years. Where kills above 50 percent were obtained, retreatment at intervals of 8 to 10 years could be expected to give good to excellent control of mesquite.

Results of aerial retreatment tests conducted at Spur and Guthrie are shown in Table 10. The average kill obtained from one application varied from 10 to 29 percent under a wide range of conditions; however, retreatment 3 to 5 years later increased the average kill from 19 percent for the initial treatment to 41 percent for two treatments. These results indicate that, under favorable conditions, repeat applications of 2,4,5-T will gradually bring mesquite under control at relatively low cost.

TABLE 10. EFFECT OF REPEATED AERIAL APPLICATIONS OF 2,4,5-T ON THE ROOT KILL OF MESQUITE

Initial treatment			Retreatment		
Date	Type of growth	Percent root kill	Date	Height of sprouts, inches	Percent root kill
		SPUR			
1949	Small trees	21	1952	24-26	34
1949	Small trees	29	1954	36-48	58
1950	Small trees	10	1953	24-36	24
1950	Small trees	10	1954	36-48	39
1951	Small trees	16	1953	24-36	49
1951	Small trees	16	1954	36-48	57
		GUTHRIE			
1950	Small trees	10	1953	36-48	42
1950	Medium trees	17	1953	36-48	32
1950	Small trees	27	1954	36-48	38
1950	Small trees	31	1955	36-60	54
1950	Small trees	26	1955	36-60	32
1951	Small trees	20	1956	36-60	47
1953	Medium trees	10	1957	36-60	30
Average percent kill		19			41

BENEFITS OF MESQUITE CONTROL

The chief benefits realized from the control of mesquite on rangeland include a marked reduction in cost of handling and caring for livestock, an increase in the carrying capacity of the land, reduced hazards of death losses from mesquite bean poisoning and the use of other sound range and livestock management practices that often are not feasible in pastures heavily infested with brush (Figure 18). The extent of the benefits derived from the control of mesquite will depend largely on the degree and type of infestation, the potential productivity of the land and the condition of desirable range vegetation and management.

Grazing Results

Benefits of Chemical Control

Grazing trials with yearling steers were conducted at the Spur station in the summers during 1945-54 on eight 20-acre native pastures that originally had moderate stand of brushy mesquite. In 1945, two upland and two bottomland sites were cleared of mesquite by removing the top wood and treating the stumps. Later, the sprout growth and seedling mesquite were controlled at intervals of 5 years by aerial application of 2,4,5-T. On four closely adjoining pastures, two on upland and two on bottomland, comparable stands of brush received no treatment. The pastures were stocked on the average from May 1 to October 3 at a moderate rate of 6.50 acres per head for an annual grazing period of 156 days.

Grazing trials for the 10-year period show an average steer gain of 204 pounds for the cleared pastures and 173 pounds for the brush pastures (Figure 19), a difference of 31 pounds per head in favor of the cleared pastures (Table 11). During the seasons of 1948, 1952 and 1953, acre-gains on cleared pastures were 42, 53 and 35 percent higher, respectively, than on the pastures infested with mesquite. The average gain of yearling steers was lowest, 148 pounds per head, on upland sites infested with mesquite, and highest, 224 pounds per head, on bottomland sites where mesquite was controlled (Figure 20). For the overall period of study, the annual acre-gain was increased an average of 18 percent by the control of mesquite. This increase was worth $1 per acre where yearling steers were valued at 20 cents per pound. Reynolds and Tschirley (23) estimated that, under normal conditions in Arizona, the control of mesquite would give a three-fold increase in grazing capacity.

In addition to the increased returns obtained by the control of mesquite, it was estimated that the

Figure 19. Cleared and mesquite-infested pastures used in the grazing trials. Control of mesquite increased steer gains an average of 31 pounds per head annually during 1945-54.

labor required for working and handling livestock on the cleared pastures was less than one-fourth that required to work cattle on the brush pastures. The cattle on the cleared pastures tended to be more gentle and those on the brush pastures usually became more difficult to handle as the season progressed.

Benefits of Root Plowing and Seeding

An area of upland native grassland of moderate potential productivity, with a fair cover of tobosa, buffalo, sideoats grama grasses, vine mesquite and a moderate stand of mesquite, was divided into two 10-acre pastures in 1953. One pasture was root-plowed and seeded during March. Good stands of Causasian bluestem, King ranch bluestem, several strains of sideoats grama, buffalo, blue grama and mixtures of these grasses were obtained on the seeded pasture. This pasture was not grazed during 1953-54; however, a light seed crop was harvested during the fall of 1954. The other 10-acre pasture, which previously had been grubbed with power equipment, was treated with 2,4,5-T to control mesquite sprout growth and seedlings. This pasture was grazed during the period the grasses were becoming established on the seeded pasture.

TABLE 11. SUMMARY OF GRAZING TRIALS WITH YEARLING STEERS DURING THE SUMMER ON CLEARED AND MESQUITE-INFESTED PASTURES, FOR THE 10-YEAR PERIOD, 1945-54

Treatment	Average number of steers	Acres per head	Number of days grazed per season	Average gain, pounds		
				Steer	Daily	Acre
Cleared, upland	6.0	8.0	154	184	1.19	22.75
Mesquite, upland	6.0	8.0	154	148	.96	17.92
Cleared, bottomland	7.0	5.0	158	224	1.41	44.24
Mesquite, bottomland	7.0	5.0	158	198	1.25	38.40
Average cleared	6.5	6.5	156	204	1.30	33.50
Average mesquite	6.5	6.5	156	173	1.10	28.16

Grazing trials with yearling steers were begun on both pastures in the spring of 1955. Results of these trials with yearling steers during the summers of 1953-58 are shown in Table 12. For the 4-year period, 1955-58, when the reseeded pasture was ready to be grazed, gains of yearling steers averaged 196 pounds per head, compared with 157 pounds per head for steers on native grass cleared of mesquite. The acre-gains also were higher on the root-plowed and reseeded pasture. For the 6 years, 1953-57, however, there was no advantage for the pasture that was root-plowed and seeded over the native grass pasture cleared of mesquite.

If the seeded grasses continue to maintain satisfactory stands and vigor under moderate grazing, a distinct advantage should develop in favor of reseeded pastures over a period of years. It would be expected that on land with high potential productivity, greater benefits likely would be realized from

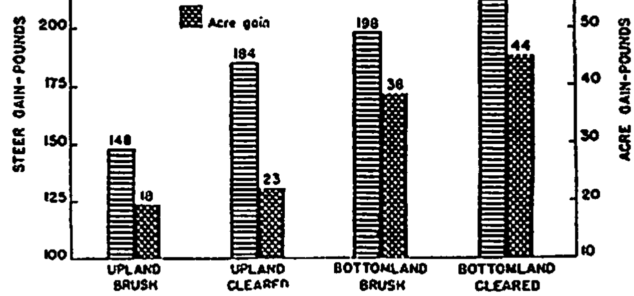


Figure 20. Influence of mesquite control on steer and acre gain during 1945-56 at Spur on upland and bottomland pastures. Bottomland pastures have produced approximately twice as much beef gain per acre as closely adjoining upland pastures.

root plowing and reseeding to adapted, palatable range grasses. Experience has shown that on land with low potential productivity, forage production is too low and unstable to justify the use of this practice.

The cost of root plowing, seeding and spraying annually with 2,4,5-T to control undesirable weeds and seedling mesquite was $20 per acre, whereas the cost of controlling mesquite with a treedozer followed by one basal application of 2,4,5-T to control sprouts and seedlings was $10 per acre. The cost of these treatments must be considered to be relative since the cost will vary with the size of the area to be treated, type and density of brush, cost of establishing a good stand of grass, nature of the land and need for subsequent weed and brush-control measures.

Effect of Shade on Buffalograss

Experimental studies were undertaken in 1938 to determine the influence of different amounts of shade on buffalograss. Special lath cages were constructed to simulate no shade, light shade, moderate shade, heavy shade and dense shade by mesquite (Figure 21). The plots were clipped during the late spring, summer and fall to determine the yield and nutritive content of the forage. Basal density of the buffalograss was estimated each spring soon after it began growth.

The yield of Buffalograss when grown in full sunlight and different amounts of shade for the 6-year period of study, 1939-44, is shown in Table 13. The data indicate that the yield of buffalograss grown in light to moderate amounts of shade was not materially affected, but that it was seriously reduced by heavy and dense shade. Increasing the shade tended to increase the protein content of the forage. This increase, however, appeared to be associated with an increase in crude-fiber content and a decrease in nitrogen-free extract (Table 14). Determinations also showed that the moisture content of the forage increased and grass leaves tended to become elongated with increasing amounts of shade. Observations indicated that the elongated leaves were much tougher to break during certain seasons of the year than those grown in light shade or full sunlight. The basal cover of buffalograss for all plots averaged 67 percent in 1939, when the studies were begun. Six years later, the basal cover declined to 52, 40, 29, 12 and 0 percent, respectively, for buffalograss grown in full sunlight, light, moderate, heavy and dense shade.

These results indicate that small amounts of artificial shade did not materially affect the yield, nutritive content and basal cover of buffalograss. Under conditions of natural shade, the added competition for soil moisture and plant food by mesquite undoubtedly reduces the productivity of the grass, especially where moderate to dense stands of brush prevail, as shown by Parker and Martin working in Arizona.

REINFESTATION OF GRASSLAND

It is common knowledge among ranchmen and farmers that effective control of well-established stands of mesquite on grazing lands depends on destroying a high percentage of the existing plants, and prevention of rapid reinfestation from seed in the soil and those brought in by grazing animals, rodents, wind, water and by sprout growth of plants that were not destroyed.

Seedling Emergence and Survival

Research conducted at Spur during 1940-56 showed that heavy emergence of mesquite seedlings might occur within 1 to 3 years following control of well-established stands of mesquite, especially if the soil and grass cover were seriously disturbed. On an area of tobosa-buffalo type grassland protected from grazing animals for 15 years, 871 seedlings of a total of 2,952 per acre that emerged within 18 months after 237 trees and small mesquite had been removed by hand grubbing, became well established

TABLE 12. SUMMARY OF GRAZING TRIALS ON ROOT-PLOWED AND RESEEDED PASTURE AND ON A NATIVE GRASS PASTURE CLEARED OF MESQUITE. 1954-58

Treatment	Item	Average gain, pounds						Average annual gain, pounds	
		1953	1954	1955	1956	1957	1958	4 years, 1955-58	6 years 1953-58
Root plowed, seeded	Steer gain	0[1]	0[1]	276	142	263	139	196	141
	Acre gain	0	0	68	43	53	42	51	37
	Daily gain	0	0	1.56	1.45	1.43	.84	1.29	.84
Native grass, control of mesquite	Steer gain	123[2]	117[2]	253	94	196	115	157	158
	Acre gain	16	17	62	28	39	34	41	35
	Daily gain	1.41	.94	1.43	.95	1.06	.69	1.03	1.10
Date grazed		4/28-8/31	4/28-9/1	5/10-11/4	4/24-9/4	5/1-11/1	4/29-10/10		
Number of days		87	125	177	132	184	165	152	145
Rate of grazing, acres per head		7.68	10.00	4.07	3.33	5.00	3.33	3.82	5.57

[1]Not grazed in 1953-54.

[2]Data from comparable native grass pasture.

(Figures 22, 23). The heaviest mortality of the seedlings occurred soon after emergence. A gradual reduction of only 16 percent in seedling numbers took place during the next 12 years. The growth of seedlings, however, was greatly restricted by severe competition of a heavy cover of grasses consisting primarily of tobosa, buffalo, vine mesquite and traces of others. Timely application of 2,4,5-T, together with the competition of grasses, might have prevented the survival of a majority of the seedlings. The survival of seedlings that emerged in later years averaged less than 20 plants per acre annually. The heavy emergence of mesquite seedlings in 1941 undoubtedly was influenced by the prolonged drouth from 1933 to 1940, which greatly reduced the basal cover of perennial grasses. Attempts to destroy well-established mesquite seedlings by burning a heavy cover of tobosa and buffalo grasses during the early spring and summer failed to destroy an appreciable number of the seedlings during a 2-year period of study.

Influence of Livestock on Seed Germination

Feeding trials were undertaken in 1940 to determine the influence of mastication and digestion by different classes of animals on the germination of mesquite seed. It was found that 97, 79 and 16 percent of a total of 745 sound beans fed in pods passed through the digestive tracts of horses, yearlings, steers and ewes, respectively, during a period of 158 hours. The greatest number of seed was expelled by the animals 42 to 60 hours after feeding. Germination of seed that had passed through the animals averaged 82 percent for the horses, 69 percent for steer yearlings and 25 percent for ewes. For seed left in pods and not fed to the animals, germination was only 26 percent, whereas germination of seed removed mechanically from the woody capsules that encase the seed was 86 percent. The longevity of seed under range conditions is not known; however, under certain conditions bean weevils (*Mimosestes amicus*) and (*Bruchus prosopis*) often destroy a high percentage of the embryos of many mature seed. Other insects that commonly attack mesquite include the flathead wood borer (*Buprestidae* spp.), the twig girdler (*Oncideres trinodatus*) and the measuring worm, a member of the Geomatridae family. A fungus (*Ganoderma zonatum*) also attacks the basal plant parts under some conditions.

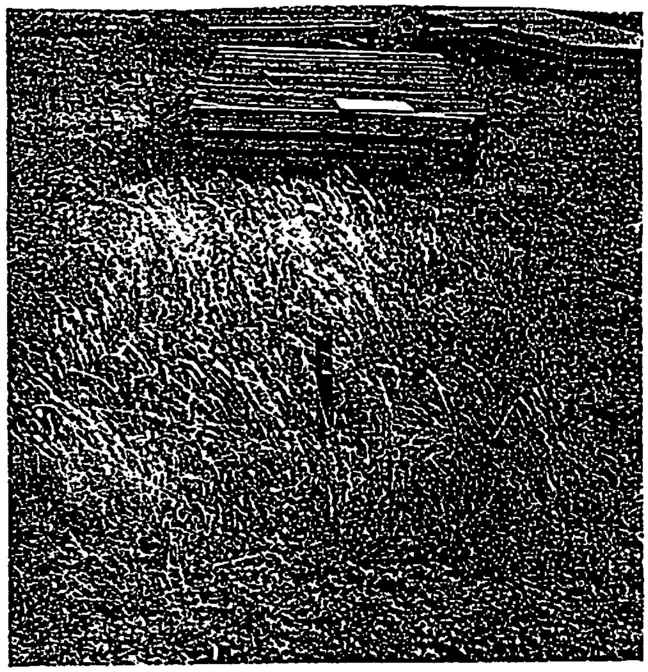


Figure 21. Buffalograss grown under heavy shade was taller, higher in moisture and protein and crude fiber contents, but lower in carbohydrates during the first 3 years of study. For the 6-year period of study, however, the average yield dropped from 1,235 pounds for grass produced in full sunlight to only 191 pounds for grass grown under heavy artificial shade.

Reinfestation Following Control Practices

To obtain information on the influence of reinfestation by seed in the soil and those brought in by rodents, birds and coyotes, a 160-acre experimental pasture was cleared of mesquite by hand grubbing. The pasture was grazed during the summers of 1940-56 by cattle which did not have access to mesquite beans for at least 10 days prior to the beginning of the grazing season. In 1940, when the land was grubbed, there was an average of 213 trees per acre. Five years later, 109 seedlings per acre had reached grub-hoe size, 18 to 24 inches tall, and were removed. In 1952, 185 additional seedlings per acre were removed from the land. Thus, since the initial clearing, 294 seedling mesquite per acre were removed during an 11-year period in addition to the original 213 trees. Observations in 1957 showed that 50 to 75 additional seedlings had become established and will need to be removed to prevent seed production. It is not known how long seedlings will continue to

TABLE 13. INFLUENCE OF DIFFERENT AMOUNTS OF SHADE ON THE YIELD, POUNDS PER ACRE, OF AIR-DRY BUFFALOGRASS, 1939-44

Shade treatment	Lath spacing	1939	1940	1941	1942	1943	1944	Average
Full sun	None	108	574	2569	1608	1970	580	1235
Light	4-inch	258	774	2636	1824	1920	702	1352
Moderate	3-inch	304	916	2828	1306	1696	570	1270
Heavy	2-inch	334	960	1852	295	384	74	650
Dense	1-inch	283	394	468	0	0	0	191

TABLE 14. INFLUENCE OF DIFFERENT AMOUNTS OF SHADE ON THE PERCENTAGE NUTRITIVE COMPOSITION OF BUFFALOGRASS, OVEN-DRY BASIS, 1939-41

Nutrient	Full sun	Light	Moderate	Heavy	Dense
Protein	8.85	9.50	9.47	10.53	12.62
Crude fat	2.13	2.11	2.19	2.37	1.97
Crude fiber	26.42	26.46	28.16	28.05	27.04
N.F.E.	49.54	49.52	47.76	46.21	41.14
Ash	13.06	12.52	12.41	12.84	20.44
Ca°	.64	.67	.57	.64	.72
P_2O_5	.44	.54	.53	.55	.67

emerge on the land, but likely the land will never reach the point of being completely free of mesquite under grazing conditions.

Additional studies, in cooperation with ranchmen, have shown that land that was hand-grubbed to remove a moderate stand of mesquite had an average of 668 mesquite seedlings 3 to 4 feet tall per acre 14 years later. Eight years after moderate to dense stands of mesquite, averaging 851 plants per acre, were controlled by root plowing at seven locations, an average of 361 seedlings, 3 to 5 feet tall, per

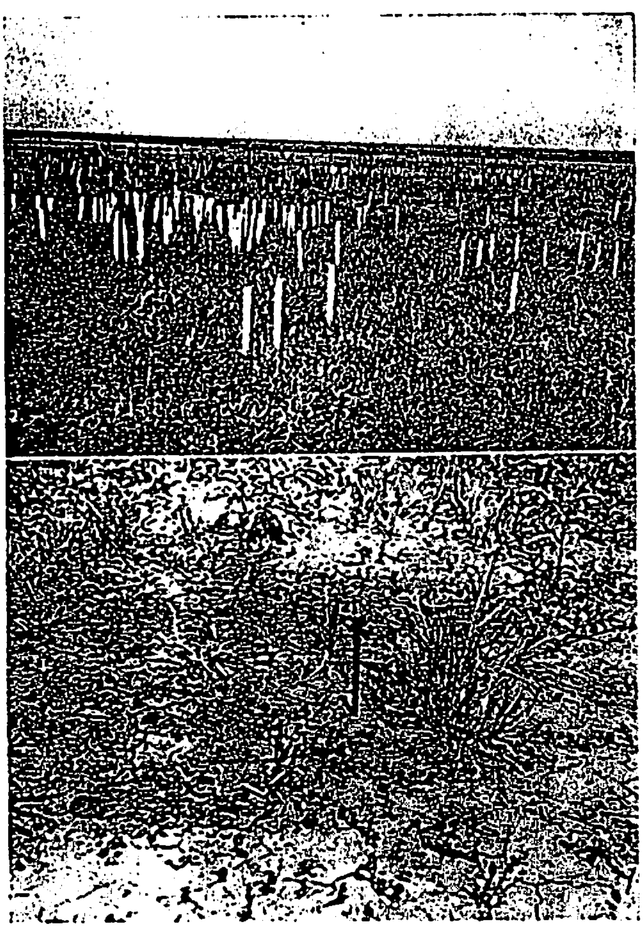


Figure 22. Above—Reinfestation of ungrazed native grassland by seedling mesquite 2 years after the area was cleared of all mesquite plants. Fifteen years later, 871 of these seedlings survived even though the area had not been grazed since 1940. Below—Heavy emergence of mesquite seedlings on badly deteriorated grassland following a severe drouth.

acre had become well established on the land (Table 2). These results indicate strongly that no one treatment will completely eliminate mesquite on grazing lands. Repeated treatments, together with sound range management practices that will favor development of a good cover of grass to reduce the number of seedlings that may become established, will be needed at intervals of 5 to 10 years.

VALUE OF MESQUITE

The value of mesquite as a forage plant is limited largely to the utilization of the seed pods, commonly called beans. Nearly all classes of livestock, wildlife and rodents relish the mature, sugary beans during the summer and fall. Chemical analyses show that the seed pods with seed contain approximately 13 percent protein, 48 percent carbohydrates, 27 percent crude fiber and 2 percent fat. The seed alone contain approximately 38 percent protein, but most of them are not digested by range animals (17). The leaves are seldom browsed to any noticeable extent during the growing season, but occasionally livestock make good use of dry leaves following an early killing frost in the fall.

The utilization of beans by grazing animals seriously hinders the success of any mesquite-control program. Even though the production of beans is highly variable from season to season, the apparent longevity of seed, 44 years in a herbarium reported by Martin (21), results in a build up of a heavy seed source in the soil. Recent work by Dollahite and Anthony (10) showed that during prolonged drouths when other forage is scant, cattle may develop mesquite bean poisoning, which results in severe losses in weight and in some cases in death. During seasons when heavy bean crops are produced, many horses and mature cattle are often lost because of compaction of the beans in the digestive tracts.

Formerly mesquite wood was used for fuel and fence posts; only limited use of mesquite for these purposes is now made. Within recent years, Marion *et. al.* (19) and others have shown that mesquite stems 1 to 3 inches in diameter have value as roughage when ground and fed to cattle. The chemical contents of such ground mesquite stems collected at monthly intervals from March to November are shown in Table 15.

Mesquite wood samples have been submitted to various commercial paper interests and other industries that make use of wood cellulose in large quantities. In all instances, other sources of wood were found to be more economical to process or they produced a higher quality product. The collection of mesquite gum that is exuded during certain seasons of the year, manufacture of charcoal and other special products offer limited uses for mesquite wood.

Other values of mesquite include protection and a source of food for quail, dove and other wildlife.

Mesquite honey is highly prized by beemen. The value of mesquite for shade to grazing animals is questionable.

PRECAUTIONS ON THE USE OF 2,4,5-T

Ranchmen in the Southwest have sprayed more than 2 million acres of mesquite without affecting the growth of susceptible plants such as cotton, grapes, watermelons, tomatoes and many other broad-leaved plants. The following suggestions are offered to avoid injury and possible damage to broad-leaved plants.

Use only low-volatile formulations of 2,4,5-T that have been tested and approved for the control of mesquite. Fumes from volatile ester formulations may affect susceptible plants several days after application. Drift resulting from the application of either volatile or low-volatile formulations will affect the growth of susceptible crops.

Do not use 2,4-D or mixtures of 2,4-D and 2,4,5-T for the control of mesquite. Sprays of 2,4-D and the mixtures are not as effective as 2,4,5-T and are much more hazardous to use where susceptible crops are grown.

Successful and experienced aerial applicators have found the following distances give a safe margin of operation for the application of low-volatile formulations of 2,4,5-T for the control of mesquite with proper equipment:

Wind velocity, miles per hour	Proximity to susceptible crops, miles	
	Upwind	Downwind
No wind	2	2
0 - 3	½	2
4 - 6	⅛	3
7 - 10	⅛	4
Over 10	Not recommended	

Airplane spraying equipment should be designed or adjusted to apply the spray solutions in coarse droplets at low pressure on the boom. Positive cut-offs should be used on each nozzle and between the main tank and the boom. The equipment should have a constant type agitator.

There should be no leaks or drip of any kind from the nozzles, boom or spraying equipment.

Loaded planes should not be ferried over susceptible plants. The use of municipal airports should be avoided.

For ground application, 2,4,5-T should not be used nearer than 1 mile downwind to susceptible crops when these crops are making rapid growth. Low-volatile esters may be used upwind within 300 feet of susceptible crops. In the fall, most summer

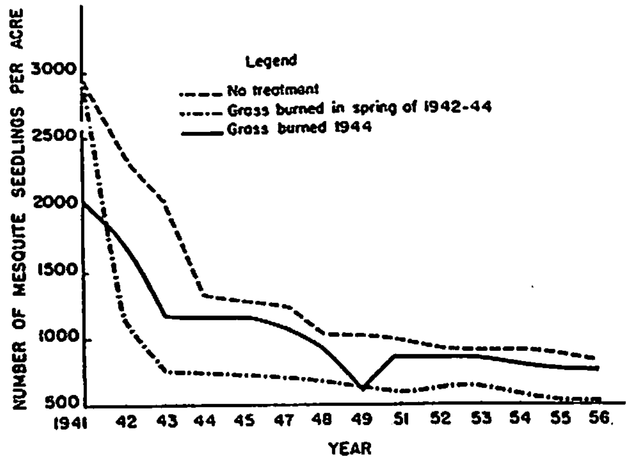


Figure 23. Survival of mesquite seedlings on ungrazed tobosa-buffalo type grasslands, during 1941-56, following the removal of 213 small trees and seedlings per acre in 1940.

crops are fairly tolerant to 2,4,5-T. Low pressures with coarse sprays are safest.

Equipment used for the application of 2,4,5-T should not be used to spray susceptible crops in other control programs unless adequate steps have been taken to clean the equipment thoroughly by specialized procedures.

2,4,5-T is not poisonous and grazing animals may remain in the area being treated with this chemical. Where poisonous weeds are present in treated pastures, there is some likelihood of the animals taking the sprayed plants when palatable forage is scant.

For greatest effectiveness and safety, employ only experienced and qualified operators who recognize the value of 2,4,5-T as well as its hazards to other crops.

Ranchmen and farmers should be informed of the value of 2,4,5-T and its limitations for the control of mesquite.

For further information on the use of 2,4,5-T for the control of mesquite, see your county agricultural agent or write to the Texas Agricultural Experiment Station, Spur, Texas.

TABLE 15. AVERAGE PERCENTAGE NUTRITIVE CONTENT OF GROUND 1 TO 3-INCH MESQUITE STEMS COLLECTED AT MONTHLY INTERVALS, MARCH TO NOVEMBER, 1957

Analysis	Average	Range
Water	7.96	6-10
Protein	7.09	4-10
Fat	1.36	.9-1.75
Fiber	41.16	33-46
Ash	6.37	3-14
N.F.E.	35.82	32-38
Ca*	2.00	1.75-3.55
P_2O_5	.07	.03-.11
Carotene[1]	18.13	6-55

[1]Parts per million.

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