TEXAS AGRICULTURAL EXPERIMENT STATION
R. D. LEWIS, Director, College Station, Texas

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Recent Developments in the Chemical Control of Brush on Texas Ranges

Units of the Texas Agricultural Experiment Station contributing to this report are: the Department of Range and Forestry, and the substations at Beeville, Sonora, Spur, Stephenville and Winter Haven. The U. S. Department of Agriculture cooperated in the research conducted at the Spur station.

March 1950

The TEXAS AGRICULTURAL AND MECHANICAL COLLEGE SYSTEM
GIBB GILCHRIST, Chancellor

PRECAUTIONS

In the Use of 2,4-D and 2,4,5-T for Brush Control

Use the proper amount. Materials should be measured and applied properly. Excessive amounts cause injury to desirable plants and are wasteful.

Apply at the right time. For foliage spray applications, the chemicals should be applied when plants are in active growth and in full leaf. Avoid windy days and the possibility of dilution by rain.

Avoid damage to nearby crops. Special care should be taken in spraying most esters of 2,4-D and 2,4,5-T because of their high volatility. Dust forms should not be used. Amines, sodium salts or other formulations of low volatility should be used in small brush areas which are immediately adjacent to susceptible crops. Damage due to drift may occur with all formulations if spraying is done during periods of appreciable wind movement. The equipment should deliver the spray solution in coarse droplets. Avoid finely-divided sprays in hazardous areas.

Cotton, alfalfa, clovers, tomatoes and other crops are extremely sensitive to small amounts of 2,4-D and 2,4,5-T.

Use separate spray equipment. Avoid contamination of equipment used for applying insecticides and fungicides by using separate sprayers for herbicides.

Employ only properly qualified operators. Commercial operators who apply hormone-type herbicides with ground or airplane spray equipment must comply with the provisions of H. B. No. 420 enacted by the 51st Legislature of Texas and the regulations of the State Department of Agriculture.

Consult your county agent or the Texas Agricultural Experiment Station for additional information.

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BULLETIN 721 MARCH 1950

Recent Developments in the Chemical Control of Brush on Texas Ranges

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ERADICATION AND CONTROL of noxious brush on range lands offer excellent opportunities for improved forage and livestock production in Texas. A large proportion of the 93.5 million acres of range land in the State is infested with undesirable woody plant species. The reduction in forage from this brush cover means a financial loss of many millions of dollars each year to ranchmen and to the industries which handle livestock and livestock products.

State and federal agencies and individual landowners, for 20 years and longer, have worked diligently to stem the spread of brush, but only a comparatively small acreage has been cleared. The methods employed have been largely ineffective or uneconomical, although successful control has been obtained in local areas. An urgent need exists for control practices adapted to the widespread and complex brush areas of Texas.

This bulletin outlines the progress of experimental work on the chemical control of various types of brush that occur in Texas. These results are based principally on trials conducted from 1947 through 1949. Application rates given are suggestions and not recommendations, as they are subject to modification by further trials.

Chemicals Used in Brush Control

Chemicals used for the control of woody plants are of two general types: (1) selective herbicides, which generally kill broadleaf plants at given dosages yet may not affect the growth of grasses and certain other plants, and (2) non-selective (contact) herbicides, which kill the above-ground parts of most plants treated. The hormone-type chemicals, 2,4-D and 2,4,5-T, are examples of selective herbicides that are absorbed and

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transported within the plant. Ammate, arsenicals, dinitro compounds, pentachlorophenol, petroleum products and trichloroacetates are representatives of the non-selective type.

Selective Herbicides

2,4-D and 2,4,5-T

2,4-D and 2,4,5-T are abbreviations used for the compounds derived from the plant growth regulators or hormones, 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid. The principal use of 2,4-D is for destroying broadleaf annual weeds; it is also effective on some perennial weeds and woody plants. The closely-related 2,4,5-T is generally more effective than 2,4-D on most woody plants. Neither has an injurious effect on most perennial grasses when applied in amounts needed to kill woody plants. No ill effects have been shown by livestock after grazing vegetation sprayed with these chemicals.

Formulations and carriers. 2,4-D is available commercially in salt, amine and ester forms. Salts and amine forms of 2,4-D may be used on brush in water sprays or in oil-water emulsions by the addition of an emulsifying agent. Esters are soluble in oil and form emulsions when dispersed in water.

2,4,5-T is now available commercially in ester and amine forms. It is also available in varying combinations with 2,4-D in ester forms.

Kerosene and diesel oil are the principal oils used as carriers for ester formulations of 2,4-D and 2,4,5-T. Oil-water emulsions prepared with suitable emulsifying agents or emulsifiable oils often provide effective and economical carrier solutions. The addition of ethylene dibromide, dinitro compounds and other chemicals to preparations containing these hormone-type herbicides may increase their effectiveness.

Methods of application. Solutions of 2,4-D and 2,4,5-T may be applied as sprays to the foliage, the base of trunks, in frills or girdles cut in the bark of standing trees and to freshly-cut stumps.

Spray solutions may be applied to brush with most types of spraying equipment, although the character and density of the brush will ordinarily govern the type of sprayer used. Portable hand sprayers are suitable for foliage treatment of scattered seedlings or small brush, and for trunk base and stump treatments. Tractor or jeep-drawn power spray equipment capable of low-volume application of a fairly coarse spray may be of value for control on limited areas of low, open brush, or following mechanical control measures. Airplane application appears to be the only feasible method which can provide rapid, economical coverage of large areas of moderate or heavy brush.

Non-selective Herbicides

Ammonium sulfamate (Ammate)

Ammonium sulfamate (Ammate) is a water-soluble chemical that is effective on many types of woody plants. It is non-toxic to man and livestock. Some precaution is necessary in handling the salt as it corrodes metals.

Ammate may be applied in the form of crystals to freshly-cut stump tops and trunk girdles, or as a foliage spray in water or kerosene emulsions containing 1 to 4 pounds of ammate per gallon. At higher concentrations ammate is injurious to perennial grasses and to some broadleaf weeds.

Ammate may be used for the control of certain hardwood trees and for some types of brush in fence rows and other localized areas. Its present cost, the relatively heavy rate of application required for satisfactory control and its non-selective character limit its use on range lands heavily infested with brush.

Arsenicals

Sodium arsenite and other chemicals containing arsenic are effective herbicides on all types of plants. Such compounds are particularly valuable for killing undesirable hardwood trees and for the control of mesquite in locations where livestock are not grazing. The use of arsenicals on range lands is not generally recommended because of their toxicity to man and animals.

Dinitro Compounds

Dinitro compounds act as selective or non-selective herbicides, depending on the carrier used. They may be used in oil-water emulsions or as oil fortifiers in contact sprays for individual plants, fence rows or rights-of-way where the loss of perennial grasses is of no significance.

Pentachlorophenol

Pentachlorophenol may be used in oils or oil emulsions for general plant control. In brush areas it has value principally for the fortification of oils used as sprays along rights-of-way and for individual plant treatment. Volume requirements limit its use in large scale applications on brush-infested range lands.

Petroleum Products

Kerosene and diesel oil have been used extensively for the control of mesquite and other trees as contact killers applied to the root crown or "bud zone." The toxic action of petroleum products is associated in part with their content of aromatic hydrocarbons and most kerosenes and diesel fuels available in

Texas contain small percentages of these toxic components. Fortification of oils with dinitro and pentachlorophenol compounds increases their toxicity and permits low-volume applications in the treatment of some species.

Trichloroacetates (TCA)

The sodium and ammonium trichloroacetates or salts of trichloroacetic acid are known as TCA. TCA is somewhat selective in herbicidal action and is effective principally on certain grasses and other plants such as prickly pear. The salts are soluble in water and may be applied as a spray to the foliage or soil. TCA has a limited value in brush control on range lands because of its harmful effect on forage grasses.

Treatments for Brush Species

Chemical control treatments are given for brush species on which information is available. The results reported are preliminary and the treatments suggested are subject to modification with further experimental work.

Blackbrush

Blackbrush forms dense brushy stands on shallow caliche or calcareous soils in the Rio Grande Plain, either alone or with mesquite and other underbrush. The vigorous sprouting habit of blackbrush suggests that chemical treatment, or a combination of mechanical and chemical methods that insure a minimum of soil disturbance, be used for its control.

Tests conducted in 1948 and 1949 at Beeville and Winter Haven indicate that blackbrush is fairly resistant to chemical treatment. Foliage applications of 2,4-D and 2,4,5-T esters in water and kerosene solutions in concentrations up to 0.6 percent acid equivalent gave inconclusive results. Oil solutions were better than water solutions, and the addition of 1 percent ethylene dibromide to oil solutions of 2,4,5-T appeared to increase their effectiveness. Ammate applied as a foliage spray in kerosene solutions containing 2 pounds per gallon gave satisfactory results; however, plot tests on 1-year-old sprout growth indicated that at least 80 pounds per acre are needed for effective control.

Sprays applied to freshly-cut stump surfaces generally were more effective than similar foliage spray treatments. Ammate applied in kerosene emulsions at the rate of 2 pounds per gallon and 2,4,5-T esters in kerosene solutions containing 0.4 to 0.6 percent acid equivalent were effective in early-summer treatments of stumps.

Fairly satisfactory control of new sprout growth was obtained with 2,4,5-T ester applied at the rate of 1.67 pounds of acid

equivalent per acre in kerosene solutions containing 1 percent ethylene dibromide. Foliage sprays containing equal proportions of 2,4-D and 2,4,5-T esters in oil solutions were less effective than an equivalent rate of 2,4,5-T alone.

Cactus

Prickly pear, cholla and other cactus types occur widely throughout Texas as undesirable plants which may be classed as brush. Lindheimer prickly pear, mesquite and associated species often form dense brush stands on deep soils of the Rio Grande Plain and adjacent regions, which have a high potential for forage production. In the Edwards Plateau and other areas, prickly pear occurs in scattered stands on rocky slopes and shallow soils. Tasajillo is found throughout various brush types as a noxious type of undergrowth.

Earlier work conducted by the Texas Agricultural Experiment Station established the effectiveness in prickly pear control of spray applications of acid arsenic pentoxide solution. Limited use has been made of this method in recent years because of the toxicity of the materials to livestock and the necessity for special spray equipment to handle the acid solutions.

Tests in 1948 and 1949 on Lindheimer prickly pear and cholla demonstrated the possibilities of control with growth-regulating chemicals which are non-toxic to livestock. Little information is available on tasajillo and other cactus types.

Prickly pear is resistant to treatment with water solutions of 2,4-D and 2,4,5-T, but satisfactory control has been obtained in the growing season with oil solutions and oil-water emulsions of 2,4,5-T esters. Both isopropyl and butyl esters gave satisfactory control, but not complete eradication, when applied as foliage sprays to the point of runoff at concentrations of 0.5 percent acid equivalent in kerosene. The addition of 0.5 percent dinitro compound and 1 percent ethylene dibromide to the 2,4,5-T ester formulations appeared to increase their effectiveness. Plants so treated lodged and decomposed in 2 to 6 weeks. Esters of 2,4,5-T applied during the dormant season, or just prior to resumption of growth, were not as effective as late spring or midsummer treatments.

Ammate applied as a foliage spray to prickly pear at the rate of 2 to 4 pounds per gallon of water failed to give satisfactory results. Oil sprays containing 10 to 15 percent pentachlorophenol or 0.5 percent dinitro compounds applied in spring and early summer, were ineffective.

Prickly pear was partially controlled by spray applications of TCA during the active growth period at the rate of one-half to three-fourths pounds per gallon of water. Newly-formed

joints were killed back, but in most cases sprouting took place actively from the older joints and trunks. In general, the tests of this chemical conducted from February through August 1949 showed that TCA was less effective in the control of Lindheimer prickly pear than the esters of 2,4,5-T.

Cholla cactus in the Plains and Trans-Pecos areas has been successfully controlled at all seasons by wetting plants with a 0.5 to 1 percent solution of 2,4,5-T ester in oil.

Cedar

Two species of cedar or juniper are important in the Edwards Plateau and adjacent areas: the sprouting, bushy redberry juniper and the non-sprouting, single-stemmed mountain cedar or Ashe juniper. Control has been principally by cutting, fire, and by bulldozing and other mechanical methods. The aggressive seeding habits and continued reinfestation of these conifers in grasslands create a problem for which chemical control measures may be desirable.

No success has been obtained to date with chemical treatment of cedar or juniper as either seedlings or mature plants. Limited tests on mountain cedar with 2,4-D esters in oil solutions containing as much as 1 or 2 percent acid equivalent failed to give control on plants 3 to 5 feet tall.

Elm

Elms may form minor components in brushy oak types or in bottomland hardwood areas where control may be desirable.

Winged elm, a common constituent of the East Texas Forest, was studied in 1948 and 1949. Large trees were killed throughout the growing season with sodium arsenite paste or 10 percent solutions of 2,4,5-T ester in kerosene applied to notches cut in the trunks. Notch applications of ammate crystals gave only partial control.

Successful control of small trees was obtained with foliage spray applications of 2,4-D or 2,4,5-T esters in water solutions containing 0.3 percent acid equivalent. These treatments were effective only during the spring growth period. Solutions containing 1 pound of ammate per gallon of water were also effective as foliage sprays at this period.

Huisache

Huisache is prevalent on pastures and abandoned cultivated land in the Coastal Prairie. Its localized occurrence in brush stands or as scattered small trees, and its usual proximity to cultivated areas, necessitate treatment with ground equipment.

Satisfactory control has been obtained with kerosene and fortified diesel oil applied at the base of trees or in scooped-out

basins which expose the root crowns. Stump treatments with diesel oil and fortified diesel oil during the 1949 growing season gave rather unsatisfactory results.

Foliage spray treatments of trees up to 10 feet tall with 2,4-D and 2,4,5-T esters in oil or oil emulsions have been generally unsatisfactory in controlling root sprouting. Concentrations of these esters up to 0.5 percent acid equivalent were ineffective in similar tests on sprout growth from frost-injured plants.

Trunk spray treatments have been more satisfactory than foliage sprays both in effectiveness and in the amount of material and labor needed. Spraying the lower 2-foot portion of trunks with kerosene containing 1 percent acid equivalent as 2,4,5-T ester and 1 percent ethylene dibromide, has given rather effective control during the growing season. This method may be used for individual tree treatments.

Lote

Lote (bluebrush) has a wide distribution in Texas. This underbrush is often associated with mesquite in the Rio Grande Plain and other regions.

Successful control of lote was obtained at all seasons in tests at Spur by thoroughly wetting the leaves and stems with a 0.5 to 1 percent solution of 2,4-D or 2,4,5-T ester in diesel oil or kerosene. Even more effective control was obtained in stump treatments with these materials. Oils alone have not proved effective.

Mesquite

Chemical treatment appears to offer considerable promise for low-cost, effective control of mesquite. Experiments conducted since 1939 at Spur established the practicability of control with kerosene and diesel fuel in open stands of the tree form.

Continuing tests with ground spray equipment and airplane spray applications indicate that 2,4,5-T offers promise for large-scale control operations. Further experimental work with this chemical is needed, and the following statements are only suggestions to those who wish to determine its effectiveness on limited trial areas.

Airplane application. Comprehensive aerial spray tests conducted in 1949 on brushy mesquite stands indicate the possibility of control of mesquite by proper application of 2,4,5-T. The most effective low-cost treatment was obtained with 2,4,5-T ester applied at a rate of two-thirds pound of acid per acre in an emulsion of 1 gallon of No. 2 diesel oil and 4 gallons of

Important Brush Species Of Tri

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East Texas Forest—

Post oak, blackjack oak, yaupon, hackberry, elm, mesquite.

Coastal Prairie—

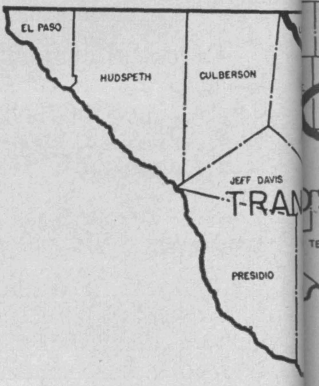
Huisache, mesquite, live oak, Macartney rose.

Blackland and Grand Prairies—

Mesquite, huisache, mountain cedar (Ashe juniper).

Rio Grande Plain—

Mesquite, whitebrush, blackbrush, guajillo, cactus, granjeno, lote, black persimmon.



Cross Timbers—

Post oak, blackjack oak, mesquite, elm, yaupon, shin oak.

Edwards Plateau—

Mountain cedar (Ashe juniper), redberry juniper, various oaks, mesquite, whitebrush, cactus.

High and Rolling Plains—

Mesquite, sand sage, shin oak, redberry juniper, lote.

Trans-Pecos—

Mesquite, tarbush, creosote bush, cactus.

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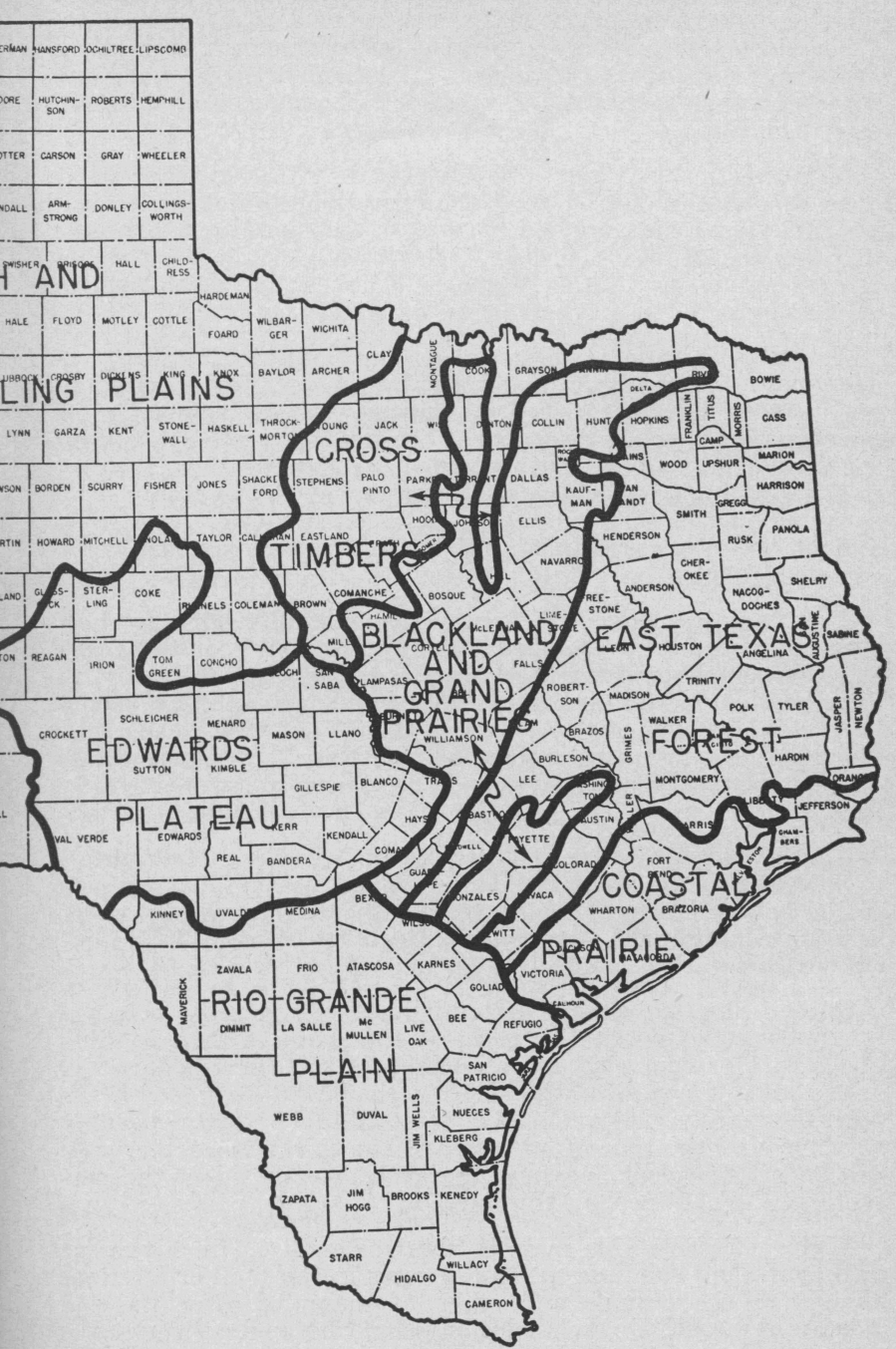
n Geographical Areas Of Texas



water. This treatment gave excellent top kills and fairly satisfactory control of sprouting. Emulsions of 2,4,5-T amine using 1 pound of acid per acre also appeared promising. Application of higher rates of 2,4,5-T acid as either amine or ester did not give increased kills. 2,4,5-T in diesel oil was not as effective as in emulsions.

Mixtures of 2,4-D and 2,4,5-T were less effective than equivalent amounts of 2,4,5-T with the exception of high molecular-weight esters when applied as two-thirds pound acid per acre in 5 gallons of No. 2 diesel. Formulations of 2,4-D either as esters, amines or salts were generally ineffective when applied at varying rates in oils, emulsions or water.

Treatments made at different seasons indicate that best results may be expected in the spring, 2 to 4 weeks after mesquite has reached the first heavy foliage growth. An abundance of moisture in the soil is desirable at the time of treatment. Spraying should be avoided during periods of dry weather, low humidity and high winds. An additional benefit to be obtained by spraying in the spring is the control of sunflower, cocklebur, annual broomweed, Russian thistle and other noxious weeds commonly found on grazing lands.

From studies conducted thus far on mesquite with airplane spraying equipment, it appears highly essential that the spray solution be delivered in rather coarse droplets at a rate of 4 to 5 gallons per acre. High atomization of spray solution should be avoided because of the danger of 2,4,5-T drifting to susceptible crops, the frequent failure of small particles to penetrate dense foliage to ground level and the generally lower effectiveness.

Ground spraying. Sprout growth and seedling mesquites 3 to 5 feet tall may be controlled during the heavy foliage period in the spring by spraying the plants thoroughly with a water solution containing 0.4 percent acid equivalent of 2,4,5-T ester. Oil solutions are less effective and more costly.

Rather effective control of individual trees may be obtained by treating the lower 12 inches of the trunk with a solution of 0.5 to 1 percent acid equivalent of 2,4,5-T ester in diesel oil or kerosene. Enough of the solution should be used to wet the bark thoroughly. One gallon will treat 20 to 40 trees, depending on their size, the type of growth and the thickness of the bark. Season of treatment does not appear to greatly affect the percentage kill obtained by this method.

Highly effective kills may be obtained with 0.5 to 1 percent acid equivalent solutions of 2,4,5-T ester in diesel oil or kerosene applied to the stumps and stubs of mesquite after the top wood is removed. Enough solution should be applied to wet the

bark and freshly-cut surfaces thoroughly. Excellent results have also been obtained on large trees by painting the freshly-cut surfaces with an undiluted commercial stock solution of 2,4-D amine containing 4 pounds of acid per gallon. The season of treatment of stumps does not appear to affect the percentage kill.

Kerosene and other oils. For effective control, oils must be applied to the ground and root crown of mesquite in amounts sufficient to soak through the bark and throughout the sprout bud zone. The most satisfactory method of application is to pour kerosene or diesel oil from a spouted can around the lower 6 inches of the mesquite trunk. Relatively low-cost control has been obtained with this method in open stands of tree mesquite growing on porous soils. The amount of oil required for effective kills of mesquite on heavy soils or in brushy types is usually too costly. Under conditions in which oils are economical, the cost of large-scale treatments may be reduced somewhat by diluting the oil with equal amounts of water to form an emulsion, maintained by mechanical agitation and an emulsifying agent.

Oak

Various types of oak form the dominant cover and create brush control problems in several of the grazing regions of the State. Shin oak has not been satisfactorily controlled with the hormone-type chemicals. Treatments at College Station and at Stephenville of post oak and blackjack oak indicate that adequate control of both brush and tree forms may be obtained by chemical methods. The following statements apply only to post oak and blackjack oak.

Thinning and killing trees. Effective control of trees up to 8 inches in diameter was obtained by spraying the lower 2 to 3 feet of trunks during the spring growth period with kerosene solutions of the isopropyl ester of 2,4,5-T at concentrations of 0.6 to 0.8 percent acid equivalent. Similar concentrations of 2,4-D esters gave less consistent results. Ammate solutions containing 1 pound per gallon were not effective when applied in this manner.

Satisfactory control of trees was obtained by application of 1 part of 2,4,5-T ester in 10 parts of kerosene to notches cut at the base of trunks.

Sprouting of trees cut in the spring was successfully controlled by application of ammate crystals to the freshly-cut stump surfaces. Effective stump treatments were also obtained during this period by spraying freshly-cut surfaces with kerosene solutions containing 0.8 to 1 percent acid equivalent of 2,4,5-T ester. Similar concentrations of 2,4-D ester, or combinations of 2,4-D and 2,4,5-T, were not as effective as 2,4,5-T alone.

Sprout and foliage treatment. Sprouts 1 to 2 years old were found to be more difficult to kill than older brush or tree forms. Ammate in water solutions containing 3 pounds per gallon gave fairly satisfactory control. The addition of 1 part of emulsifiable oil to 10 parts of such ammate solutions increased their effectiveness. 2,4,5-T in kerosene solutions containing 0.6 to 0.8 percent acid equivalent of the isopropyl ester was only moderately effective on 1-year-old sprouts. Foliage spray treatments with kerosene solutions containing either 0.4 percent acid equivalent of 2,4,5-T ester or 0.6 percent of 2,4-D ester were fairly effective when applied in the spring. This type of treatment applied with ground equipment required proportionately more time and material than spray applications to trunk bases.

Rose

Macartney rose has become a pest on grazing land in the Coastal Prairie and adjacent areas. Grazing animals have contributed materially to its spread by eating the fruits and depositing viable seeds in their droppings. Macartney rose sprouts profusely from the base and from shallow lateral roots if the top is removed or disturbed.

Foliage sprays containing 0.1 percent acid equivalent of 2,4,5-T ester or 0.2 percent of 2,4-D ester in water gave fairly good control of small plants. Large plants and dense clumps may require more than one application.

Ammate applied as a foliage spray at rates up to 1.5 pounds per gallon was not as effective as the hormone treatments. Addition of hormone chemicals to ammate solutions did not increase their effectiveness.

Boron, applied as sodium tetraborate (Borascu) at rates up to 15 pounds per 100 square feet in circular bands around the base of the plant, was unsatisfactory in treating standing plants and in preventing sprouting in plants which had been cut off at the ground. At the rates used, this material also causes soil sterility.

Sand Sage

Sand sage is a troublesome invader in large areas of the Rolling Plains and along the Canadian River.

Effective control can be obtained with a single airplane application of 2,4-D in May, according to results obtained at the U. S. Southern Great Plains Field Station at Woodward, Oklahoma. Particulars on rates and methods of application may be obtained from that station.

Whitebrush

Whitebrush (beebrush) forms relatively dense stands in medium-textured soils in the Rio Grande Plain and the Edwards

Plateau. The denser stands may include a few scattered mesquite trees, but stands of moderate density usually contain granjeno, mesquite, lote and other brush. Whitebrush is similar to mesquite in its development of a zone of dormant buds at the root crown.

Tests conducted at Winter Haven in 1948 and 1949 have not disclosed an effective chemical treatment. Foliage spray applications of the 2,4-D and 2,4,5-T esters gave generally unsatisfactory results. Stump treatments were superior to foliage spray applications. When applied to freshly-cut stumps, oil solutions of 2,4-D esters containing up to 0.6 percent acid equivalent have given better results than those containing 2,4,5-T. Water solutions of esters are inferior to oil solutions. Stump treatments with ammate in water solutions or in kerosene emulsions at the rate of 2 pounds per gallon have given fairly satisfactory control.

Yaupon

Yaupon often forms a dense undergrowth in the East Texas Forest and adjoining regions. Stands in brushy or cutover areas may become so dense as to limit forage yields and tree reproduction.

Effective treatment of yaupon has been obtained with the isopropyl ester of 2,4-D or 2,4,5-T in kerosene solutions applied as a foliage spray or to freshly-cut stump surfaces. Concentrations of 0.6 to 0.8 percent acid equivalent of either ester applied as a foliage spray or stump treatment gave satisfactory control during the growing season. Stump treatments with 2,4-D at these concentrations were effective only in the spring. Ammate solutions containing 1 pound per gallon gave fairly satisfactory control as foliage sprays applied in the spring and summer.

Making Up Spray Solutions

Acid equivalent. Rates of application of 2,4-D and 2,4,5-T are usually expressed in terms of the amount of acid equivalent involved. Acid equivalent refers to the amount of active 2,4-D or 2,4,5-T in a particular formulation. The amount of acid equivalent (*not* 2,4-D or 2,4,5-T ester or acetate) is customarily stated on the container as pounds per gallon.

Individual plant treatment. In individual plant treatment involving hand spraying, the rates of application are usually expressed in terms of percent or parts per million (p.p.m.). It should be remembered that 1,000 p.p.m. is another way of stating one-tenth of 1 percent. The following table lists the volumes of spray solution containing 1,000 p.p.m. acid equivalent which can be made up using herbicides with the most common acid equivalents.

Chemical treatments that appear the most effective for brush control

Species	Method of application	Season	Chemical treatment
Blackbrush	Stump spray	Midsummer	Ammate in kerosene
Cactus	Foliage spray	Growing season	2,4,5-T ester in oil
Cedar			None
Elm, Winged	Foliage spray Trunk notch	Spring Growing season	2,4-D ester in water Sodium arsenite paste; 2,4,5-T ester in oil
Huisache	Trunk base pour Trunk base spray	Yearlong Growing season	Kerosene or diesel oil 2,4,5-T ester in oil
Lote	Foliage or stump spray	Yearlong	2,4-D or 2,4,5-T ester in oil
Mesquite	Foliage spray Trunk base pour Trunk base spray	Spring Yearlong Yearlong	2,4,5-T ester in oil-water emulsion Kerosene or diesel oil 2,4,5-T ester in oil
Oak, Post and Blackjack	Trunk base spray Stump spray Foliage spray	Spring Spring Spring	2,4,5-T ester in oil Ammate crystals 2,4,5-T ester in oil
Rose, Macartney	Foliage spray	Growing season	2,4-D ester in water
Sage, Sand	Foliage spray	Spring	2,4-D salt, amine or ester
Whitebrush	Stump spray	Growing season	Ammate in kerosene
Yaupon	Foliage or stump spray	Spring	2,4-D ester in oil

Acid equivalent of herbicide (lbs. per gal.)	Fluid measure of herbicide for spray solutions containing 1,000 p.p.m. (0.1 percent)					
	1 oz.*	4 oz.	½ pt.	1 pt.	1 qt.	1 gal.
	Gallons of spray solution					
2.00	1.88	7.5	15	30	60	240
3.00	2.80	11.2	22	45	90	360
3.34	3.12	12.5	25	50	100	400
4.00	3.75	15.0	30	60	120	480

*1 fluid oz. is equal to 2 tablespoons.

This table can be used for preparing spray solutions having any desired percentage or p.p.m. by adjusting the amount of herbicide to be added. For example, it is desired to make 3 gallons of spray solution containing 8,000 p.p.m. (0.8 percent). The herbicide at hand contains 3.34 pounds acid equivalent per gallon. On line 3.34 of the table it is found that 3.12 gallons (the table value nearest 3 gallons) of spray solution contain 1 ounce of herbicide for each 1,000 p.p.m. (0.1 percent). 3.12 gallons of spray solution containing 8,000 p.p.m. (0.8 percent) would require 8 × 1 ounce, or 8 ounces of herbicide. For amounts of spray solution intermediate between the values given in the table, proportionate amounts of herbicide can be computed.

Acreage treatment. Application rates for area treatment are usually expressed in "pounds of acid per acre." In such applications the actual sprayer output or delivered volume of spray material per acre must be known. This output varies with size of nozzle openings, speed of sprayer, pressure, length of boom and other factors.

The following table shows the amount (in pints) of herbicide required for application of specified amounts of acid per acre using herbicides with the most common acid equivalents.

Acid equivalent of herbicide (lbs. per gal.)	Rate of application in lbs. per acre				
	1/2 lb.	2/3 lb.	3/4 lb.	1 lb.	1½ lbs.
	Pints of herbicide required in spray solution				
2.00	2.00	2.67	3.00	4.00	6.00
3.00	1.33	1.78	2.00	2.67	4.00
3.34	1.20	1.60	1.80	2.40	3.60
4.00	1.00	1.33	1.50	2.00	3.00

The herbicide required, determined by the table above, is made up to the output volume of the sprayer. Fractions of pints may be estimated in field work. The amount of herbicide necessary for a given rate of application remains the same regardless of the volume of spray material applied.

Common and Botanical Names of Species Mentioned

Beebrush (see Whitebrush)	
Blackbrush	*Acacia amentacea*
Cactus	
Cholla	*Opuntia imbricata*
Lindheimer prickly pear	*Opuntia lindheimeri*
Tasajillo	*Opuntia leptocaulis*
Cedar (see Juniper)	
Creosote bush	*Larrea divaricata*
Elm, Winged	*Ulmus alata*
Granjeno	*Celtis pallida*
Guajillo	*Acacia berlandieri*
Hackberry (see also Granjeno)	*Celtis spp.*
Huisache	*Acacia farnesiana*
Juniper	
Ashe	*Juniperus ashei*
Redberry	*Juniperus pinchoti*
Lote	*Condalia obtusifolia*
Mesquite	*Prosopis juliflora var. glandulosa*
Oak	
Blackjack	*Quercus marylandica*
Live	*Quercus virginiana*
Post	*Quercus stellata*
Shin	*Quercus havardi, mohriana, etc.*
Persimmon, Black or Texas	*Diospyros texana*
Rose, Macartney	*Rosa bracteata*
Sage, Sand	*Artemisia filifolia*
Tarbush	*Flourensia cernua*
Whitebrush	*Aloysia ligustrina*
Yaupon	*Ilex vomitoria*

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