Brush Control Research in Oklahoma

Bulletin B-712
February 1974

Agricultural Experiment Station • Oklahoma State University

CONTENTS

Definitions

Percent Defoliation — the amount of leaf kill in the fall after a spring or summer spraying.

Percent Canopy Reduction — the amount of branch kill determined one or more years after spraying.

Percent Apparent Kill — the amount of trees without live top or sprout regrowth one year after spraying.

Herbicide Rate — all rates of herbicide are expressed as pounds of active herbicide.

Abbreviations

gpa — gallons per acre

dbh — diameter at breast height

ml — milliliter (29.6 ml = 1 ounce)

a.e. — acid equivalent

L.V. — low volatile

lb/A — pounds per acre

Tbl/in — Tablespoons per inch tree diameter

Brush Control Research In Oklahoma[1]

Harry M. Elwell, P. W. Santelmann, J. F. Stritzke, and Howard Greer[2]
Agronomy Department

Introduction

There are about 11.2 million acres of woody plants (brush) in the state having very little economical value for timber production (Appendix Table I). This is according to surveys by the Oklahoma Game and Fish Commission (1943), the State Board of Agriculture Forestry Division (26), the Soil Conservation Service, extension agents (verbal reports), and by the U. S. Agriculture Census (1964). Much of this brush-infested area was once savannah (grassland with intermingling of trees), but due to poor management, much of this area is now infested with a moderate to dense stand of brush. For example, Dwyer and Santelmann (8) found that the majority of post[3] and blackjack oak trees in one area were less than 20 years old.

Some of the first brush control research in Oklahoma was done at the SCS Red Plains Conservation Experiment Station, established near Guthrie. In the fall of 1934, the oak trees were removed from an area by hand cutting and grubbing. A sickle-bar mower was then used to remove the small brush and to keep the sprouts under control. Adequate native grasses were present so that a good grass cover developed rapidly when brush was controlled. Three years after removal of brush and three annual spring mowings for sprout control, the grass density was as good as that on adjacent open pastures and meadow land (1). In these early studies, it was found that there was less water runoff and soil loss in areas where brush was controlled (7). The average annual run-off from a

Research reported herein was conducted under Oklahoma Station Project No. 1477 and 2113

[1]Cooperative investigations of the Plant Science Research Division, Agricultural Research Service, U. S. Department of Agriculture and the Oklahoma Agricultural Experiment Station.
[2]Research Agronomist, Plant Science Research Division, Agricultural Research Service, U. S. Department of Agriculture, Stillwater, Oklahoma; Professor, Assistant Professor, and Associate Professor, respectively, Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma 74074.
[3]Refer to Appendix Table III for scientific names of woody plants.

converted brush area was 1.2 percent compared to 3.1 percent from an adjacent oak woodland pasture. The average annual soil loss for each area was 0.03 and 0.15 tons/A, respectively.

These studies indicated that densely-wooded, oak-covered land would support a protective vegetative cover of native grass if the brush was removed or controlled. Additional studies were then initiated to evaluate the best way to control brush and develop an area for grass. Hand labor and power cutting equipment were the first methods tested. Sprout control from the roots of oak brush was found to be a major problem with mechanical control. When herbicides became available they were tested for brush control and grass release. Improvement of land use has resulted from these herbicide treatments. Some of the herbicides were not harmful to pine and foresters became interested in the use of herbicides for control of low-valued hardwoods for pine release.

Types of Control

Mechanical Removal

One of the objectives of early studies (4, 5) was to determine the man and machine hours required to remove the blackjack and post oak brush in various stand densities in areas on and near the Guthrie station. The length of time was found to vary considerably with size of trees and density of stand (Table 1). It took longer to remove larger trees but some

Table 1. Labor required to remove oak brush and trees from various sites selected in Central Oklahoma.

Site	Number of brush plants/A in diameter inches[1]				Hours labor/A cutting & trimming trees and piling brush[2]
	< 2	2 ± 4	4 ± 8	$8 +$	
1	4283	392	54	2	60.3
2	5260	182	104	0	128.0
3	2240	480	280	0	90.8
4	8470	97	31	5	72.9
5	10240	1040	412	121	64.0
6	17990	336	188	0	36.2
7	22600	35	0	0	5.5
8	20590	35	0	0	2.1
9	23430	40	0	0	8.0
10[3]	17000	100	98	0	43.5
11[3]	15520	80	232	6	74.5

[1]Number determined from counts in one (6′ x 100′) belt across each brush area in site 1 through 6 and from 3 (6′ x 100′) belts in sites 7 through 11.
[2]Hours of labor did not include time required to burn brush and cut small stem brush with a mower. It took from 1 to 1½ hours to mow the small remaining brush with a power mower. The saw used at sites 1 through 6 for removing the larger trees was a small two-wheeled gasoline powered saw whereas a small tractor equipped with a circular saw was used on sites 7, 8, 10, & 11. An ax only was used on site 9.
[3]The amount of useable firewood was determined to be 4 and 15½ cords of wood respectively for sites 10 and 11.

of these trees were suitable for firewood. For example, there were 15.5 cords of fireplace wood on one area which required 74.5 hours of labor to clear. This fireplace wood could be sold to reduce the removal costs for man and machine hours.

A circular saw, mounted on a farm-type tractor, was found to work quite effectively on trees up to 4 inches in diameter (5). However, the trees had to be removed after cutting so they wouldn't be in the way of the saw. A circular saw (powered with a small 7½-horse-powered gasoline motor) mounted on two small rubber-tired wheels and with metal handlebars for moving, was also tested for brush cutting. The labor problem to remove trees after they had been cut by a tractor or mobile saw was found to be lessened with a tractor mounted high-lift, metal buck rake (5).

Sprout regrowth from stumps and roots of cut oaks was found to be a major problem, so a study was initiated in 1948 to determine if removal of oak trees and small brush during each of the months from March through October had any effect on sprout regrowth. This study was conducted on an area with a 3 to 5 percent slope and with a Stephenville-Darnell fine sandy loam soil. The area had previously been cut over to remove some trees for firewood and posts. The brush was mechanically removed in 1948. It was found that the time of cutting effected regrowth (Table 2), in that the highest percentage of resprouting occurred when the brush was cut in May, followed by September and August. The least resprouting occurred when the brush was cut in October. No significant change of sprout number resulted after the first

Table 2. The effect of brush clearing and annual mowing on oak sprouts near Guthrie, Oklahoma.

	Stems per Acre[1]			
Month of Mowing	Before Clearing in 1948	After 1st Mowing (1949)	After 2nd Mowing (1950)	After 3rd Mowing (1951)
March	14984	28396 (189)[2]	26535	25337
April	14984	28532 (190)	26898	25446
May	12398	45883 (370)	55720	37571
June	12398	24030 (194)	51764	50080
July	16606	34775 (209)	49295	42594
August	16606	42108 (254)	54123	38042
Sept.	17954	63162 (351)	60766	59060
October	17954	28672 (160)	57753	65995

[1]Numbers determined from 6′ x 100′ belt transects. Counts each month for original growth prior to removal and 4 or 5 months after each annual mowing. Annual mowing done during the same month in 1949, 1950 and 1951 as when cleared in 1948 except September and October for 1949 which was regrowth from the original cutting in 1948. Annual, spring, and summer rainfall 1948 through 1951 about normal and sufficient for woody plant growth. Drought conditions had occurred during 1946 and 1947 such that some of the oak had been killed. Annual precipitation for 1949 was 40.57, for 1950 23.28 and for 1951 27.28 inches.
[2]Percent stems compared to original stand.

yearly mowing. In all cases, there were more sprouts at the end of the study than before brush cutting had started.

Several other mechanical methods of brush removal were studied by Porterfield and Roth (27). They found that a crawler tractor with a 10-foot blade could remove and windrow for burning the oak trees on an acre in 2.2 hours (1,808 oak trees/A varying from 1 to 14 inches in diameter). The first summer following the dozing treatment, the number of oak sprouts on the treated area equalled that on an adjacent untreated area. However, they found that disk harrowing the land once after the dozing reduced the sprout regrowth 34 percent. Oak-sprout regrowth was reduced 63 percent by disk harrowing and disk plowing the land after dozing. All of the land treated with the dozer had to be re-seeded to re-establish the native grasses.

Burning

Only limited research on burning for brush control has been conducted in Oklahoma. Early burning studies compared soil and water losses, but not the effect of the fire on the sprouts (20). In general, burning appeared to increase the number of sprouts from established blackjack and post oak trees. Oak sprouts were found to increase by 59 percent by two annual April burns (22). Burning has been successful for control of small juniper trees (3, 6) but has had little if any effect on larger trees (3). Trees that were completely defoliated from the burn were usually killed.

Herbicide Control

Some of the early chemicals used for brush control were not selective. For example, AMS[4] was first tried in September of 1944 and gave good control of the oaks but also suppressed the native grasses. The introduction of 2,4-D in 1945 was the start of selective herbicides that could be used to control brush with no damage to native grass. A number of studies comparing the methods of applications and the brush species response to the various chemicals have been conducted during the last 25 years in Oklahoma and the results of these studies will be discussed under the various brush species. A summary of the response of the various woody plants to some of the more commonly used herbicides is given in Appendix Table III.

Blackjack and Post Oak Control with Herbicides

Foliage Sprays

Early Studies with 2,4-D and 2,4,5-T. The favorable results of good oak control and native grass release from the 1945 wetting foliage spray

[4]Refer to Appendix Table II for chemical names of all herbicides.

of 2,4-D to regrowth oak brush led to additional studies in 1946 and 1947. From this series of studies it was found that April applications of 2,4-D for initial treatments were not as effective as treating in May. This was much more evident with the amine formulation of 2,4-D than with ester formulations.

In 1947, 2,4,5-T was also tested. Results with 2,4,5-T were better and more consistent than 2,4-D. Additional testing of the low volatile esters of these phenoxy herbicides was done in 1951 to determine the effect of various rates and to compare 2,4-D and 2,4,5-T (15). Good control (85 to 92 percent tree kill) of four year old sprouts was obtained with 2,4-D and 2,4,5-T alone and in a 1-1 mixture when applied as a foliage wetting spray to the point of runoff for two consecutive years. It also appeared that 2 lbs of herbicide/100 gallons of water was about as effective as 4 lbs/100 gallons.

The age of the oak resprout was also noted to have an influence on the response to herbicides. Brush that had been mowed annually for 5 years was not controlled as well as 4-year old sprouts not mowed (Table 3). Time of last mowing had an influence on response to herbicide. The apparent kill of October mowed sprouts was better than Spring and Summer mowed sprouts.

Aerial Application of Herbicides. The first aerial applications of herbicides were tried in 1947. AMS was applied by air at 20 lb/A and did not give satisfactory control. Aerial treatments of 2,4-D and 2,4,5-T

Table 3. Apparent kill of oak regrowth wiht 2,4-D plus 2,4,5-T (2 + 1 lb of herbicide respective/100 gallons of water) applied as a wetting foliage spray May, 1953 and 1954.[1]

	Percent Kill	
Month when cut in 1948[2]	Sprouts Left to Grow 1948-1952 (4 years)	Sprouts Mowed Annually 1949 through 1952
March	45	12
April	56	20
May	43	27
June	62	37
July	60	38
August	75	28
September	82	55
October	91	86
Area not cut in 1948 or mowed 1949-1953	72	

[1]Oak regrowth was blackjack, post and dwarf chinquapin oaks. Soil was a Stephenville-Darnell series of fine sandy loam. Total inches of rainfall were 20.65 for 1952 (−11.61 below normal), 35.89 for 1953, and 17.07 for 1954 (−14.83 below normal). Area was located near Guthrie, Oklahoma.

[2]Areas treated 1953 and 1954 were each 100 feet wide and 460 feet in length and crossed all months of cutting and mowing.

were applied at 3 lb/A with aerosol-type spray equipment in a diesel oil-in-water emulsion at 5 or 10 gallons/A volumes. The ester formulations of phenoxy herbicides resulted in good brush control and excellent grass release (11, 19). However, a single application of 3 lb/A of 2,4,5-T was not as effective as repeated lower rates (Table 4). The control of post and other white oaks was consistently better than control of blackjack and other red oaks. In these early studies the best kill (31 percent) on blackjack oak was from two sprayings with 2 lb/A of 2,4,5-T.

Silvex was also found to be effective for control of oak brush (12) and in 1956 aerial studies were initiated to compare silvex with 2,4,5-T. Brush control with the herbicides was similar except the single application of 2,4,5-T gave better control of blackjack and post oak than the single application of silvex and variability between locations was greater with silvex than with 2,4,5-T (Table 5). The best results with both herbicides were obtained with 3 annual treatments.

Dichlorprop was compared with 2,4,5-T and silvex in 1957. Good blackjack and post oak kill were obtained with all treatments except the single application of the amine formulation of 2,4,5-T (Table 6). A study

Table 4. Effectiveness of aerial foliage sprays of 2,4,5-T[1] alone and in combination with 2,4-D or oak defoliation and kill.[1]

		Rate (lb/A)[3]		Oak Control			
	Herbicide	First	Second	Blackjack Oak[4]		Post Oak[4]	
Code[2]	Treatment	Year	Year	Def.	Kill	Def.	Kill
A	2,4,5-T	1	0	31	3	58	19
B	"	2	0	49	18	70	33
C	"	1	1	65	16	83	44
D	"	2	1	70	16	89	50
E	"	2	2	79	31	89	60
F	"	2	0	47	11	65	32
G	"	2	0	54	16	75	34
H	"	3	0	60	18	70	30
AA	2,4,5-T + 2,4-D	2	0	41	17	50	16
BB	" "	3	0	48	13	63	26
CC	" "	1.5	1.5	60	22	85	40
DD	" "	3	1.5	74	20	86	50
EE	" "	3	3	84	27	92	57
FF	" "	3	0	53	15	58	22
GG	" "	3	0	54	18	71	26
HH	" "	4.5	0	51	11	61	20

[1]Low volatile ester formulations used, 2,4,5-T and 2,4-D were mixed at a 1 to 1 ratio.
[2]Data on code treatment A through H is an average for Alex, Bristow, and Pawhuska studies. Data on code treatment AA through HH is for an area near Pawhuska. All treatment codes except codes F,G,FF, and GG were applied at 5 gallons/A of diesel oil in water emulsion. Code treatment F and FF received a double flying of the half-rate and code treatments G and GG was applied in diesel oil (total spray volume of 5 gallons/A).
[3]Refers to pounds of acid applied per acre. First year treatments applied in June 1952 and second year treatments applied in June 1953.
[4]Percent defoliation and percent apparent kill taken in September 1953. Post oak and white oak are both included in the data under post oak. Blackjack and other red oaks are included in the data under blackjack oak.

Table 5. Percentage canopy reduction and apparent kill of oak and hickory with 2,4,5-T and silvex each at 2 rates for 1, 2, and 3 annual airplane applications.[1]

Treatment and Location[2]	Rate (lb/A) and Year Applied 1956	1957	1958		Blackjack Oak[3] Canopy Red.	Blackjack Oak[3] Kill	Post Oak[3] Canopy Red.	Post Oak[3] Kill	Hickory[3] Canopy Red.	Hickory[3] Kill
					(percent)					
Low volatile ester of 2,4,5-T										
Talihina	2.2	--	--		64	47	89	79	80	64
Stilwell	2.2	--	--		61	39	92	84	71	52
				Average	63	43	91	82	76	58
Talihina	2.2	1.0	--		61	44	90	80	73	58
Stilwell	2.2	1.0	--		61	33	91	81	84	58
				Average	61	39	91	81	79	58
Talihina	1.6	1.5	1.0		86	66	99	97	94	84
Stilwell	1.6	1.5	1.0		86	66	96	92	76	65
				Average	86	66	98	95	85	75
Low volatile ester of silvex										
Talihina	2.2	--	--		57	36	85	53	65	49
Stilwell	2.2	--	--		34	18	61	52	77	53
				Average	46	27	73	53	71	51
Talihina	2.2	1.0	--		58	35	97	86	64	33
Stilwell	2.2	1.0	--		65	48	94	94	53	47
				Average	62	42	96	90	59	40
Talihina	1.6	1.5	1.0		99	94	100	100	97	94
Stilwell	1.6	1.5	1.0		72	52	96	85	83	50
				Average	86	73	98	93	90	72

[1]The herbicide applications were made each year the last part of May or the first part of June. A bywinged airplane was used for all treatments, Spray was diesel oil-in-water emulsion at 5 gpa in 40 foot swaths.
[2]Total annual inches of rainfall for Talihina were 36.50 for 1956, 69.20 for 1957; and 59.86 for 1958. For Stilwell the total annual inches of rainfall were 36.30 for 1956; 62.75 for 1957, and 51.65 for 1958.
[3]Post oak and white oak are both included in the data under post oak. Blackjack and other red oaks are included in the data under blackjack oak.

with invert emulsions in 1959 and 1960 compared a dichlorprop - 2,4,5-T (1:1) mixture with 2,4,5-T. Apparent kill from the mixture was 56 percent compared to only 11 percent with 2,4,5-T alone (Table 7). In a 1963 aerial study, defoliation of blackjack oak was 61, 19, and 66 percent respectively with 2,4,5-T, silvex, and dichlorprop and defoliation of post oak was 54, 57, and 67 percent, respectively.

From these studies 2,4,5-T emerged as the herbicide generally most effective and therefore most of the research effort was then devoted to it.

Formulation Effect of 2,4,5-T. Early studies had not completely resolved the effect of the various esters so a replicated aerial study comparing three long chain esters (isooctyl, butoxy ethanol, and propylene glycol butyl ether) at 2 lb/A rate was initiated in 1959. Canopy reduction and apparent kill of oaks were not significantly different with any of these esters. Canopy reduction from a single application averaged 48

Table 6. Percentage canopy reduction and apparent kill of oak brush with single and repeated herbicide treatments[1].

Herbicide Applied	Rate (lb/A) and year Applied		Canopy Reduction[2] Oak Trees Diameter (Inches)			Apparent Kill[2] Oak Trees Diameter (Inches)		
	1957	1958	<2	2—4	>4	<2	2—4	>4
2,4,5-T Amine salt	4.0	--	56	87	93	45	72	78
2,4,5-T Amine salt	4.0	2.0	86	94	100	82	87	100
2,4,5-T (Butyl ester)	2.0	--	59	100	100	59	100	100
2,4,5-T (LV ester)[3]	1.8	--	94	100	100	94	100	100
2,4,5-T (LV ester)[3]	1.8	1.0	99	99	100	97	97	100
Silvex (LV ester)[4]	1.8	--	94	100	100	86	100	100
Silvex (LV ester)[4]	1.8	1.0	100	99	100	100	95	100
Dichlorprop (LV ester)[3]	1.5	--	90	100	100	90	100	100
Dichlorprop (LV ester)[3]	1.5	1.0	100	100	100	100	100	100
2,4,5-T (LV ester)[5]	1.8	--	67	90	100	58	76	100
2,4,5-T (LV ester)[5]	1.8	1.0	71	98	100	66	60	100

[1]Applications made in May each year on areas located close to Stillwater. A bywinged airplane was used having 7 nozzles on the boom delivering 5 gallons of diesel oil-in-water emulsion/A in 40 foot swaths. Soils were a Stephenville-Darnell fine sandy loam. Total inches of rainfall were for 1956, 16.68; for 1957, 48.59; and for 1958, 31.82.
[2]Canopy reduction and apparent kill determine 16 months after second treatment. Oak trees were blackjack and post oak.
[3]Butoxy ethanol ester
[4]Propylene glycol butyl ether ester
[5]Isoetyl ester

percent and apparent kill averaged 31 percent. A field survey by Eaton et al. (10) also indicated that the formulation of low volatile ester had little or no apparent influence on 2,4,5-T performance for brush control.

Spray Additives and Carriers with 2,4,5-T. Various additives and carriers have been evaluated in an attempt to enhance the activity of aerially applied 2,4,5-T. Diesel oil and a nonphytotoxic oil were compared on blackjack and post oak at four locations in Osage County as carrier alone and as oil-in-water emulsions for applying 2,4,5-T. Canopy reduction and apparent kill on both oaks were very similar for the 4 types of carriers. Canopy reduction of blackjack varied from 50 to 57 percent while a 61 to 70 percent variation occurred with post oak. The apparent kill of blackjack oak varied from 9 to 15 percent while the apparent kill on post oak varied from 26 to 31 percent.

In 1966, various volumes (5, 7.5, and 10 gpa) of diesel oil as spray diluent for 2 lb/A of 2,4,5-T were evaluated. No difference was noted with the 5 and 7.5 gpa volumes, but the kill of post oak was better (66 percent compared to 32 percent) at 10 gpa, while the kill of blackjack oak was decreased (8 percent compared to 28 percent) at this higher volume. Oak control with water as a carrier when applied by airplane was only one-half that obtained when the carrier was diesel oil or diesel oil-in-water emulsion (15).

Table 7. Percentage apparent kill and defoliation of oaks, hickory, and elms with herbicides in invert and diesel oil-in-water emulsion applied by airplane near Talihina, Oklahoma[1].

Type of spray application, year, and herbicide applied	Lb/A			Oaks[2]		Hickory[2]		Winged Elm	
	1959	1960	1961	Canopy Red.	Kill	Canopy Red.	Kill	Canopy Red.	Kill
Spinning Disk Monowinged airplane - invert emulsion						(Percent)			
2,4,5-T	2.0	--	--	7	5	21	11	0	0
2,4,5-T	2.0	2.0	--	20	11	79	76	0	0
Slivex	2.0	2.0	--	50	36	44	35	0	0
Silvex + 2,4,5-T (1:1)	2.0	2.0	--	49	37	66	63	0	0
Dichlorprop + 2,4,5-T (1:1)	2.0	2.0	--	81	56	77	74	3	0
Boom with nozzles on bywinged airplane - standard emulsion									
2,4,5-T	2.0	2.0	--	60	47	67	65	8	8
2,4,5,-T OS amine	--	2.0	2.0	66	41	89	86	3	0
Dichlorprop	--	2.0	1.6	84	26	92	72	1	0

[1]Soil on the treated areas was a sandy loam surface with a clay loam subsoil. There were a number of various size short leaf pine intermingled in the hardwoods. Annual inches of rainfall for 1959 were 52.71; for 1960, 56.19; and for 1961, 60.90.
[2]Evaluations were made in September of 1961. The oaks were mostly blackjack and post oak with some red and white oaks.

In another study (1969) 8 highly refined oils were tested alone and as an oil-in-water emulsion as carriers for 2 lb/A of 2,4,5-T. Each treatment was applied to 10 individual blackjack oak trees at 10 gpa volumes. The oils alone as carrier were equal to or better than their respective emulsions. There were also some differences among the various oils. Diesel oil as a carrier alone or in emulsion was not as effective as some of the more highly refined oils. Folicote[5] at 1 pint and 1 quart added to a water spray mix was also used in the study and results were comparable to diesel oil as an additive.

The effect of the carrier appears to be associated with herbicide rate and may also be affected by weather conditions. For example, a more intensive study comparing diesel oil with Sun 11-E oil and Folicote in 1969 indicated that a pint of Folicote in the spray mix or ½ gallon of 11-E in the spray mix was more effective than diesel oil when 2.5 lb/A of 2,4,5-T was applied but not with 1.5 lb/A.

Surfactants were also evaluated for their effect on herbicide response. Results from the 1961-62 study indicated that the anionic and nonionic surfactants as a group were more consistently effective than cationic surfactants (Table 8). Only 19 percent apparent kill on post oak resulted when the mono-alkyl polyoxyethylene amine cationic surfactant was used in the spray mix.

The anionic and nonionic surfactants used in the first study were further evaluated in combination with 2,4,5-T in 1962 and 1963. They

[5]Folicote is a wax emulsion containing 60 percent solids (Obtained from Sun Oil Co.)

Table 8. Percent defoliation and apparent kill of oaks with various surfactants added to 2 lb/A of butoxy ethanol ester of 2,4,5-T applied as foliage spray in July each year, 1961 and 1962, near Stillwater, Oklahoma[1].

	Blackjack Oak[3]		Post Oak[3]	
Surfactant[2]	**Def.**	**Kill**	**Def.**	**Kill**
		(Percent)		
Commercial Formulation[3]	80	44	96	65
Nonionic				
Alkyphenyl ether of polyethylene glycol (Tergitol NPX)	87	54	89	61
Polyoxyethylene thioether (Sterox SK)	77	45	77	56
Alkylaryl polyether alcohol (Triton X 100)	78	41	84	62
Alkylaryl polyether alcohol (Triton X 114)	90	61	90	50
Anionic				
Sulfonated alkyl ester (Triton GR 7)	81	59	87	62
Amine salt of alkylaryl sulfonic acid (Emcol H-86 C)	87	53	98	76
Cationic				
Mono-alkyl polyoxyethylene amine (Ethomeen S 15)	80	38	67	19
Mono-alkyl polyoxyethylene amine (Ethomeen S 25)	80	49	77	53
P-diisobutyl phenoxyethoxyethyl dimethybenzyl ammonium chloride (Hyamine 1622)	76	51	77	46

[1]Soil on areas treated was Stephenville-Darnell fine sandy loam. The oak was a 3-year old regrowth from cutover. The annual inches of rainfall for 1961 was 38.89 and for 1962, 32.43.
[2].01 gallon of surfactant was added to the .5 gallon of herbicide and enough diesel oil added to make one gallon. This was then mixed with 4 gallons of water. The spray was applied at the rate of 5 gallons/A with a compressed air-hand sprayer equipped with a boom having 2 teejet nozzles. There were 5 plots each 20 by 68 feet for each treatment.
[3]Data taken 3 months after second treatment.

were tested with the butoxy ethanol, propylene glycol butyl ether, and isooctyl esters of 2,4,5-T and compared with company formulations containing their surfactants. In all cases, the company's formulation resulted in better defoliation than 2,4,5-T without surfactant. Also, no major differences were noted among the various added surfactants and the defoliation was comparable to the companies formulated herbicide.

Invert emulsions (water-in-diesel oil) as carriers for brush herbicides have also been tested. In the first study 5.5 to 10.5 gpa volumes were compared while only 5 gpa volumes were compared in a second study. In the first study, apparent kill of oaks was only 11 percent with the diesel oil in water emulsion (Table 7). However, in another study, the defoliation from the standard and the invert emulsions were found to be similar. Also, apparent kill on oaks sprayed with invert emulsion containing dichlorprop and 2,4,5-T was as good as the standard emulsion of 2,4,5-T. Use of invert emulsions by fixed wing aircraft for large area spraying has not been very successful. Oak defoliation often was poor and the spinning disks used for applying the inverts often broke.

The effect of adding NH_4SCN to 2,4,5-T for oak control has shown some promise. There appeared to be an increase in activity on blackjack oak when the rate of NH_4SCN was 0.6 lbA (Table 9). However, results may be dependent on rate since no effect was noted at the .2 lb/A rate.

Summary Information on Aerial Spraying with 2,4,5-T. Good oak brush control was obtained when an initial treatment of 2 lb/A of 2,4,5-T was followed one or two years later with a retreatment with I or 2 lb/A of 2,4,5-T. The best apparent kill on oak brush (91 percent) was from three applications of 2,4,5-T (15), but from these early studies and from large scale spraying since then, two years of spraying (either consecutive or with a one year skip) with 2 lb/A of 2,4,5-T (low volatile ester) has become the standard practice for oak brush control.

The oak control from two sprayings has been found to be quite variable and varies from 22 to 76 percent apparent tree kill (Table 10). Some of this variation in results is attributed to spray coverage and time of spraying. Eaton et al. (9, 10) found that maximum defoliation occurred from spraying 6 to 8 weeks after last killing frost and with good spray coverage (at least 16 percent spray coverage). But, good defoliation the

Table 9. Percent canopy reduction and apparent kill of 4 hardwood species from 2 aerial applications of various herbicides.[1]

Herbicide Treatment[2]	Rate (lb/A)	Canopy Reduction: Oaks: Black jack	Post	Hickory	Elm	Apparent Kill: Oaks: Black jack	Post	Hickory	Winged Elm
					(Percent)				
McAlester, Oklahoma — Applied June, 1965 and June, 1966									
2,4,5-T	2	65	94	96	22	49	91	90	6
2,4,5-T + NH_4SCN	2 + .2	70	95	99	31	52	92	90	1
2,4,5-T + NH_4SCN	2 + .4	79	98	92	61	50	97	92	18
2,4,5-T + NH_4SCN	2 + .6	90	96	94	86	80	92	80	68
2,4,5-T + Picloram	2 + 1[3]	83	100	--	92	56	100	--	85
2,4,5-T + NH_4SCN	2 + .6[3]	85	92	--	50	54	91	--	10
Clayton, Oklahoma — Applied May, 1967 and May, 1968									
2,4,5-T	2	90	85	75	58	19	55	46	2
2,4,5-T + NH_4SCN	2 + .2	85	92	82	74	14	57	56	17
2,4,5-T + Amitrol-T	2 + .2	70	87	84	56	30	44	44	0

[1]Herbicides aerially applied as diesel oil-in-water emulsion at 5 gallons/A in 40 foot swaths.
[2]2,4,5-T was low volatile ester.
[3]Retreatment in 1966 was with 2 lbs/A of 2,4,5-T alone.

Table 10. The effect of two aerial applications of 2 lb/A of 2,4,5-T (low volatile ester) on blackjack and post oaks.[1]

		Blackjack Oak		Post Oak		Average	
Date Sprayed	Location	Canopy Red.	Kill	Canopy Red.	Kill	Canopy Red.	Kill
				(Percent)			
1952 and 1953	Alex	57	46	76	69	67	58
1952 and 1953	Bristow	60	45	69	59	64	52
1952 and 1954	Alex	62	20	75	24	69	22
1952 and 1954	Bristow	73	39	80	50	77	45
1953 and 1954	Bowring	61	55	53	36	57	46
1953 and 1954	Bristow	72	44	85	63	79	53
1953 and 1955	Bristow	78	45	78	52	78	49
1958 and 1959	Talihina	--	--	--	--	60	47
1959 and 1960	Talihina	71	52	82	52	77	52
1965 and 1966	McAlester	76	58	96	93	86	76
1966 and 1968	Cushing	65	--	81	--	73	--
1967 and 1968	Blocker	74	--	77	--	75	--
1967 and 1968	Clayton	88	16	88	56	88	36
1968 and 1969	Pawnee	65	--	82	--	73	--
1968 and 1970	Troy	67	--	84	--	76	--
1970 and 1971	Wetumka	--	--	--	--	88	64
1970 and 1971	Blocker	86	59	85	65	86	62
Average		70	44	79	56	75	50

[1]This is a summary of results from experiments where 2 lbs/A of 2,4,5-T was applied for two years. Most applications were in two consecutive years but sometimes unfavorable conditions occurred the second year so the second spraying was delayed one year. A — in the table means no data was taken.

first year does not necessarily correlate with canopy reduction and final tree kill the second year (Table 11). For example, on blackjack oak there was a canopy reduction of 29 percent from a 1966 spraying at Cushing which had a defoliation of 71 percent and in 1971 at Lamar a 92 percent canopy reduction resulted after a first year defoliation of 75 percent.

The data on post oak give a good example of variation in apparent tree kill. The first year defoliation for three different studies (Shamrock, Howe, and Lamar) was 83 percent whereas the percent apparent kill was 12, 28, and 90 percent respectively. Much of this variation is attributed to the growing condition of the brush at and for one month following spraying and possibly even due to rainfall the previous year. The best canopy reduction and apparent kill of oaks was obtained when May, June and July of year preceeding spraying was dry and year of spraying was wet. Poor results appeared to be associated with wet May, June and July occurring the year before spraying and with dry conditions the year of spraying.

Spraying for two consecutive years with 2 lb/A of 2,4,5-T generally resulted in good canopy reduction and fair brush kill, but more econom-

Table 11. The effect of aerial application of 2,4,5-T (low volatile ester) on blackjack and post oaks.[1]

			Blackjack Oak			Post Oak			Average of Oaks		
Rate lb/A	Date Sprayed	Location	Def.	Canopy Red.	Kill	Def.	Canopy Red.	Kill	Def.	Canopy Red.	Kill
							(Percent)				
3	June-52	Pawhuska	--	--	--	--	--	--	--	40	36
2	6/20/52	Bristow	--	13	5	--	18	10	--	16	8
2	6/15/52	Alex	--	27	5	--	39	21	--	33	13
2	June-53	Bristow	--	40	25	--	73	24	--	57	25
2	June-54	Bristow	--	82	23	--	75	43	--	79	33
2.2	May-56	Stilwell	--	61	39	--	92	84	--	76	62
2.2	May-56	Talihina	--	64	47	--	89	79	--	76	63
1.8	5/27/57	Stillwater	--	--	--	--	--	--	--	86	78
1.5	6/29/57	Yale	--	56	32	--	78	40	--	67	36
1.5	9/20/57	Talihina	--	10	4	--	35	29	--	23	17
1.5	5/26/58	Stillwater	19	44	22	53	67	18	36	56	20
2.0	7/10/58	McAlester	74	--	--	82	--	--	78	--	--
1.5	5/20/58	Talihina	--	32	20	--	51	11	--	42	16
2.0	May-59	Talihina	--	25	10	--	27	8	--	26	9
2	July-61	Osage	48	53	12	57	65	28	52	59	20
2	6/13/63	Stillwater	--	--	--	--	--	--	--	61	--
2	May-64	Beggs	--	--	--	--	--	--	--	61	--
2	5/22/65	Pittsburg	--	79	40	--	89	49	--	84	45
2	5/27/65	Atoka	--	70	33	--	82	52	--	76	43
2	6/14/65	Osage	--	--	--	--	--	--	--	82	--
2	6/17/65	Pittsburg	--	--	--	--	--	--	--	72	--
2	7/7/65	Paradise	--	42	--	--	51	--	--	46	--
2	6/8/65	Cookson	--	--	--	--	--	--	60	--	--
2	5/25/66	Cherokee Game Ref.	42	--	--	42	--	--	42	23	--
2	6/28/66	Barnsdall	74	--	--	80	--	--	77	--	--
2	7/14/66	Cushing	71	29	--	66	29	--	68	29	--
3	8/16/66	Shamrock	60	23	4	83	60	12	72	42	8
2	6/14/67	Clayton	72	--	--	78	--	--	75	--	--
2	67	Blocker	--	36	--	--	68	--	--	52	--
2	7/11/68	Ada	--	66	25	--	52	18	--	59	22
2	5/14/68	Troy	63	--	--	61	--	--	62	--	--
2	6/19/68	McAlester	--	64	40	--	85	63	--	74	52
2	7/5/68	Morrison	40	23	--	45	53	--	42	28	--
2	June-69	Tahlequah	65	--	--	77	--	--	71	--	--
2	May-70	Troy	72	77	43	85	77	43	78	77	43
2	June-70	Lamar	77	71	14	78	83	42	78	77	28
2	7/8/70	Blocker	75	--	--	78	--	--	76	--	--
2	6/25/70	Howe	70	50	6	83	68	28	76	59	17
1.6	6/18/71	Lamar	75	92	72	83	95	90	79	94	81
2	5/29/71	Tahlequah	72	70	40	82	95	90	77	82	65

[1]This is a summary of results from experiments where one application of 2,4,5-T was made. A -- in the table means no data was taken.

ical brush control would be possible if spraying could be done only in those years when good brush kill would result.

Picloram Studies. The effects of adding picloram to 2,4,5-T were studied in a number of experiments. Aerial tests with picloram were started in 1965 near McAlester, Oklahoma. Picloram at 1 lb/A was added to the conventional 2 lb/A rate of 2,4,5-T and better apparent kill of the oaks was obtained then when 2,4,5-T was used alone. In 1966 additional comparisons of 2,4,5-T and picloram were made. The best results were obtained with 2 lb/A of 2,4,5-T plus 1 lb/A of picloram (Table 12). These initial studies indicated that for oak control the rate of 2,4,5-T should not be reduced.

Aerial treatments with picloram and 2,4,5-T were also tried in March and April of 1967 and 1968. Oak control from March treatments was not satisfactory, but control from April treatments was much better (Table 13). Various picloram treatments were applied to individual blackjack oak trees April 10, 1968 and none of them gave good defoliation. The best defoliation (44 percent) was with 1 lb/A of potassium salt of picloram.

Results with mixtures of silvex and picloram were found to be comparable to results with the 2,4,5-T plus picloram treatments (Tables 13 and 14). In 1968, a formulated triethylamine mixture of 2,4,5-T and picloram in a one-to-one ratio was used. This mixture at a 1.5 plus 1.5 lb/A of 2,4,5-T and picloram was evaluated at various locations in Oklahoma and results (Table 15) were comparable to results obtained with two pound of 2,4,5-T plus 1 pound of picloram. In most of these studies the apparent oak kill from a single application of a 2,4,5-T plus picloram mixture was as good as that usually obtained from two applications of 2,4,5-T alone.

Dormant Topical Spray

Aerial treatment of dormant brush with 2,4,5-T and mixtures of 2,4-D and 2,4,5-T were tested in March of 1950. None of the March dormant treatments with 2,4,5-T, 2,4-D or a mixture of the two resulted in effective defoliation of blackjack and post oaks. The 2,4,5-T at 3 lbs in 10 gpa of diesel oil delayed the set of oak leaves for approximately 3 weeks. However, after the short delay period both the blackjack and post oaks developed normal leaf growth. It appears that not enough herbicide uptake resulted from the March treatments since combinations of picloram with 2,4,5-T also were not effective when applied in March (Table 13).

Basal Bark Application

The herbicide mixture used in basal bark application appeared to be more important than the time of treatment. For example, no differences could be detected between November and March treatments, but 2,4,5-T alone or in the mixture resulted in better control than 2,4-D

Table 12. Percent canopy reduction and apparent kill of oaks and other trees from aerial applications of 2,4,5-T alone and in a mixture with picloram.

		Canopy Reduction						Apparent Kill					
		Oaks						Oaks					
Herbicide Treatment	Rate lbs/A	Blackjack	Post	Hickory	Winged Elm	Hawthorn	Tree Huckleberry	Blackjack	Post	Hickory	Winged Elm	Hawthorn	Tree Huckleberry
Ada, Oklahoma — applied June 10, 1966[1]													
2,4,5-T + Picloram	1 + 1	18	44	12	71	44	29	11	39	0	59	10	12
2,4,5-T + Picloram	2 + 1	86	100	84	92	99	86	74	100	81	88	94	81
2,4,5-T + Picloram	2 + 2	25	66	44	86	72	43	17	62	17	84	58	33
Cherokee Game Refuge — applied May 25, 1966													
2,4,5-T + Picloram	1 + 1	38	77	58	100								
2,4,5-T + Picloram	2 + 1	49	86	54	100	--	--	--	--	--	--	--	--
2,4,5-T + Picloram	2 + 2	11	37	55	62	--	--	--	--	--	--	--	--
2,4,5-T + Picloram	1 + 2	45	78	70	89	--	--	--	--	--	--	--	--
2,4,5-T + NH_4SCN	2 + .2	31	35	48	20	--	--	--	--	--	--	--	--
2,4,5-T	2	16	11	48	20	--	--	--	--	--	--	--	--
Ada, Oklahoma — applied July 11, 1968[2]													
2,4,5-T + Picloram	2 + 2	68	82	52	93	--	71	42	65	33	83	--	37
2,4,5-T + Picloram	2 + 1	86	88	80	90	70	83	59	84	77	81	0	68
2,4,5-T + Picloram*	2 + 1	73	92	77	98	--	80	49	85	62	93	--	43
2,4,5-T + NH_4SCN	2 + .55	85	65	31	46	--	25	44	27	0	0	--	0
2,4,5-T	2	47	39	47	36	50	34	6	8	11	7	0	0

[1]The June 10, 1966, treated areas had made a moderate regrowth following 2 lb/A aerial treatments each year, 1958-1959. Winged elm had invaded the areas.
[2]Areas treated July 11, 1968, except starred area, was aerially treated with 2 lb/A of 2,4,5-T + 0.55 lb/A Amitrol-T in 1960. The starred area treated first time in 1968.

Table 13. Percent canopy reduction and percent apparent kill of various brush species aerially treated in March and April with various herbicide mixtures containing picloram.

		Canopy Reduction[1]			Apparent Kill[1]		
Herbicide Treatment	Rate lbs./A	Black-jack	Post Oak	Winged Elm	Black-jack	Post Oak	Winged Elm
				(Percent)			
Clarita, Oklahoma — applied March 28, 1967							
Picloram (K-salt)[2]	2	23	25	97	--	--	--
Picloram + 2,4,5-T[3]	1 + 1	21	12	82	--	--	--
Picloram + 2,4,5-T[4]	1 + 1	17	16	99	--	--	--
Picloram + 2,4,5-T[4]	2 + 1	19	20	95	--	--	--
Clarita, Oklahoma — applied April 30, 1968[5]							
Picloram + 2,4,5-T	2 + 2	54	80	93	39	68	87
Picloram + 2,4,5-T	2 + 1	50	77	81	25	55	83
Picloram + 2,4,5-T	2 + ½	37	81	73	14	50	59
Picloram + Silvex	2 + 2	70	90	94	49	81	90
Picloram + Silvex	2 + 1	68	83	93	33	68	86
Picloram + Silvex	2 + ½	51	71	65	24	53	29

[1]Data taken year following treatments.
[2]Potassium salt of picloram applied in 5 gallons water/A.
[3]Triisopropanolamine salt of picloram and 2,4,5-T applied in 5 gallons water/A.
[4]Triisopropanolamine salt of picloram and 2,4,5-T applied in diesel oil-in-water (1-4) emulsion at 5 gallons/A volume.
[5]Herbicide mixtures each applied with diesel oil to make 1 gallon in 4 gallons of water per acre. The areas treated in 1968 had been aerially treated with 2,4,5-T at 2 lb/A each of years 1958 and 1959. There was a fairly dense regrowth of winged elm and some regrowth of other species when treatments were made in 1968.

alone. The point of spray application also appeared to be important with the best point of application being just above the soil surface (Table 16). Control of blackjack and post oak with basal treatments was usually satisfactory if the stems were thoroughly saturated (14).

Injector

Good defoliation of trees was possible by basal injection of herbicides (Tables 17 and 18). Both the spacing and the amount of herbicide applied at each injection had an influence on the results. For example, the percent defoliation of blackjack and post oak with 2 ml of 2,4,5-T ester/inch of diameter was twice the defoliation with a 1 ml/inch injection (Table 17). A 3-fold defoliation increase was noted with 2 ml of dicamba per inch over 1 ml/in. All herbicides tested in 1966 (2,4,5-T ester, 2,4,5-T diamine, 2,4,5-T amine, 2,4-D, picloram, dicamba and bromacil) caused good defoliation of blackjack and post oak.

Various injection equipment can be used for application, providing correct injection spacing and concentration are used. For example, close spacing was more important with the Hypo-Hatchet with injections at waist height than with the Little Tree Injector with injections at the base of the tree (Table 18).

Table 14. Percentage brush defoliation and grass yields on areas treated with various rates of phenoxy herbicides plus picloram, NH_4SCN, MSMA, dicamba and paraquat on Fred Collins Ranch, Troy, Oklahoma.

Herbicide Applied[1] May 14, 1968	lb/A	Defoliation as of October 1968: Black Oak	White Oak	Winged Elm	Hickory	Misc. Species	Grass Yield lb/A 1968
					(Percent)		
Silvex + NH_4SCN	2.0 + 0.55	87	57	56	43	32	1872
2,4,5-T + NH_4SCH	2.0 + 0.55	63	61	47	41	51	1388
2,4,5-T + Picloram[2]	2.0 + 0.50	70	61	77	28	82	1824
2,4,5-T + Picloram[2]	2.0 + 1.0	66	74	74	44	56	2190
2,4,5-T + Picloram[2]	1.0 + 1.0	79	52	84	27	59	1912
2,4,5-T + Picloram[3]	2.0 + 0.5	79	70	87	42	81	2054
2,4,5-T + Picloram[3]	2.0 + 1.0	71	63	77	30	41	2536
2,4,5-T + Picloram[3]	1.0 + 1.0	59	88	87	56	78	2604
2,4,5-T + Paraquat	2.0 + 1.0	76	64	79	20	73	2308
Silvex + Picloram[4]	2.0 + 1.0	60	60	64	60	40	2220
Silvex + Picloram[4]	2.0 + 0.5	81	85	79	34	87	2030
Picloram + 2,4,5-T[3] + NH_4SCN	1.0 + 1.0 + 0.55	83	81	90	0	35	1742
2,4-D + Dichlorprop + MSMA	1.5 + 1.5 + 0.55	77	70	59	0	0	1700
2,4,5-T + Dicamba	2.0 + 1.0	56	53	52	30	0	1192
Untreated in 1968	0	--	--	--	--	--	102

[1]Herbicide applied by Fred Vencent of Madill, Oklahoma, flying a Pawnee airplane. All areas treated in 1968 had previously been treated in 1959 and retreated in 1960 with 2,4,5-T at 2 lb/A each year. Most brush species had fully recovered from earlier defoliation.
[2]Picloram ester
[3]premixed of 2,4,5-T plus picloram (Dow's 225) at 1:1 ratio used and the low volatile ester of 2,4,5-T added for correct rate.
[4]Potassium salt of picloram. Low volatile ester of silvex.

Basal Versus Injection Treatments

An experiment was conducted to compare the man hours and pounds of 2,4,5-T that would be needed to effectively treat blackjack and post oaks with either injector or basal bark applications. Three ml of 2,4,5-T at 1 gallon (4 lbs a.e.) in 9 gallons of diesel oil carrier were injected per inch of tree dbh (diameter at breast height). The injections were made near the soil and encircled the tree. The basal bark 2,4,5-T applications (same concentration) were made with a compressed air hand sprayer to saturate to runoff the basal 10 to 12 inches of the bark of each treated tree. Both injector and basal bark treatments were applied to 100 oaks consisting of trees less than 3 inches, 4 to 6 inches, and greater than 7 inches dbh. In addition, 1-acre areas with a dense stand of blackjack and post oaks (1000 trees per acre) were treated with a "Little Tree Injector" and by basal bark applications. A powered hydraulic sprayer with a 50-foot hose, a hand gun with a pipe extension, and a teejet nozzle was used

Table 15. Percent canopy reduction[1] and percent apparent kill[1] of various brush species with various combinations of aerially applied herbicides at Howe and McAlester, Oklahoma.

		Blackjack Oak		Post Oak		Hickory		Winged Elm	
Herbicide Treatment	Rate (lbs/A)	Canopy Red.	Kill	Canopy Red.	Kill	Canopy Red.	Kill	Canopy Red.	Kill
Howe Oklahoma — Applied June 17, 1968[2]					(Percent)				
2,4,5-T + Picloram	1.5 + 1.5	79	66	94	90	65	35	98	89
2,4-D + Dichlorprop	1.3 + 1.3	56	16	76	63	55	29	44	2
2,4-D + Dichlorprop[3]	1.3 + 1.3	66	44	86	76	91	78	44	1
2,4-D + Dichlorprop + MSMA	1.3 + 1.3 + .55	70	47	92	87	61	29	48	14
McAlester, Oklahoma — Applied June 19, 1968[2]									
2,4,5-T + Picloram	1.5 + 1.5	54	12	99	97	79	43	90	67
2,4-D + Dichlorprop[3]	1.5 + 1.5	81	59	71	49	77	59	47	0
2,4-D +Dichlorprop + MSMA	1.5 + 1.5 + .5	75	53	78	54	83	73	36	0
2,4,5-T[3]	2	64	40	85	63	76	68	24	0
2,4,5-T + MSMA	2 + .5	69	37	84	77	79	54	29	0
2,4,5-T + Amitrole	2 + 1.4	32	70	83	91	70	79	40	0
2,4,5-T + Dicamba	2 + .5	71	33	73	38	74	56	53	16

[1]Rating taken year after treatment.
[2]Spray was herbicide plus diesel oil to make 1 gallon with 4 gallons of water/A. Plots at Howe burned over on March 27, 1969. All herbicides applied at McAlester were on areas that had been aerially treated with 2 lb/A of 2,4,5-T in 1958 and 1959. All woody species had recovered from earlier treatments and there was an increase in density of winged elm.
[3]NH_4SCN added to spray mix at 0.5 lb/A.

Table 16. The effect of stem and basal application methods of herbicides on defoliation and canopy reduction of several brush species.

		Brush Species			
Herbicide Treatment[1]	Application Method	Oak	American Elm	China-berry	Hack-berry
Stillwater, Oklahoma — Applied March 1967			% Defoliation		
2,4,D + 2,4,5-T[2]	Basal Bark[4]	99	74	--	--
2,4,D + 2,4,5-T[2]	Cane Stem[5]	52	90	--	--
2,4,5-T[3]	Basal Bark[4]	--	62	--	--
2,4,5-T[3]	Cane Stem[5]	91	94	--	--
Perkins Oklahoma — Applied March 1967			% Canopy Reduction		
2,4,D + 2,4,5-T	Cane Stem[6]	72	41	100	93
2,4,5-T	Cane Stem[6]	78	67	100	90
Stillwater, Oklahoma — Applied July 1968			% Defoliation		
2,4,D + 2,4,5-T	Cane Stem[6]	--	43	100	--
2,4-D + Dichlorprop	Cane Stem[6]	--	60	94	--
2,4,5-T	Cane Stem[6]	--	65	100	--

[1]All herbicides mixed at the rate of 16 lbs of herbicide/100 gallons of diesel fuel.
[2]Dinoxal formulation at a 1:1 ratio used.
[3]Trinoxol formulation used.
[4]Base of tree saturated with spray mix.
[5]Lower ⅔ of tree stem wet with spray mix.
[6]Lower ⅓ of tree stem wet with spray mix.

Table 17. Percent defoliation of blackjack oak, post oak, and persimmon from herbicides applied with a tree injector[1].

Herbicide Treatment	Concentration of Applied Chemical lb/gallon[3]	Percent Defoliation[2]: Blackjack and Post Oak, Milliliter/inch of Diameter 1	Blackjack and Post Oak, Milliliter/inch of Diameter 2	Persimmon, Milliliter/inch of Diameter 1	Persimmon, Milliliter/inch of Diameter 2
2,4,5-T (LV ester)	4	53	97	50	83
2,4,5-T (Diamine salt)	4	100	65	32	27
2,4,5-T (Amine salt)	4	100	100	50	78
2,4,-D (Amine salt)	4	100	90	0	20
Picloram (Potassium salt)	2	93	98	100	---
Dicamba	4	30	90	83	100
Bromocil	0.8	94	100	18	17

[1]Injections with "Little Injector" made at the soil of each treated tree. Herbicide placed in injector incession with plastic hypodermic syringe.
[2]Evaluations were made 6 months after an April treatment in 1966.
[3]Formulations of 2,4,5-T, 2,4-D, picloram, and dicamba undiluted. Bromocil lb active chemical/gallon of water (prepared with 80% wettable powder).

Table 18. Percent canopy reduction and apparent kill of post oak from herbicide applied with Hypo-hatchet and Little tree injector at 3 spacings.

Method and Herbicide 1 ml/injection	Percent Canopy Reduction 10 Months After Treatment: Spacing Between Injections (inches) 1	2	3	Average	Average Apparent Kill
Hypo-hatchet[2]					
Hydroxydimethylarsine oxide of Cacodylic acid (S-510)	83	74	38	65 bc	0
Monosodium acid methanearsonate (S-550)	70	37	28	45 e	0
S-510 plus S-550 (1:1)	82	66	47	65 bc	0
S-510 + S-550 (1:1) plus 4 oz. picloram/gallon	88	81	58	76 ab	10
2,4-D diethylamine	89	62	48	66 bc	17
2,4,5-T diethylamine	94	51	34	60 cd	23
Little Injector[3]					
2,4,5-T diethylamine	97	88	66	84 a	46

[1]Soils on treated areas were a Stephenville-Darnell fine sandy loam. The total inches of rainfall for 1969 were 27.84.
[2]The Hypo-hatchet injections were at waist height. Only 1 milliliter of undiluted herbicide injected. The injections encircled each of 10 treated trees/each of 1, 2, and 3 inch spacings.
[3]The Little Injector was used to make the incessions. Each incession was spaced at 3, 6, and 9 inches apart/each of 10 trees. These injections were 3 to 4 inches above the soil and encircled each tree. The undiluted 4 lb of (2,4,5-T/gallon) was placed in each incession with a syringe.

for the basal bark treatments so the spray could be directed to the base of each tree.

Three times more man hours were required to effectively treat the small oak trees less than 3 inches in diameter with the injector than with basal bark applications. The small trees would not absorb the thrust of the injector so more time was required to make the injections. Only ¼ gallon of solution was used with the injector compared to ½ gallon for basal bark treatments (Table 19). The man hours needed for the injector treatments on medium-size trees were twice those for the basal bark applications, but about 2½ times more 2,4,5-T-diesel oil spray was used for the basal bark than the injector. On large trees about the same number of man hours were required to make both treatments, but 4 times more spray was required for basal bark treatments. In treatments on the acre areas about the same man hours were involved in making the basal bark and injector applications, but 3½ times more 2,4,5-T-diesel oil spray was required for the basal bark application.

Soil Treatments

Fair to good defoliation and kill of oaks were obtained with ground application of urea substituted herbicides with rates of 3.2, 4.8, and 6.4 lb/A. In 1955 and 1956, when annual rainfall was about 28 inches, fenuron was more effective than monuron, especially at the lower rates. However, in 1954 with only 18 inches of annual rainfall, none of the urea herbicides were effective the year of treatment. Good kill (63 to 66 percent) resulted from the 12 lb/A rate of the urea-type herbicides 30 months after treating.

Elm Control with Herbicides

Elm trees occur as a subdominant species in much of the blackjack and post oak areas of the state. The American elm is distributed over most of the state and winged elm is primarily located in the southeast fourth of the state. The elms are primarily located along the drainage ways in unsprayed brush areas, but many of the elm plants have invaded

Table 19. Man hours and herbicide solution used in injector and basal bark treatments on blackjack and post oaks near Stillwater, Oklahoma.

Tree Size Treated[1]	Man Hours and Solution Used In Treating 100 Trees[2]			
	Injector		Basal Bark	
	Man hours	Gallons	Man hours	Gallons
Small	0.75	0.25	0.25	0.50
Medium	1.00	0.75	0.50	1.80
Large	1.25	1.00	1.30	4.00
		Per Acre		
Dense stand all sizes[3]	10.00	7.00	9.50	25.00

[1]Small plants were $\leq$ 3″ in diameter, medium plants were 4″ to 6″ in diameter and large plants were $\geq$ 7″ in diameter.
[2]Herbicide 2,4,5-T (1 gallon of 4 a.e./gallon) in 9 gallons of diesel oil. Injector Little type with injections spaced 1-inch diameter to encircle each tree at soil. Basal bark made to 10 to 12 inches and encircling each tree at the soil. Solution applied as wetting spray with compressed air hand sprayer.
[3]About 1000 of oak trees/A from 2 to 8 inches in diameter.

upland sites after spraying and some are invading abandoned cropland areas.

Foliage Spray

Phenoxy Herbicides. The phenoxy herbicides applied as foliage sprays were not very effective for elm control (Table 8 and References 25 and 28). Good defoliation is sometimes obtained, but the trees often fully recover. This is especially true with 2,4-D (28) and may also be the case with silvex (Table 20). 2,4,5-T is more effective in that it does cause some canopy reduction (24, 28). The best results were obtained when spraying was done at the half-leaf stage of development. The diamine formulation of 2,4,5-T also appears to be more effective than the low volatile ester formulation (Table 20). Kirby (24) found that excellent control with 2,4,5-T ester was possible with two years of treatment when applied to completely wet the leaves and twigs of the tree.

Ammonium thiocyanate (NH_4SCN) was found to increase the effectiveness of 2,4,5-T in some studies (Table 9), but had no effect in other studies (Table 12). Two applications of 2 lb/A of 2,4,5-T plus 0.6 lb/A of NH_4SCN resulted in 68 percent apparent kill of winged elm whereas the 0.2 lb/A of NH_4SCN only gave an apparent kill of 1 percent (Table

Table 20. Percent canopy reduction and percent kill of 4 brush species with various herbicide treatments applied in 10 gallons of water/A with an airblast sprayer on June 9, 1964 near Wagoner, Oklahoma.[1]

		Percent Canopy Reduction 4 Yrs. & 4 Months after spraying				Percent Kill 4 Yrs. and 4 months after treatment			
Herbicide Applied[2]	lb/A	Persimmon	Elms[3]	Dogwood[3]	Blackberry	Persimmon	Elms[2]	Dogwood[2]	Blackberry
Low volatile ester of 2,4,5-T	1.0	66	28	3	34	42	21	0	0
Diamine of 2,4,5-T	1.0	69	58	26	43	51	36	0	25
Low volatile ester of silvex	1.0	48	8	7	13	26	0	0	0
2,4,5-T plus picloram	1.0 + 0.25	93	46	28	52	73	11	13	21
Picloram potassium salt	0.5	61	33	9	31	43	7	0	9
Picloram potassium salt	1.0	49	40	46	18	26	13	40	0
Picloram potassium salt	1.5	76	57	58	51	53	36	30	40
2,4-D plus picloram	1.0 + 0.25	70	41	0	17	40	18	0	17

[1]Soil on the treated areas was sandy clay loam with a clay loam subsoil. The total inches of rainfall for 1964 were 32.09.
[2]Herbicide applied to 40 feet by 100 feet plots with Potts air blast sprayer 60 strips 20 feet wide. Persimmon was 3 years old growback brush following a fire. Trees 6 to 7 feet in height, air velocity from sprayer was about 90 mph.
[3]The elms were American and winged species and the dogwood was roughleaf species.

9). In another study a single July application of 2 lb/A of 2,4,5-T plus 0.55 lb/A of NH_4SCN was no better than 2,4,5-T alone (Table 12). The variation in results can be partially attributed to rate of NH_4SCN, but physiological condition of the trees at spraying may also have an influence, since results from July spraying were poor.

Picloram Studies. The first studies with picloram in 1964 indicated that it gave fair control of elm when applied alone or in combination with 2,4-D (Table 20). More effective control was obtained with 1 lb/A of picloram applied with 2 lb/A 2,4,5-T (Table 9). Additional studies with picloram in combination with 2,4,5-T were conducted over the next several years (17). Variable results were obtained from 1+1, 2+1, 2+2 lb/A combinations of 2,4,5-T and picloram. Decreasing the rate of picloram to 0.5 lb/A in the combination decreased control in one study, but was just as effective as the 1 lb/A rate in two other studies. No direct comparison of results between 1.5 lb/A each of 2,4,5-T plus picloram and the other combinations of 2,4,5-T and picloram were made, but defoliation ranged from 89 to 94 percent and apparent kill from 67 to 88 percent for the 1:1 mixture. Picloram mixed with silvex has also given good control of winged elm (Table 13 and 14).

Injection, Basal and Soil Treatment

As basal injected treatments, 2,4,5-T, silvex and 2,4-D were very effective for control of winged elm and fairly effective on American elm (24). However, the time, carrier and concentration of herbicide injection appeared to be important. Ester formulations of 2,4-D and 2,4,5-T when applied in water carriers were ineffective in March but gave fair to good control of winged elm when applied in December or June. Applying the esters in diesel oil resulted in good control of the elm at all three dates. Also, injections of 4 ml. of 0.4 pounds a.e. of herbicide / gallon were more effective than more dilute concentrations. Injection treatments with dicamba, cacodylic acid and picloram alone and in combination with 2,4-D and 2,4,5-T also gave satisfactory control of winged elm (28).

Basal bark treatments have not been as reliable as injection treatments for elm control. Fair to good control of winged elm was obtained from basal spraying with ester formulations of 2,4-D and 2,4,5-T (16 lb/100 gallon diesel) (24, 28). Amine formulations of all the herbicides were not effective as basal bark treatments.

Soil application of 10 lb/A of picloram gave excellent control of elm with both March and June treatment dates (25, 28). Five lb/A gave good control when applied in June but only fair control when applied in December or March. Dicamba applied to the soil in December and March only gave fair control but June treatments resulted in good control of winged elm. Control from soil applied fenuron, prometrone, and 2,3,6-TBA was poor.

Hawthorn Control with Herbicides

Hawthorn occurs quite frequently in eastern Oklahoma and particurlarly in dense stands in Muskogee County. This woody plant often invades sites retired from cultivation and is sometimes associated with persimmon, wild blackberry and rose. Hawthorn may be found as a minor species in oak and elm associations.

Foliage Treatments

The phenoxy herbicides (2,4-D, 2,4,5-T, dichlorprop and silvex) had little effect on hawthorn while dicamba and picloram only had slight effect. However, combinations of 2,4,5-T and picloram have given control (Table 12). Also, a foliage spray test in July, 1960 with 2-chloro-4 fluro phenoxy acetic acid at 3 and 4 lb/100 gallons of water applied as a wetting spray gave very good defoliation of hawthorn trees 3 to 5 feet in height. Additional tests with this compound alone and in combination with other herbicides were conducted in 1971. The 3 lb/A rate of 2-chloro-4-fluro phenoxy acetic alone and in mixtures with 2,4,5-T, 2,4-D, dicamba and picloram caused about 50 percent canopy reduction of hawthorn.

Soil Treatments

Various soil treatments (picloram, dicamba and fenuron) have been tested for hawthorn control. The most effective chemical has been picloram and it is only effective at high rates (8 lb/A or 3 Tbl/in dbh of 10 percent pellets). Fenuron granule at a high dose rate (3 Tbl/in dbh of 25 percent pellets) also gave fair defoliation and kill, but a 12 lb/A rate applied as a broadcast treatment did not kill any trees. Dicamba as a soil treatment caused some defoliation, but no tree kill.

Hickory Control with Herbicides

There are 5 major species of hickory (*Carya myristicaeformis* Nutt., *Carya ovata* [Mill.] K. Koch., *Carya laciniosa* Michx., *Carya tomentosa* Nutt, and *Carya texana* Buckl.) in Oklahoma. Some of the species occur in the blackjack and post oak areas in central Oklahoma, but hickory is a major problem only in southern and eastern Oklahoma.

In several studies (Tables 5, 8, and 12) it was found that hickory was generally easier to control than blackjack oak with 2,4,5-T and sometimes control of hickory was as good as for post oak, but this was not always the case (Table 14). The oil soluble amine formulation of 2,4,5-T was found to be effective on hickory (Table 8). Additions of NH_4SCN to 2,4,5-T had little influence on hickory control (Tables 9 and 12) but did increase activity of a 2,4-D plus dichloroprop treatment (Table 15).

Silvex was not as effective as 2,4,5-T in one study (Table 8) but gave control similar to 2,4,5-T in another study (Table 14). Control from dichloroprop was comparable to control with 2,4,5-T (Table 8). Hickory control from mixtures of silvex or dichlorprop with 2,4,5-T or a mixture of dichlorprop and 2,4-D was similar to hickory control with 2,4,5-T alone.

Adding picloram to the various phenoxy herbicides had little influence on control in two studies (Table 14, 15), but helped some in another study (Table 12). Much of the variation in response of the hickory to the herbicides may be due to species response since no attempt was made to separate the species in any of the studies.

Juniper Control with Herbicides

The two major juniper species in Oklahoma are the eastern redcedar and ashe juniper. The eastern redcedar is already a problem in some 350,000 acres of rangeland in Oklahoma and has the potential of becoming a problem on many more acres if burning is not practiced after removal of oak brush. Much of the oak brush areas in Oklahoma have seedling eastern redcedar as an understory species. The main area of infestation is central and northeastern portion of the state, but infestations are also found in most other areas of the state. Ashe juniper is primarily located in the Arbuckle Mountain area of southern Oklahoma.

Buehring et al. reviewed the problem and evaluated various herbicides for control of eastern redcedar (2, 3). Foliage treatments with phenoxy treatments were not effective for controlling eastern redcedar, but paraquat at 1 lb/A and dicamba at 3 lb/A were effective. Picloram plus 2,4,5-T (1.5 lb/A of each) also was effective. Ashe juniper appear to be more resistant to the foliar applied herbicides than eastern redcedar (6). Picloram, dicamba, and paraquat were not very effective as foliage sprays, on ashe juniper, but a combination of picloram and paraquat did give good tree kill.

Injection treatments of ester formulations of 2,4,5-T were not effective, but the concentrated amine formulation did give good defoliation of eastern redcedar when injections were made in March (2, 3). Also the amine formulations of 2,4-D was more effective than the ester formulation. Picloram was very effective as an injected treatment. Additional injection work in 1970 and 1971 indicated that paraquat was also very effective. Fair results were also obtained with dicamba and an oil soluble amine of 2,4-D, but dichlorprop was unsatisfactory. The major limitation with injection is the application. The tree limbs often extend to ground level and it takes an average of about 20 seconds to inject each tree.

Kill of eastern redcedar with soil applied herbicides was only fair (2, 3). Only the highest rate of picloram (6 Tbl/in dbh of 10 percent granulars) and fenac (9 Tbl/in dbh) gave satisfactory kill. Some applications of dicamba, fenuron and monuron-TCA were all ineffective. Ashe juniper also is resistant to soil applied herbicides. Fenuron and bromacil gave only fair control and 45 lb/A of 10 percent picloram only resulted in 76 percent kill of the trees (6).

Persimmon Control with Herbicides

Foliage Studies

Persimmon is one of the woody species which invades the grasslands and cultivated lands which have been returned to pasture. Persimmon occurs throughout central, eastern and southern Oklahoma. This species is easily defoliated with 2,4,5-T at 1 lb/A or less but sprouts readily from both stems and roots after treatment.

Table 21. Percent defoliation of persimmon, sumac and wild blackberry with various phenoxy herbicide treatments.

Herbicide Treatment[1]	Rate lbs/A	Percent Defoliation Four Months After Treatment		
		Persimmon	Sumac	Wild Blackberry
Low Volatile Ester Formulation				
2,4-D	¾	67	74	61
	1	40	90	--
	1½	17	90	--
2,4-D + 2,4,5-T[2]	¾	89	99	20
	1	78	90	--
	1½	86	90	25
2,4,5-T	¾	90	80	51
	1	78	89	65
	1½	85	90	--
Silvex	¾	84	87	90
	1	86	90	34
	1½	87	90	90
Diamine Salt Formulation				
2,4-D	¾	50	90	25
	1	49	90	--
	1½	58	90	20
2,4-D + 2,4,5-T[2]	¾	90	90	19
	1	77	90	--
	1½	49	90	83
2,4,5-T	¾	87	90	59
	1	83	87	73
	1½	82	90	90
Silvex	¾	87	90	11
	1	71	89	28
	1½	79	90	60

[1]Herbicide applied June 1963 near Wagoner, Oklahoma with compressed air hand sprayer. Plot size was 10 X 30 feet and replicated 3 times. Applied in water at 36 gallons/A rate.
[2]A 1:1 mixture of 2,4-D and 2,4,5-T.

Silvex and 2,4,5-T both gave good defoliation of persimmon (Table 21) and were more effective than 2,4-D (Tables 21 and 22). The diamine and low volatile ester formulations of the phenoxy herbicides are comparable in their effect on persimmon (Tables 20, 21, 22, and 23).

Herbicide rate is important with the phenoxy herbicides. A rate of ¾ lb/A was as good or better than a 1.5 lb/A rate (Table 21). In fact, a 0.25 lb/A rate was better than 0.75 lb/A for canopy reduction 53 weeks after treatment and equal 102 weeks after treatment (23). Timing of application also appears to be very important. Treatments on plants in April when the leaves were only ⅓ expanded were not as effective as May treatments applied when the leaves were fully expanded (Table 22).

Additives were also tried in foliage sprays of 2,4,5-T in an attempt to increase persimmon kill. Some of these include NH_4SCN, MAA, ethephon, TIBA, and various surfactant (Table 24). Percent kill and defoliation have generally been good when NH_4SCN was added to 2,4,5-T (Tables 23, 24 and 25) and resprouting less than with 2,4,5-T alone (Table 24). Ethephon appeared to increase both defoliation and tree kill (Table 24) as did MAA (Table 24) and TIBA (Table 25).

The results from use of surfactants and various formulations of low volatile esters of 2,4,5-T are given in Table 26. Use of 2,4,5-T at 1 lb/A without surfactants caused only about one-half the defoliation of persimmon that the same rate did with surfactant. Persimmon defoliation with each surfactant in the formulations used was equal to or better than any

Table 22. Percent defoliation of sumac, persimmon, and wild blackberry from a burn or with .8 lb/A of herbicides applied aerially in mid-April and mid-May 1963 near Wagoner, Oklahoma.[1]

Treatment or Herbicides	Percent Defoliation 5 or 6 Months After Treatment					
	Sumac		Persimmon		Wild Blackberry	
Applied[2]	April	May	April	May	April	May
Burned April 15, 1963	27	--	22	--	4	--
Low Volatile Ester Formulation						
2,4-D	50	94	22	36	14	28
2,4-D + 2,4,5-T	24	98	11	48	14	34
2,4,5-T	40	100	5	46	11	66
Diamine Salt Formulation						
2,4-D	53	100	0	25	0	19
2,4-D + 2,4,5-T	22	100	19	67	0	30
2,4,5-T	20	--	16	--	8	--

[1]Soil for the treated areas was Dennis-Bates series with a silt to clay loam with sandstone rock outcrop. Total inches of rainfall for 1963 were 25.38.
[2]Each herbicide or mixture was applied with a bywinged airplane delivering 3 gallons of diesel-in-water emulsion/A in a 40 foot swath. Plot size was 160 X 660 feet. A 1:1 mixture of 2,4-D and 2,4,5-T.

Table 23. Percent defoliation of persimmon with various herbicide treatments applied with an airblast sprayer June 3, 1965 near Oilton, Oklahoma[1].

Herbicide Treatments[2]	lb/A	Average Percent Defoliation 3 Months After Treatment[3]
Diamine 2,4,5-T	1.0	94
Low volatile ester of 2,4,5-T	1.0	88
2,4,5-T + picloram	0.5 + 0.5	95
2,4,5-T + picloram	0.75 + 0.25	99
2,4,5-T + picloram	1.00 + 0.50	100
2,4,5-T + dicamba	0.75 + 0.25	82
2,4,5-T + dicamba	0.50 + 0.50	98
2,4,5-T + dicamba	1.00 + 0.50	99
2,4,5-T + NH_4SCN	1.00 + 0.10	96
2,4,5-T + NH_4SCN	1.00 + 0.20	92
2,4,5-T + NH_4SCN	1.00 + 0.30	89

[1]Soil on treated areas was a sandy loam surface with a clay loam subsoil. Total inches of rainfall for 1965 were 33.01 (Cushing record).
[2]Each herbicide or combination applied in 20 gallons of diesel fuel-water emulsion/A.
[3]None of the persimmon plants treated with 2,4,5-T plus picloram had roots or stem sprouts when the evaluations were made. The treated persimmon for all other treatments had some stem or root sprouts. A wild fire burned over this treated area in the spring of 1966 before an apparent kill could be determined.

Table 24. Percentage defoliation of persimmon with various herbicide and additives from foliar applications made June 10, 1969.[1]

Herbicide Applied[2]	lb/A	Average[3] Percent Defoliation	Percent[3] Trees with Sprouts
2,4,5-T	1.0	83	70
2,4,5-T + NH_4SCN	1.0 + 0.25	95	20
2,4,5-T + MAA	1.0 + 0.25	91	30
2,4,5-T + Ethephon[4] (acid)	1.0 + 0.50	91	40
2,4,5-T + Ethephon (acid)	1.0 + 1.0	84	30
2,4,5-T + Ethephon (ester)	1.0 + 0.50	80	70
2,4,5-T + Picloram	0.25 + 0.25	73	20
2,4,5-T + Picloram	0.50 + 0.50	71	0
2,4-D + MAA	3.0 + 1.33	16	20

[1]Soil on the treated area was a sandy clay surface and a clay loam subsoil. Total precipitation for 1969 was 26.50 inches (Cushing record).
[2]Ten persimmon 3 to 5 feet in height treated with each herbicide and additive. A compressed-air-hand sprayer was used to apply spray over tops of each plant. Spray was herbicide plus an equal amount of diesel oil-in-water applied at a rate of 10 gallons/A. Low volatile esters of phenoxy herbicides used.
[3]Persimmon with sprout regrowth either from above ground-part-of-plant or from roots. Data taken September 19, 1969.
[4]Ethephon is a plant growth regulating chemical [(2-chloroethyl) phosphonic acid] used to produce ethylene type plant responses.

Table 25. Percent defoliation of persimmon with foliage sprays of 2,4,5-T alone and with TIBA and NH_4SCN as additives[1]

Herbicide[2] Treatment	Rate lb/A	Percent Average Canopy Reduction 15 months after Treatment
2,4,5-T	1.0	32
2,4,5-T + TIBA	1.0 + 0.12	96
2,4,5-T + TIBA	1.0 + 0.06	48
2,4,5-T + TIBA	1.0 + 0.03	63
2,4,5-T + NH_4SCN	1.0 + 0.25	40
2,4,5-T + NH_4SCN	1.0 + 0.13	43
2,4,5-T + NH_4SCN	1.0 + 0.06	58

[1]Area located near Oilton, Oklahoma. Soil on the treated area was a loam surface with a clay loam subsoil. The total inches of rainfall for 1963 were 29.41 and for 1964 were 29.51 (Cushing record).
[2]The butoxy ethanol ester of 2,4,5-T used and herbicide treatments applied in a diesel oil-in-water emulsion at 5 gallons/A through a compressed air hand sprayer on July 15, 1963.
[3]TIBA — 2,3,5-triiodobenzoic acid

Table 26. The effect of adding various surfactants to foliage sprays of 2,4,5-T on canopy reduction of persimmon.[1]

Surfactant used with 2,4,5-T[2]	Percent Canopy Reduction 15 months after treatment with various esters of 2,4,5-T: Butoxy ethanol	Propylene glycol butyl ether	Isooctyl
None	48	45	53
Company surfactant	80	77	83
Alkylaryl polyether alcohol	80	73	80
Alkylaryl polyether alcohol	82	85	--
Alkyphenyl ether of polyethylene alycol	55	68	--
Polyoxyethylene thioether	75	63	--
Amine salt of aryl sulfonic acid	67	33	43
Sulfonated alkyl ester	53	45	53

[1]Area located near Oilton, Oklahoma. Soil on the treated areas was a loam surface with a clay loam subsoil. The total annual inches of rainfall for 1963 were 29.41 and for 1964 29.51 (Cushing record).
[2]The herbicide treatments applied in 5 gallons/A of diesel oil-in-water emulsion. Each surfactant added was at 0.5 percent of the total spray/A. The applications were made July 15, 1963 with a compressed air hand sprayer. 2,4,5-T was applied at the 1 lb/A rate.

of the added surfactants. All three 2,4,5-T low volatile esters tested gave approximately the same persimmon defoliation (ranged from 77 to 82 percent.)

Picloram, especially in combination with low rates of 2,4,5-T, has looked very promising for persimmon control (Tables 20, 23, 24 and 27). Combinations with dicamba alone and in combination with 2,4,5-T has also given effective control (Tables 23 and 27). Both of these herbicides have given good defoliation and apparent kill at 0.5 lb/A when mixed with 0.5 lb/A of 2,4,5-T and appear to control stem and root regrowth better than 2,4,5-T alone. Paraquat and amitrol were found to be ineffective on persimmon (23).

Soil Treatments

Soil application of picloram and dicamba at 3, 6 and 9 lb/A have also been tried on persimmon trees. In one study both dicamba and picloram at the 3 lb/A rate gave an average apparent kill of 57 percent. Increasing the rate of picloram and dicamba to six pounds increased apparent kill to 75 and 71 percent, respectively. Fenuron was not effective at 6 lb/A (23).

Basal and Injection

Basal treatments and injection of diluted 2,4,5-T ester have not been very effective on persimmon, but injecting undiluted 2,4,5-T amine (4 lb/gallon material) caused a 86 percent canopy reduction of persimmon (Table 28). Complete top kill was possible by injecting undiluted solutions of dicamba (Table 28) or mixtures of 2,4,5-T and dicamba (23). Injections of dichlorprop and fenac caused no canopy reduction and a 1:1 mixture of 2,4-D plus dichlorprop only caused a slight canopy reduction (Table 28). Injections of undiluted cacodylic acid resulted in 80 percent canopy reduction of persimmon 83 weeks after treatment but

Table 27. Persimmon control from herbicides foliar applied July 11, 1968[1].

Herbicide Treatments[3]	lb/A	Percent Control[2]	
		Apparent Kill	Canopy Reduction
Picloram	0.50	49	59
Picloram	0.75	49	61
Picloram	1.00	70	81
Picloram + 2,4,5-T	0.50 + 0.50	68	74
Picloram + 2,4,5-T	0.75 + 0.75	67	72
2,4,5-T	0.75	43	56
2,4,5-T	1.00	45	47
Dicamba	1.00	65	75
Dicamba	2.00	80	95
Dicamba	3.00	73	77
Dicamba + 2,4,5-T	0.50 + 0.50	66	80
Dicamba + 2,4,5-T	1.00 + 1.00	71	81
Dicamba + 2,4,5-T	1.50 + 1.50	77	83

[1]Area located 17 miles east of Stillwater. Each treated area was 14 X 58 feet. Soil on treated area was a sandy clay loam surface with a clay loam subsoil. Annual inches of rainfall for 1968 were 33.04 and for 1969 were 27.84 (Stillwater record).
[2]Data taken August 14, 1969 and is average for three reps.
[3]Picloram alone was potassium salt. Picloram + 2,4,5-T treatments were triethylamine salts. 2,4,5-T alone and in combination with dicamba was the low volitile ester formulation.

Table 28. Persimmon control from basal injection of various herbicides.[1]

Herbicide Injection and Concentration of Solution	Canopy Reduction	Apparent Kill
	(Percent)	
Dicamba		
2 lbs/9 gallons	90	20
4 lbs/9 gallons	93	30
4 lbs/gallon[2]	100	100
2,4,5-T amine		
4 lbs/9 gallons	33	0
4 lbs/gallon[2]	86	40
2,4-D amine		
4 lbs/9 gallons	68	20
4 lbs/gallon[2]	78	50
2,4,5-T + Picloram (amine formulation) — 1:1 ratio		
1 lb/9 gallons	13	0
2 lbs/9 gallons	22	0
4 lbs/9 gallons	65	30
Picloram (K-salt)		
2 lb/9 gallons	58	0
2 lbs/9 gallons	62	40
4 lbs/9 gallons	85	30
2,4-D plus Dichlorprop (LV esters) 1:1 ratio		
4 lbs/9 gallons	9	0
4 lbs/gallons[2]	0	0
2,4-D plus Picloram		
1 lb/9 gallons	9	0
2 lbs/9 gallons	13	0
4 lbs/9 gallons	20	0
Dichlorprop		
4 lbs/9 gallons	0	0
4 lbs/gallon[2]	0	0
Fenac		
4 lbs/9 gallons	0	0
4 lbs/gallon[2]	0	0

[1]Each treatment applied to 10 individual trees located on an area 17 miles east of Stillwater on July 19, 1968. One injection was made for each inch of tree diameter and injections were equally spaced to encircle the base of the treated tree. Trees were 3 to 5 inches in diameter.
[2]This is the undiluted herbicide and only 1 ml of the undiluted herbicide was applied at each injection. All of the other treatments were diluted and 3 ml applied at each injection.

tree kill was low and 131 weeks after treatment only a 53 percent canopy reduction was observed (23).

Control of Other Brush Species with Herbicides

Blackberry

Control of blackberry with the phenoxy herbicides has been variable. Defoliation has been fair to excellent if sprayed in May or June (Tables 21 and 22) while results from an April spraying were all poor (Table 22). Control from 2,4-D alone or in mixtures are not as effective as 2,4,5-T alone (Table 22). Silvex at the 1½ lb/A rate appeared to be as effective as 2,4,5-T (Table 21). The plant kill was usually poor with the phenoxy herbicide (Table 20) and repeat treatments were usually needed.

Picloram alone and as a mixture with 2,4-D and 2,4,5-T did give some kill of blackberry plants (Table 20).

Buckbrush

Buckbrush, also called coralberry, is an understory plant on some of the blackjack and post oak sites, and also occurs in association with western ironweed in pastures and rangelands.

A dense stand of buckbrush near Oilton was treated May 1, 1960 with the butyl ester and butoxy ethanol ester of 2,4-D, the butoxy ethanol ester of dichlorprop, and the butyl ester of 2-chloro-4-fluro phenoxy acetic acid. Each herbicide was used at 1, 1.5, and 2 lb/A in diesel oil-in-water carrier at 40 gallons/A. The buckbrush was from 24 to 30 inches in height and had just attained full leaf.

Apparent kill of buckbrush with the herbicides was highest (80 percent from 2-chloro-4-fluro phenoxy acetic acid and least (31 percent) from dichlorprop. Apparent kill for the butyl and butoxy ethanol esters of 2,4-D at 2 lb/A was 60 and 67 percent, respectively. With most herbicides the kill was best with the 2 lb/A rates.

Chinaberry

Chinaberry appears to be very susceptable to cane stem treatments of 2,4-D and 2,4,5-T (Table 16). All treatments resulted in 100 percent defoliation the 1st year of treatment and 100 percent canopy reduction the year following treatment.

Dogwood

Roughleaf dogwood has been very resistant to the phenoxy herbicides. Pichloram was more effective than the phenoxy herbicides and picloram alone and in combination with 2,4,5-T gave fair control of dogwood (Table 20).

Elbowbush

Elbowbush occurs quite often in pastures in the southeastern corner of Oklahoma. This woody plant forms dense clump growth. It will form roots from various joints along the stem where they contact the soil. Thus, a single plant may develop into a many stemmed growth.

Some of the various treatments that have been tried are basal bark, foliage spray with the low volatile ester of 2,4,5-T, soil applications with fenuron 25 percent pellets, monuron 80 percent wettable powder, 2,3,6-TBA 25 percent granules, 2,3,6-TBA liquid at 4 lb/gallon, and a foliage spray of AMS. The basal bark and soil spray treatments were made July 11, 1957 with a compressed air hand sprayer. Only 70 percent canopy reduction was obtained with the 2,4,5-T (30 lb/100 gallon diesel) as basal bark treatment. Results with soil applied herbicides were variable with canopy reduction ranging from none to 90 percent. Foliage applied 2,4,5-T (L. V. ester) caused a canopy reduction of 60 percent.

Greenbrier

Greenbrier occurs naturally with blackjack and post oak and can become a problem when the oak brush is removed. It forms dense mats and can seriously reduce grass yields and limit movement of livestock. Phenoxy herbicide treatments were only fair for control and both foliage and basal stem sprays gave better control than did soil applications.

Hackberry

Blackberry is susceptible to stem treatments of 2,4,5-T and 2,4-D and canopy reduction was 90 percent or better after treatment (Table 16).

Mesquite

Mesquite occurs in 22 counties in Oklahoma, but is only a brush problem in the western and southwestern corner of the state. Fair to good defoliation of honey mesquite resulted from ½ lb/A of 2,4,5-T. The major problem has been the resprouting from the base of the plants. For example, canopy reduction from an aerial spraying was 80 percent but there were 4 times as many stems after treatment than before. Using combinations of 2,4,5-T with dicamba and picloram reduced the number of stems slightly. The best control was from mixtures containing picloram. A ¼ lb/A rate of picloram, however, was not enough in the mixture. Also, using a saturated wetting spray on trees gave better defoliation than applications at 10 gal/A.

Saltcedar

Saltcedar grows extensively along the flood plains of the rivers of western Oklahoma. Studies on the control of saltcedar were with 2,4,5-T as a basal bark treatment and with soil applications of fenuron, 2,3,6-TBA, and monuron. These herbicides were applied on duplicate plots 1 rod square having a dense stand of saltcedar from 5 to 7 feet in height. All treatments were made in March. The basal bark and soil treatments as liquid spray were applied with a compressed air hand sprayer. The pellets of fenuron and granules of 2,3,6-TBA were hand applied. Rates for each herbicide applied to the soil were 6, 8, 12, and 15 lb/A. Soil on the treated sites was a deep sandy loam flood plain along the Cimarron River near Perkins, Oklahoma.

Defoliation of salt cedar with fenuron pellets or with monuron at 6 lb/A of active herbicide applied on soil around each plant was about 80 percent. Control from herbicide placed on soil around each tree was usually better than from applying herbicide in bands every 5 to 10 feet apart. Monuron at 8 lb/A applied on the soil around each plant gave 100 percent defoliation while the fenuron pellets used the same way gave 85 percent defoliation. Soil applied urea herbicides gave considerably more control of salt cedar than basal bark treatments with 2,4,5-T or soil applied 2,3,6-TBA. Floods prevented evaluation of these treatments for apparent kill. A new infestation of the salt cedar generally occurred following flooding.

Field use of AMS at 0.75 lb/gallon applied as a wetting foliage spray gave 75 percent defoliation of saltcedar growing in irrigation ditches near Haskell, Oklahoma.

Sumac

Excellent defoliation (Tables 21 and 22) and control of sumac can be obtained with foliage sprays of 2,4-D, 2,4,5-T and silvex. Both amine and ester formulations were effective at 0.8 lb/A when applied in May, but reduced defoliation was noted with April applications.

Tree Huckleberry

Tree huckleberry occurs as an understory species in the eastern part of Oklahoma. Tree huckleberry was not controlled with 2,4,5-T alone, but fair to good control was obtained from mixtures of 2,4,5-T and picloram (Table 12).

Vegetation Release with Brush Control

Pine Release

Shortleaf pine is tolerant to the 2 lb/A rate of 2,4,5-T and good growth of pine usually occured after control of hardwoods (16). For example, the heaviest stand of pine seedlings occurred on plots where the hardwood trees were controlled with 2,4,5-T. September spraying caused more damage to pine and less hardwood control than did the May sprayings. Silvex at 2 lb/A caused more injury to pine than 2,4,5-T. A 1:1 mixture of 2,4-D and dichlorprop also caused considerable injury to pine.

Apparent injury to pine (brown coloration of foliage and twisting of pine needles in tip branches) with 2 lb/A of 2,4,5-T was only 0.5 percent. Adding NH_4SCN or Amitrol T (A mixture of amitrol and NH_4SCN) at 0.2 lb/A to the spray mix caused more pine injury (considerable twisting of treminal twigs and some browning of needles).

Grass Release

The amount of grass produced after herbicide control of brush was found to be variable, but in all cases more forage was produced on the treated areas (18). Grass yields from blackjack and post oak infested areas varied from around 100 lb/A up to 900 lb/A depending on moisture condition, amount of brush in area, management of grass and location in the state. The amount of grass release after spraying also depended on the amount of desirable grass in the treated area, amount of brush controlled, productivity of site and amount of effective moisture available for growth.

The highest yield of grass obtained two or three years after spraying for brush control was about 4,000 lb/A. This occurred in two areas in central Oklahoma and represents a four-fold increase in grass production over the untreated brush areas. In eastern Oklahoma a 10 fold increase in grass production was obtained in some of the sprayed plots (240 lbs in untreated area and 2350 lbs in sprayed area). The total grass production in southern and eastern Oklahoma after spraying was not as good as in central Oklahoma. This is partially attributed to the greater number of desirable grass plants in the central Oklahoma brush area. For example, desirable grass yields from the brush areas in central Oklahoma were 800 to 1,100 lb/A while desirable grass yields from most brush areas in eastern and southern Oklahoma were less than 200 lb/A.

Literature Cited

1. Bennett, H. H. 1939. Soil Conservation 993 pp. McGraw-Hill Book Co., Inc. New York and London.
2. Buehring, Normie. 1969. Responses of eastern redcedar (*Juniperus virginiana* L.) to various control procedures. M.S. Thesis. Oklahoma State University.
3. Buehring, Normie, P. W. Santelmann, and H. M. Elwell. 1971. Responses of eastern redcedar to control procedures. Jour. of Range Mgt. 24:378-382.
4. Cox, M. B. and H. M. Elwell. 1944. Brush removal for pasture improvement. Agri. Eng. 25:253-261.

5. ______________. 1947. Brush and tree removing machinery. Okla. Agri. Expt. Sta. Bul. 310.
6. Dalrymple, R. L. 1969. Cedar control in southern Okla. So. Weed Conf. 22:272-273.
7. Daniel, H. A., H. M. Elwell, and M. B. Cox. 1947. Conservation and land use investigations. Okla. Agri. Expt. Sta. Bul. 309, 32 pp.
8. Dwyer, D. D. and P. W. Santelmann. 1964. A comparison of post oak-blackjack oak communities on two major soil types in north central Oklahoma. Okla. State Univ. Expt. Sta. Bul. B 626.
9. Eaton, B. J. 1968. M.S. Thesis. Factors influencing the effectiveness of commercial aerial applications of 2,4,5-Trichlorophenoxyacetic acid for control of blackjack and post oak. Oklahoma State University.
10. Eaton, B. J., H. M. Elwell, and P. W. Santelmann. 1970. Factors influencing commercial aerial applications of 2,4,5-T. Weed Science 18:37-41.
11. Elwell, H. M., 1950. From brush to grass farming. The Jour. of Agri. Progress. Norwich, England 4:174-171 and 181.
12. ______________. 1953. New herbicide control oak brush and results in increased native grass production. Weeds 2:302-303.
13. ______________. 1960. Land improvement through brush control. Soil Conservation.
14. ______________. 1963. Injector and basal bark methods for brush control. Agri. Chem. 32.
15. ______________. 1964. Oak brush control improves grazing land. Agro. Jour. 55:411-415.
16. ______________. 1967. Herbicides for release of shortleaf pine and native grasses. Weeds 15:104-107.
17. Elwell, H. M. 1968. Winged elm control with picloram and 2,4,5-T with and without additives. Weeds 16:131-133.
18. ______________. 1968. Phenoxy herbicides control blackjack and post oak - release native grasses. Down to Earth 24:3-5.
19. ______________. and M. B. Cox. 1950. New methods of brush control for more grass. Jour. Range Mgt. 3:46-51.
20. ______________. H. A. Daniel, and T. A. Fenlon. 1941. The effect of burning pastures and woodland vegetation. Okla. Expt. Sta. Bul. 247.
21. ______________. W. C. Elder, D. L. Klingman, and R. Larson. 1954. Aerial applications on oak in Okla. Proc. North Centr. Weed Conf. 11:91.
22. ______________. W. E. McMurphy, and P. W. Santelmann. 1970. Burning and 2,4,5-T on post and blackjack oak rangelands in

Okla. Oklahoma State Univ. Agri. Expt. Sta. and USDA Bul. B 675.

23. Failes, K. E. 1969. M. S. Thesis. The evaluation of various herbicides and wilt fungus *(Cephalosporium diospyri, Crandall)* for control of persimmon *(Diospyrous virginiana,* L.). Oklahoma State University.

24. Kirby, B. W. 1965. M. S. Thesis. Responses of winged elm *(Ulmus alata* Michx.) to various methods and times of herbicide treatment. Oklahoma State University.

25. Kirby, B. W., P. Stryker, and P. Santelmann. 1967. Ground treatments for control of winged elm on rangeland. Jour. Range Mgt. 20:158-160.

26. Phillips, G. R., F. J. Gibbs, and W. R. Mattoon. 1959. Forest trees of Oklahoma. Edition 9, Forestry Division, State Board of Agric., Oklahoma.

27. Porterfield, Jay G. and L. O. Roth. 1957. Some machines and methods for removal and control of brush. Okla. State Univ. Agri. Exp. Sta. Bul. B 496.

28. Stryker, P. G. 1966. M. S. Thesis. The evaluation of various herbicides for the control of winged elm *(Ulmus alata,* Michx.) Okla- State University.

Appendix Table I. Acreage of woody (brush) plants with low forestry value in Oklahoma.

Woody (bush) Plants[1]	Approximate million of acres	Location in Oklahoma
Post Oak-Blackjack Oak	4.5	A 28 county belt (central cross timbers) across the east central area of the state from northeast to southwest. Trace acreage also in Haskel, LeFlore, Sequoyah, Cherokee, Adair, Delaware, Craig, Washington and Choctaw counties. Some areas in western Kingfisher, Dewey, Major, Blaine, Caddo, and Comanche counties.
Scrub oak and winged elm association	1.5	Some acreages in LeFlore, Haskell, Pittsburg, Coal, Choctaw, Bryan, Marshall, Love, Carter, Johnson, Pontotoc, and Hughes counties.
Shinnery Oak	0.8	Most acreages in southern Woodward and Roger Mills with some acreages in Beckham and Harmon counties.
Sand sage and Skunkbush	0.8	Along river flood plains and deep sandy soil areas of western Oklahoma.
Mesquite	0.6	Acreages in Greer County with trace acres in Harmon, Jackson, Kiowa, Tillman, Comanche, Cotton, Jefferson, Coal, and Kingfisher counties.
Persimmon, Sassafras, Sumac, and Wild Blackberry	1.5	Extensive acreage in Ottawa, Craig, Nowata, Washington, Rogers, Mayes and Wagoner counties. Some persimmon in the eastern half of the state. Trace stands in some of the western counties.
Buckbrush, Crabapple, Willow Hawthorn and Miscellaneous species.	0.6	Hawthorn mainly in Muskogee County but spreading throughout eastern Oklahoma. Other species in trace acreages of the state.
Eastern Redcedar	0.8	Trace acreages in Oklahoma with infestation increasing. Small trees as understory in many of the oak areas.
Saltcedar	0.1	Mostly acreages along river flood plains in western Oklahoma.
Total	11.2	

[1]Oklahoma also has 3 million acres of shortleaf pine-oak, and 2.8 million acres of oak-hickory-pine valuable for timber production in the eastern and southern one-third of the state.

Appendix Table II. Common name or designation and chemical name of herbicides.

Common Name or Designation	
amitrole	3-amino-s-triazole
AMS	ammonium sulfamate
bromacil	5-bromo-3-sec-butyl-6-methyluracil
cacodylic acid	hydroxydimethylarsine oxide
dicamba	3, 6-dichloro-o-anisic acid
dichlorprop	2-(2,4-dichlorophenoxy) propionic acid
fenac	(2,3,6-trichlorophenyl) acetic acid
fenuron	1,1-dimethyl-3-phenylurea
MAA	methanearsonic acid
monuron	3-(p-chlorophenyl)-1,1-dimethylurea
MSMA	monosodium methanearsonate
paraquat	1,1′-dimethyl-4,4′-bipyridinium ion
picloram	4-amino-3,5,6-trichloropicolinic acid
prometone	2,4-bis (isopropylamino)-6-methoxy-s-triazine
silvex	2-(2,4,5-trichlorophenoxy) propionic acid
TCA	trichloroacetic acid
2,3,6-TBA	2,3,6-trichlorobenzoic acid
2,4-D	(2,4-dichlorophenoxy) acetic acid
2,4,5-T	(2,4,5-trichlorophenoxy) acetic acid

Appendix Table III. Summary response of the various woody plants to herbicides.

Species[1]	Herbicides as foliage sprays (FS)—lb/A for control or R for resistant.—means no data.						Herbicide effective on spp. as Basal Bark (BB), Stump (St), (Injected (Ij), Soil (S).				Remarks
	2,4,5-T	2,4-D	2,4-D + dichlorprop	Silvex	Picloram	Dicamba	2,4,5-T	2,4-D	Picloram	Dicamba	
Ash (Fraxinus spp.)	R	R	R	R	R	R	R	R	R	R	A mixture of 2,4,5-T plus picloram (2+1 lb/A) is partially effective as a FS.
Blackberry (Wild) (Rubus spp.)	1	R	R	R	–	R	BB	R	–	–	Retreatment necessary the 2nd or 3rd year. The 2,4,5-T ester in diesel oil as basal bark (cane stem treatments is effective.
Buckbrush (Symphoricarpos orbiculatus)	2	1	2	R	R	–	–	–	–	–	Must use the ester formulations and spray within a two week period after leaves are fully expanded. This usually is early May.
Chinaberry (Melia azedarach)	–	–	–	–	–	–	BB	BB	–	–	None
Crabapple, Prairie (Pyrus ioensis)	R	R	R	R	R	R	Ij	Ij	S	R	Resistant to all herbicides in FS. Responds to 2,4,5-T and 2,4-D in injector treatment and responds to picloram as a soil treatment.
Dogwood (Cornus drummondi)	R	R	R	R	–	–	–	–	–	–	Resistant to phenoxys alone in FS. Fair control with 2,4,5-T and picloram 2:1 lb/A in FS. May need retreatment 2nd or 3rd year.
Elm American (Ulmus americana)	R	R	R	R	3	R	Ij	Ij	Ij	Ij	Resistant to phenoxys alone in FS. Some control with 2,4,5-T or silvex + picloram (2:1 lb/A in FS). Responds to all herbicides in Ij treatments.
Elm Winged (Ulmus alata)	R	R	R	R	3	R	BB& Ij	BB& Ij	Ij& S	Ij	Resistant to phenoxys alone in FS. Ester of 2,4,5-T + NH_4SCN (2 + 0.55 lb/A) gives fair control, and 2,4,5-T + picloram (2 + 1 lb/A) good control. Responds to all herbicides Ij and picloram and dicamba as soil treatments.
Elbowbush (Forestiera pubescens)	R	R	R	R	–	–	R	R	–	–	Resistant to phenoxys in all treatments. Controlled with Ammonium sulfamate (50 lb/A) as drench spray.
Greenbrier (Smilax spp.)	R	R	R	R	–	–	R	R	–	–	Resistant to all herbicides as FS, BB, and soil treatments.

Appendix Table III. Summary response of the various woody plants to herbicides (continued).

Species	Herbicides as foliage sprays (FS)—lb/A for control or R for resistant.—means no data.						Herbicide effective on spp. as Basal Bark (BB), Stump (St), (Injected (Ij), Soil (S).				Remarks
	2,4,5-T	2,4-D	2,4-D + dichlorprop	Silvex	Picloram	Dicamba	2,4,5-T	2,4-D	Picloram	Dicamba	
Hackberry (Celtis spp.)	2	2	3	2	1	—	BB& Ij	BB& Ij	Soil	—	Easily killed with all herbicides in FS, BB, St, Ij and soil treatments.
Hawthorn (Crataegus spp.)	R	R	R	R	R	R	Ij	Ij	S	—	Resistant to all herbicides in FS. Responds to 2,4,5-T in diesel oil and picloram pellets as soil treatment.
Hickory (Carya spp.)	2	R	3	R	R	R	BB,St &Ij	BB,St &Ij	—	—	The effect from 2,4,5-T in FS quite variable. Controlled with 2,4,5-T ester in diesel oil as Ij treatments.
Honeylocust (Gleditsia triacanthos)	2	2	2	2	—	—	BB, St& Ij	BB, St& Ij	—	—	Easily defoliated with phenoxys in FS. Retreatments 2nd or 3rd year needed to control sprouts. Responds to 2,4,5-T in diesel oil as BB or Ij treatment.
Juniper, Ashe (Juniperus ashei)	R	R	R	R	R	R	R	R	R	R	Foliage spray of Picloram plus paraquat is effective.
Locust, black (Robinia pseudo acacia)	2	2	3	2	—	—	BB, St&	BB, St&	—	—	Same phenoxy response as for honeylocust.
Maple (Acer spp) Red (Arubrum)	R	R	R	R	R	R	R	R	—	—	Resistant to phenoxys in FS and BB, St, and Ij treatments. Fair control with 2,4,5-T + picloram (2 + 1 lb/A) in FS.
Mesquite (honey) (Prosopis juliflora var. glandulosa)	½ to 1	R	R	—	¼ to ½	¼ to ½	—	—	S	S	Easily defoliated with 2,4,5-T in FS but resprouts are better controlled with 2,4,5-T + picloram or dicamba (¼ + ¼ lb/A in FS). Need some retreatments 3rd or 5th year. Kerosene poured around base of the tree will kill entire plant.
Mulberry (Morus spp)	R	R	R	R	—	—	R	R	—	—	Resistant to phenoxys in FS, BB, St, and Ij.
Oak, black (Quercus nigra)	2	3	3	3	1	2	BB, St& Ij	BB, St& Ij	—	—	Need retreatments 2nd or 3rd year. Controlled with 2,4,5-T in diesel oil in BB, St, and Ij treatments.
Oak, blackjack (Q. marilandica)	2	3	3	2	1	2	BB, St& Ij	BB, St& Ij	R	R	Repeated treatments 2nd or 3rd year increases control. The 2,4,5-T in diesel oil is effective BB, St, and Ij treatments.

Appendix Table III. Summary response of the various woody plants to herbicides (continued).

Species[1]	Herbicides as foliage sprays (FS)—lb/A for control or R for resistant.—means no data.						Herbicide effective on spp. as Basal Bark (BB), Stump (St), (Injected (Ij), Soil (S).				Remarks
	2,4,5-T	2,4-D	2,4-D + dichlorprop	Silvex	Picloram	Dicamba	2,4,5-T	2,4-D	Picloram	Dicamba	
Oak, Dwarf chinquapin (Q. prinoides)	2	3	3	2	R	R	BB	BB	R	R	Control fair to good with phenoxys in FS. Controlled with 2,4,5-T in diesel oil in BB treatments.
Oak, Pin (Q. palustris)	2	3	3	2	R	R	BB, St& Ij	BB, St& Ij	R	R	Is somewhat resistant to phenoxys in FS. Retreatments 2nd or 3rd year increases control. Responds to 2,4,5-T in diesel oil as BB, St, and Ij treatments.
Oak, post (Q. stellata)	2	3	3	2	R	R	BB, St& Ij	BB, St& Ij	R	R	Generally easy to control with Phenoxys in FS. Good control with 2,4,5-T in diesel oil as BB, St, and Ij treatments.
Oak, White (Q, alba)	2	3	3	2	R	R	BB, St& Ij	BB, St& Ij	R	R	
Osageorange (Maxlura pomifera)	2	–	–	–	–	–	–	–	–	–	Easily controlled with 2,4,5-T in FS.
Pecan (native stands) (Carya illinoensis)	2	2	2	R	–	–	BB, St. Ij	–	–	–	Sometimes quite resistant to phenoxys in FS. Controlled with 2,4,5-T in diesel oil Ij treated.
Persimmon (Diospyros virginiana)	1	1	2	1	½	2	R	R	Ij & S	Ij & S	Easily defoliated with 2,4,5-T in FS, but resprouts are somewhat resistant to 2,4-D and silvex. Killed with 2,4,5-T + picloram or dicamba (0.75 + 0.25) or (0.75 + 0.50 lb/A) respectively. Resistant to herbicide treatments as BB and St. Killed by herbicide in Ij treatments.
Pine, short-leaf (Pinus echinata)	R	R	R	R	1 to 3	–	R	R	S & Ij	–	Resistant to 2,4,5-T in FS. Good for hardwood control to release pine. May be killed with picloram in FS or soil treatments.
Plum, wild (Prunus spp)	2	2	3	R	–	–	BB	BB	–	–	Controlled with 2,4,5-T and 2,4-D in FS. Need retreatments 3rd or 5th year. Killed with 2,4,5-T or 2,4-D in diesel oil in BB treatments.
Redbud, eastern (Cercis canadensis)	R	R	R	R	–	–	R	R	–	–	Resistant to phenoxys in FS.

Appendix Table III. Summary response of the various woody plants to herbicides (continued).

Species[1]	Herbicides as foliage sprays (FS)—lb/A for control or R for resistant.—means no data.						Herbicide effective on spp. as Basal Bark (BB), Stump (St), (injected (Ij), Soil (S).				Remarks
	2,4,5-T	2,4-D	2,4-D + dichlorprop	Silvex	Picloram	Dicamba	2,4,5-T	2,4-D	Picloram	Dicamba	
Redcedar, eastern (Juniperus virginiana)	R	R	R	R	3	R	R	R	Ij	Ij	Resistant to all phenoxys alone in FS. Fair control with 2,4,5-T + picloram (1.5 + 1.5 lb/A) in FS. Good control with picloram and dicamba Ij treatments or with picloram pellets soil applied.
Rose, wild varieties (Rosa spp.)	1	R	R	R	–	–	BB	BB	S	–	Controlled with 2,4,5-T in FS. Need retreatment 3rd or 5th year.
Sassafras (Sassafras albidum)	2	R	3	2	1	–	BB	BB	–	–	Controlled with phenoxys in FS. Needs retreatment 2nd or 3rd year. Controlled with 2,4,5-T in diesel oil as BB or Ij treatments.
Saltcedar (Tamarix gallica)	R	R	R	2	–	–	–	–	–	–	Controlled with silvex but is resistant to other phenoxys in FS.
Sweetgum (Liquidambar styraciflua)	2	R	3	2	–	–	–	–	–	–	Easily controlled with phenoxys in FS.
Sumac (Rhus spp)	1	1	1	1	R	–	BB	BB	R	–	Easily controlled with 2,4-D or 2,4,5-T in FS. Needs retreatment every 3rd or 5th year. Controlled with 2,4-D or 2,4,5-T in diesel oil as BB treatments.
Tree huckleberry (Vaccinium arbereum	R	R	R	R	–	–	–	–	–	–	Repeated treatments with 2,4,5-T at 2 lb/A will control some of the plants.
Walnut (Juglans spp)	2	R	R	R	–	–	Ij &BB	R	–	–	Similar to hickory as to control with the phenoxys.
Willow (Salix spp)	R	2	R	R	–	–	BB &Ij	BB &Ij	–	–	Controlled with 2,4-D in FS. Needs retreatment 2nd or 3rd year.