RESPONSES OF WINGED ELM (*ULMUS ALATA* MICHX.) TO VARIOUS METHODS AND TIMES OF HERBICIDE TREATMENT

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INTRODUCTION

Southeastern Oklahoma has the possibility of becoming one of the leading areas in beef production in the state. The path toward this goal has several problems that need solving. Probably the most severe of these problems is brush control. At the initiation of a brush control program scrub oak (*Quercus* spp.) are invariably the species considered. Treatments are focused on the oaks because of their dominance in the overstory. Proper site selection, good management and the use of selective herbicides is the most effective way of changing worthless brush land into valuable grassland (13). Brush sprayed in connection with the Agriculture Cost Sharing program should be very closely supervised and areas where winged elm (*Ulmus alata* Michx.) is a problem should not be approved for payment under this program (5). The presently recommended aerial application of 2,4,5, trichlorophenoxyacetic acid (2,4,5-T) for the treatment of brush is usually effective in the control of the oaks. After the oaks are controlled, grass production is drastically increased and winged elm, if present, often increases in stature and abundance. Until the oak is controlled winged elm is usually only part of the understory. Due to prolific seed production, a rapid growth habit, and resistance to presently recommended aerial treatments for brush control, winged elm very quickly becomes a serious problem (17, 27, 47, 48). Many ranchers in Southeastern Oklahoma have reported winged elm to show a rapid recovery after aerial treatments for brush control (35).

The purpose of this study was to find chemical methods of control for winged elm. Different chemical methods of application, and the susceptibility of various sizes of trees were studied.

LITERATURE REVIEW

Growth Habits. The winged elm belongs to the family Ulmaceae and is a native, perennial, cool season plant. The species completes its growth and flowering by July, according to Gould (15). It is medium in size, has a maximum spread of 50 to 60 feet, and may reach 80 to 100 feet high (18, 26, 34). It has a lacy, or somewhat drooping habit. A special characteristic is the corky, persistent wings, or projections, often found on the branchlets (18).

Winged elm generally occurs only as scattered trees in mixture with other hardwoods. It is not a major component of any forest cover type in eastern United States. In the Central States it occurs as a minor species in the white oak, black oak type.

The perfect flowers are vernal and appear before the leaf buds unfold. They are born on drooping pedicels in short, few-flowered forcicles. The fruit is a samara, ripening before or with the unfolding of the leaves (38).

Ecological Factors. The soil requirements of winged elm are much the same as for American elm as is evidenced by its range. The species can be found on a great variety of soils occuring in the Southeast United States. Winged elm grows fairly well on dry as well as on rich moist soils, according to the United States Department of Agriculture (46). Usually winged elm is found on dry gravelly uplands, less commonly in alluvial soil on the borders of swamps and the banks of streams, and occasionally in swamps. The area of winged elm inhabitance is Southeast Virginia, Southwestern Indiana, Southern Illinois, and Southern Missouri and southward to Central Florida and the valley of the Guadalupe River, Texas; ranging westward in Oklahoma to Garfield County, as stated by Sargetn (38).

Annual precipitation within its growing area averages 45 to 60 inches. One-half or more of this precipitation falls within the warm months -- April to September. The growing season averages from 180 to 300 days, and average annual temperature from 55° to 70° (45).

Under favorable climatic conditions winged elm is a prolific seed producer and seeds are viable soon after maturity. Seeds will germinate as high as 96 percent soon after harvest. If the seeds are covered with more than one-fourth inch of loamy soil, they would not emerge. After germination the most growth of the seedling is above the soil line, but after a few days development below the soil line increases as the above soil portion of the plant slows down (24).

Competitiveness. Putnam (35) states that winged elm in open conditions grows rapidly, but many of its hardwood associates will exceed the diameter growth of the species in the open. Under forest conditions its growth rate is usually considered poor in relation to its associates.

Elwell (12) found that in a transplanted nursery winged elm grows rapidly. The elm plantings were approximately three years old and were cut back to 24 inches above the soil. At the end of two growing seasons, stem diameter had increased an inch. Height had increased 37 inches and limb length had increased 35 inches. This followed very closely the findings of Dalrymple (6) in a winged elm release study. Winged elm diameter, height, and leader growth was greater in the overstory control treatment than in the untreated check plots.

Chemical Control. Many chemicals have been tried for the control of winged elm. Some of the new ones, like the older ones, have not been satisfactory as far as the control of winged elm is concerned. The control of woody species by an aerial application is most effective in May, June and early July (41).

A limited amount of research has been done on the chemical control of winged elm itself. Elwell (11,12) and Dalrymple (6) have been active in research on the winged elm problem in Southeastern Oklahoma. Darrow (7) has reported that general recommendations can not be made for the control by aerial spray application on bottom-land hardwood mixtures containing elm. It has been stated that winged elm is resistant to aerial application (12). In other areas it has been reported that it has been controlled to some degree by recommended aerial practices (2). The available soil moisture greatly influences the effectiveness of any chemical treatment (1, 9, 14, 30, 36).

Foliar. The presently recommended aerial treatments for blackjack and post oak control is two pounds acid equivalent of 2,4,5-T plus one-half to one gallon diesel oil in three and one-half to four gallons water per acre (10, 20, 29, 37,44).

It has been reported that transplanted winged elm five feet tall have apparently been killed with 2,4,5-T applied as a simulated aerial treatment. This was on a limited basis of three bushes transplanted out of their natural environment. The bushes were treated April 30, 1963, and rated for defoliation November 11, 1963. The elm were sprayed at the rate of two pounds 2,4,5-T, low volatile ester plus one-half gallon diesel oil in four gallons of water per acre (12).

In some areas of the United States winged elm has been reported intermediate in susceptibility to foliar treatments of 2,4,5-T (2, 25). In other research (3) winged elm was reported to respond rather immediately to a foliage treatment of 2,4,5-T. It was reported that one week after treatment winged elm was one of the first species to show effect after spraying. Two weeks after treatment, winged elm was reported to have turned brown. Defoliated was the descriptive term three weeks following treatment. The fourth week it appeared dead and eighteen weeks later it was in full leaf again.

Injection. Several non-foliar methods are used to control brush species resistant to foliar treatments. Non-foliar methods usually give a higher percent kill as well as a greater assurance of kill.

One of these is injection, a slow and laborous method of treatment for the control of brush. Injection is done with the aid of an injector, which is a two-inch cylinder about four feet long with a slightly convex bit on one end and a valve. The tool is filled with herbicide and carrier. After a tree has been selected, the bit is thrust into the trunk and enough solution is released to fill the incision. One incision is made per inch diameter at breast height (DBH) and the incisions are made as near soil surface as possible (32). Trees injected in the dormant season often will leaf out in the spring but will die if injected properly (4). The method is very effective on almost all species if the herbicide and carrier are selected wisely, and the administration of the treatment is applied with care.

The most common injection treatment is to apply 2,4,5-T ester, four pounds active, diluted to 1:9 with diesel oil (9, 27, 30, 43, 46). This combination has been reported as an effective year round treatment on most hardwood species. Carriers suggested here have been diesel oil and water. During the growing season there was no difference reported between 1:9 and 1:18 ratios of 2,4,5-T and diesel oil or water (22). Bullock (4) reported injections with 1:9 and 1:19 ratios of 2,4,5-T and diesel oil to be very effective, on all species, including elm.

Injections two inches from the soil line are more effective than injections placed 12 inches high (33). Good control has resulted from the injection of low volatile ester of 2,4,5-T in carrier at the ratio of 1:9 with 8 ml. of solution per injection (34). Others have reported the application of 5 ml. of solution per injection (32). The triethylamine salt formulation of 2,4,5-T is as effective, as the butoxyethanol ester formulation when applied as a frill treatment with the exception of very latter part of the growing season, as reported by Keating (23).

The success of the injection program is almost entirely dependent upon the efficiency of the crew. If the following six steps are carried out the effectiveness of the treatment is increased (19).

(1) Incisions must extend completely around the tree.

(2) The incisions are placed as low as possible on the stem.

(3) Incisions extend into the wood or xylem as deeply as possible.

(4) Injection cups filled with chemical.

(5) Incisions spaced two inches apart.

(6) Injection cups horizontal to the ground.

There are many advantages to the dormant application of chemicals for brush control.

Basal Bark. One part 2,4,5-T, four pounds acid equivalent per gallon in 24 parts diesel oil is the most commonly applied mixture for basal bark treatments. Low volatile ester of 2,4,5-T mixed with diesel oil are most effective. In some cases a mix of one part 2,4,5-T and 50 parts diesel oil have been used (34). May is the most effective date for treatment (16).

The basal bark treatment with 2,4,5-T was reported as intermediate on winged elm since resprouting occurred after treatment (2). Basal bark treatments at the rate of 16 pounds of 2,4,5-T in 100 gallons of oil will control woody plants up to 5 inches DBH and also several species that are tolerant to foliage sprays. The treatment should circle the trunk, and the spray should be continued until soil immediately at the base of the tree is wet from the run-off. The spray can be applied at any time of the year.

Treated Stump. When woody plants are removed by cutting, 2,4-D or 2,4,5-T applied to the freshly cut stump will keep most species from sprouting. The mixture should be mixed with one part herbicide in 24 parts diesel oil. The stump should be circled with spray until there is run-off. Complete coverage of the freshly cut surface is essential, especially where the wood and bark joins. Treatments can be made any time of the year. Some shrubs and trees that tolerate foliage sprays can be killed by this method (20, 28, 39, 42).

One of the most promising new herbicides is picloram (4-amino-3,5, 6-trichlorophicolinic acid). Nation and Lichy (31) have reported that in the eastern United States that after two years winged elm has been controlled 99 percent with four-tenth and seven-tenth pound of acid equivalent picloram per 100 gallons of water. One hundred percent control was obtained with 1.4 pounds picloram per one hundred gallons of water. Also, 100 percent control was obtained with 4 pounds of the ester of 2,4,5-T. Since the sprays were applied as leaf-stem sprays with total coverage being desired, the gallonage rates varied according to the density of the brush but in general ranged from 200 to 500 gallons per acre.

Observations made two months after application indicated a slower "brownout" rate on the brush treated with piclorum as compared to the brush treated with the ester 2,4,5-T (33). It was also reported that winged elm was more resistant to a leaf spray than to a leaf-stem spray of seven-tenths pound of actual piclorum per 100 gallons of water.

Piclorum has also been tested in the form of pellets. Wiltse (49) has reported control of winged elm with 60 pounds of tordon per acre. Piclorum as a soil treatment gave good defoliation the same growing season it was applied. The piclorum was reported to have given faster reaction than did fenuron (3-phenyl-1, 1-dimethyl urea). Fenuron was also reported to be slow acting by Peevy (33).

Tests show the application of fenuron at rates of one and two tablespoons of pellets (4 to 8 grams of active fenuron) per stem to be an effective control (8,34,40). This single tree treatment was more effective than broadcast applications at rates up to six pounds per acre on the control of post oak and blackjack oat in Texas (8). Peevy (34) reports that fenuron is more effective for controlling upland hardwoods than other herbicides applied in the same manner.

Winged elm grown on upland sandy or sandy loam soils is included in range brush control in some locations. Five or six pounds actual fenuron are recommended (21). The application of fenuron by airplane was advised.

Fenuron has been tested for the control of upland hardwoods applied at the rate of one gram per inch of DBH. Strip application of fenuron shows promise for control of winged elm in some areas (22). Application of the treatment is recommended in the spring from bud growth to full leaf development (21, 34).

MATERIALS AND METHODS

Experiment I - The effect of different treatments on the control of winged elm.

A rocky upland site in Haskell County in eastern Oklahoma was selected for this study. Throughout this experiment "small" refers to trees 2 to 3 inches DBH and "large" to trees 3 to 5 inches DBH. The treatments were applied to the two sizes of winged elm in a randomized complete-block design replicated eight times. Dates of applications were between June 13 and 15, 1962.

The following treatments were applied:

(1) Girdle Burn - The tree trunks were burned six inches high from the soil line with a compressed kerosene burner. The burner contained kerosene under pressure and burned through a coil. The fire was held on the small trees for 30 seconds and large trees for 45 seconds. This treatment was an attempt to simulate the effect of a range fire on the trees.

(2) Injection - One part of a four pound per gallon 2,4,5-T butoxyethanol ester in nine parts diesel oil was injected, approximately one inch above the soil line. The incisions were cut at a 45° angle. Solution was allowed to flow into the incision until the incision was barely overflowing. One injection was made per inch of DBH. An average of 5 ml. was applied in each incision.

(3) Basal Spray - Eight to 10 inches of the lower trunk were sprayed until there was adequate run-off to slightly moisten the soil around the root collar. A solution of one part 2,4,5-T ester and 24 parts diesel oil was used. A hand sprayer with

a pressure of 20 psi, 80015 fan type nozzle was used to spray each trunk for 12 seconds on the small trees and 17 seconds on the large trees. An average of 150 ml. was applied to each tree trunk.

(4) Treated stump - Elm trees were cut off three inches above the soil line with a chain saw. Each stump was sprayed with the same mixture and sprayer as used in treatment three. The stump was sprayed until there was run-off and the soil was slightly moistened around the stump. An average of 45 ml. was sprayed on each stump.

(5) Untreated stump - This treatment was similar to four except no chemical was applied to the stump.

(6) Foliage-stem spray - Trees were sprayed with a mixture containing three pounds active 2,4,5-T ester in 100 gallons water. A hand sprayer with extensions on it plus an adjustable nozzle were used to spray the foliage and stems. The foliage was sprayed until it dripped with spray. One and one-fourth pint was the average applied per tree. The wind was very calm.

(7) Dessicate Foliage - The spray mix for this treatment was six parts DNBP (dinitro-o-sec-butylphenol as Dow General) and 40 parts diesel oil. An average of one and one-eighth pint of spray was applied to each tree. The rest of the treatment was exactly like treatment six.

(8) Check - Nothing was done to the trees what were designated as checks.

The trees and stumps that survived the first treatments were retreated June 7, 1963. Three trees survived the basal bark treatment, one small and one large. They each received a basal bark retreatment of 2,4,5-T ester, 16 pound active ingredient per 100 gallon (AIHG) diesel oil. The mix was applied the same way as the first basal spray treatments. Trees that survived the earlier treatments were girdle burn, spray foliage, dessicate foliage, and untreated stump. These four treatments received a foliage-stem application of three pounds 2,4,5-T ester AIHG water. Treatments were administered exactly as the two previous foliage treatments.

<u>Experiment 2</u> - Basal and foliar treatments of 2,4,5-T as they are affected by tree size.

A rocky, lowland site in Pittsburg County in eastern Oklahoma was selected for this study. The treatments were applied in a randomized complete-block design replicated 10 times, each replication consisting of one tree. Winged elm about 2, 4, 6, 8, 10 and 12 feet tall were selected for this study. Four treatments were applied to each size:

(1) Stem-foliage spray - The spray was applied to each tree until the foliage and stems were dripping with spray. This was done by directing the spray on all sides and from different angles of the crown. The spray contained four pounds of active 2,4,5-T ester in 99 gallons of carrier. The carrier was comprised of one part diesel oil and four parts of water.

(2) Basal Bark - The 2,4,5-T ester of 16 pounds AIHG diesel oil was sprayed on the lower eight inches of the trunks of 10 trees of each size. The trunks were sprayed until there was enough run-off to wet the ground around the root collar.

(3) Stem-Foliage Spray check - Check received no treatment.

(4) Basal bark checks - These trees received a basal bark treatment as in treatment two but only diesel oil was applied.

Treatments were applied the morning of June 6, 1963, with an adjustable nozzle on a hand sprayer. At 8:30 a.m. that day air temperature was 86° F and soil temperature was 78° F. Wind was 5 m.p.h. from southeast to northwest. Weather was clear.

Experiment 3 - The effect of five herbicides compared on winged elm.

A shallow and sloping soil in Pittsburg County in eastern Oklahoma was selected for this study. Winged elm trees for this study were from one to one and three-fourths inch DBH. Most trees were approximately 10 feet tall and were part of the understory of larger American elm and oak.

The following 13 treatments were applied in a randomized complete-block design replicated 10 times.

(1) Granular dicamba 10 percent (2 methoxy 3, 6 dichlorobenzoic acid or Banvel-D) was applied at the recommended rate which was two tablespoons per inch DBH. The chemical was placed within six inches of the trunk on all sides by hand.

(2) Dimethylamine salt of liquid dicamba was sprayed on the soil in a ring six inches around the base of the tree. The spray was mixed at the rate of four pounds of a.i. per 100 gallons of solution, using water as a carrier. One-fourth pint of solution was sprayed on the soil per inch DBH.

(3) Dicamba was applied at twice the rate as treatment two.

(4) One-half pound of liquid picloram (potassium salt) AIHG of water was applied as a foliage-stem spray until the leaves dripped with spray. This was accomplished by directing the spray on the foliage from all sides at different angles.

(5) Picloram was applied as in treatment four except one pound of picloram AIHG of water was used.

(6) Granular picloram, 10 percent, was evenly applied to 25 square feet around the base of the trees at a rate of five pounds a.i. per acre.

(7) Granular picloram was applied as in treatment six except that the rate of tordon was 10 lbs. a.i. per acre.

(8) Granular fenuron was applied at the recommended rate. The rate was one tablespoon of fenuron, 25 percent, applied to one-half to one square foot of the soil around the base of the tree. This was equal to 1279 lbs. fenuron per acre on a broadcast basis.

(9) Prometone (2, methoxy bis /isopropylamine/-s-Triazine) was applied at the rate of 10 pounds AIHG spray mix. The remainder of the mix, 97½ gallons, was composed of four parts water and one part diesel oil. It was applied as a basal bark treatment and was applied in excess of normal basal bark treatments. The trunk was sprayed until there was enough run-off to completely wet the soil around the root collar. Approximately 120 ml. was applied per trunk.

(10) Prometone was applied as in treatment 9 at the rate of 20 pounds AIHG.

(11) This treatment was applied at the rate of 20 pounds AIHG, prometone and two pounds of 2,4,5-T ester was added to the spray mix.

(12) The 2,3,6-TBA (Trysben 200) was applied at four pounds active per 98 gallons water. Treatment was applied as a foliage spray as were previous foliage spray treatments.

(13) Check plots had no chemical treatment of any kind applied.

Treatments were applied June 5 and 6, 1963. June 5, the wind was five m.p.h. from southeast to northwest. Air temperature was 89°F and soil temperature was 85°F. June 6, the air temperature was 86°F and soil temperature was 78°F. Wind was 5 m.p.h. from southeast to northwest.

Experiment 4 - The injection of 2,4,5-T in winged elm.

A shallow and rocky soil in Pittsburg County in eastern Oklahoma was selected for this study. In this experiment, trees were injected with three rates of 2,4,5-T ester in three different carriers. The objective of this study was to measure the effectiveness of different diluents and dilutions of 2,4,5-T (butoxy ethanol ester) when applied by the injector method.

The following treatments were applied to a randomized complete-block design replicated 10 times.

(1) The 2,4,5-T ester in water at the ratio of 1:9, 1:18, and 1:27.

(2) The 2,4,5-T ester in diesel oil at the ratio of 1:9, 1:18, and 1:27.

(3) The 2,4,5-T ester in base oil at the ratio of 1:9, 1:18,and 1:27.

Each winged elm tree was considered a plot. The incisions were made and the chemicals applied in two independent operations. An injector was filled to two-thirds capacity with water to add weight to the injector and to insure a deeper incision. The immediate vicinity of the tree stem was cleared out to provide uniform working conditions. Four incisions were made per tree as close to the soil line as possible, horizontal to the soil surface. With the aid of an automatic syringe 4 ml. of injection mix was inserted into each incision. The winged elm trees were between two and one-half to three and one-half inches DBH and average 18.5 feet tall. Treatments were applied December 22, 1962. Soil temperature was 44°F and air temperature was 52°F at 1:00 p.m.

Experiment 5 - The injection of 2,4,5-T in American elm (*Ulmus americana*).

A flat, lowland in Noble County in North Central Oklahoma was selected for this test. The treatments were applied exactly as treatments in experiment four. Experiment five was located in Payne County, Oklahoma, near Stillwater. Treatments were applied February 18, 1963, and soil and air temperatures were 41 and 48°F respectively. Treated trees were 2.5 to 3.5 inches DBH.

Experiment 6 - Comparison of different phenoxy herbicides and basal applications on winged elm.

The site for this study was on a shallow and sloping upland in Haskell County in eastern Oklahoma. The objective of this study was to determine the effects on winged elm of 2,4,5-T ester, 2,4,5-T amine, 2,4-D ester, and silvex (2-[2,4,5-Trichlorophenoxy] Propinoic acid) and different methods of applications.

All plots were established on a gently sloping, shallow, and rocky soil. Plots were laid out in a randomized complete-block design. Each treatment was replicated 10 times, each replication consisting of one tree.

The treatments were as follows:

(1) 2,4,5-T ester, 2,4,5-T amine, Kuron (propylene glycol butyl ether ester of silvex, and 2,4-D ester were each mixed with diesel oil at the ration of 1:9 and applied as an injection treatment.

(2) The 2,4,5-T ester, 2,4,5-T amine, silvex, and 2,4-D ester were mixed in diesel oil at the ratio of 1:28 and applied to the trunks of the elm trees as a basal spray.

These treatments were applied December 21, 1962. The temperature was 38°F at 10:30 a.m. Weather was cloudy and damp. The day before the treatments were applied there was one inch of rain. The trees were two and one-half to three and one-half inches DBH and averaged 15 feet tall.

The basal sprays were applied with a three gallon hand sprayer. A pressure of 20 psi was used with an 80015 nozzle. The spray was directed on the lower 8 to 10 inches of the trunk of the tree for 12 seconds. This applied between 77 and 80 ml. of solution per tree. Eighty ml. of spray was enough to wet the lower 8 to 10 inches of the trunk and to wet the immediate soil around the base of the tree.

Injection treatments consisted of making the incision of the stem a separate operation and applying the chemical as described in experiment 4.

The amine formulation of 2,4,5-T was suspended in oil with constant agitation.

<u>Experiment 7</u> - Comparison of different chemicals and basal applications on American elm.

A site in Noble County in north central Oklahoma was selected for this study. The preceeding experiment was applied to American elm, with the addition of Silvex in the oil soluble amine form. Test location was near Stillwater in Payne County, Oklahoma. Date of application was February 19, 1963, and air temperature was 51°F. Trees were 2.5 to 3.5 inches DBH.

Experiment 8 - Natural mortality of winged elm seedlings in nature.

An area in Haskell County in eastern Oklahoma was selected for this study. The natural mortality of winged elm seedlings was observed in this experiment. Seedlings two inches tall and in their second growing season were used for this study. The seedlings were in their natural environment under heavy brush. This experiment was replicated five times and each replicate was nine square feet. Mortality rate was measured throughout the growing seasons. Readings were taken by dividing each yard square replicate into 16 sub units and counting the seedlings in each sub unit. This experiment was established June 15, 1962. Light reaching the surface of each replication ranged from 250 to 1500 foot candles in one replication, to 500 to 3900 in another at mid day.

Experiment 9 - The effect of water extract from winged elm seed on germination.

This experiment was initiated to determine if there is an inhibitory compound in the distilled water extract of winged elm seed. In test A, 40 grams of intact winged elm seed were placed in a 500 ml. beaker and the beaker was filled with distilled water and covered with foil. In test B, 56.9 grams of intact winged elm seed were treated as in test A.

The seeds were allowed to soak for the desired period at room temperature. Nine ml. of solution was removed and used to moisten a germination material (Kimpak) which had been placed in a 3.5 inch square plastic box. Nine ml. distilled water was used as a moistening agent for the checks. Seeds of various species were placed on the moist germinating material, which was under a lid sealed with masking tape. Seeds were allowed to germinate at 30°C under alternating light in a germinator. Species used to measure germination were alfalfa (Medicago sativa), current year crabgrass (Digitaria sanguinalis), two year old crabgrass, tomato (Lycopersicon esculentum), pearl millet (Setaria italica), winged elm, and cucumber (Cucumis sativus).

Both studies were replicated five times in a randomized complete-block design, each replicate consisting of 25 or 50 seeds. Percent germination and total length was measured.

Experiment 10 - The effect of shade on the growth and development of winged elm.

This experiment was designed to evaluate the effect of shade on the growth and development of winged elm seedlings. Two year old seedlings were removed from their natural environment and transplanted into flats and allowed to recover. After recovery the seedlings were thinned to eight per cent flat and placed under 50, 75, and 88 percent shade. The shades were made of plastic shade cloth. The flats were watered regularly and the seedlings were allowed to grow for one growing season.

This experiment was replicated four times, each replication consisting of eight plants. Length, dry weight and number of leaves were measured.

RESULTS

Experiment 1 - The effect of different treatments, including 2,4,5-T, on the control of winged elm.

Almost all the treatments showed some effect 16 days after treatment, the exception being the large trees treated with the basal bark treatment. Both large and small trees of the two foliage applications showed an immediate response to the 2,4,5-T and the DNBP. Both sizes of the stump treatments showed no response after being cut off. The girdle burn treatment showed the least effect of any treatments, except the basal bark. Only the lower branches of the trees treated with girdle burn showed any effect at all. This effect was probably from the upward movement of the heat during the burning of the lower trunk.

All the foliage on the small trees receiving the basal bark spray had turned yellow or brown 16 days after treatment. The large trees receiving the same treatment showed no effect. With the injection treatment, all the leaves on both tree sizes were brown or a bright yellow from the bottom of the crown to the top. All checks were green and appeared normal.

These treatments were observed closely for the entire growing season. Thirty-six days following treatment trees in the injection and foliage spray plots had turned brown completely and the leaves had curled. The treated stumps, both large and small, had started to dry out and crack from the center to the edge. Basal bark treated small trees had 100 percent brown leaves and they were curled. The large basal bark trees were somewhat lacking in the overall effect.

Trees that had been girdle burned only had the lower one-fourth of the leaves showing effect after 36 days. In trees treated with DNBP for dessication, all the leaves had turned brown or dropped off, but some of these trees had showed evidence of feathering or resprouting. Most of the resprouting occurred on the main stem.

There were 62.5 percent of the untreated small stumps that had started resprouting 36 days after treatment. The number of sprouts per stump ranged from one to thirty and from one-half to three inches long. Three of the large untreated stumps had resprouts ranging from three to eight per stump and from one-half to three inches long. All checks were green and actively growing.

At the end of 68 days all treatments except injection and treated stump had green leaves present, either from feathering or leaves that were never affected.

Initial defoliation was excellent on both sizes of the dessicate-foliage treatment. However, feathering was rated as much as ten on some trees. Hereafter, defoliation is expressed in percent and feathering is rated on a 0 to 10 scale with 0=no feathering and 10=severe feathering. The feathering originally started on the lower three feet of the trunk but eventually spread to all parts of the tree on branches larger than one inch in diameter.

Every untreated small stump had sprouts ranging from two to six inches long and possessed from two to fifteen leaves. Less than half the larger untreated stumps had sprouted. The number of sprouts ranged from five to thirty with the first sprouts emerging from between the bark and wood of the stump. Over one-half of these stump tops had started to crack as the treated stumps.

The spray foliage trees had good initial defoliation but one-eighth of the trees in each size had begun to feather. These feathers came from branches and twigs primarily smaller than one inch in diameter.

Most trees in the small girdle burn and all in the large class appeared completely recovered. All trees treated with the basal bark treatment had at least 95 percent defoliation with no feathering.

Also, 68 days after treatment a population increase of chewing caterpillars were observed. The worm was the variable oak worm (*Heterocampa manteo* Dbldy.). Some of the leaves of winged elm and the oak were eaten by the caterpillars but probably not enough foliage was removed to influence the treatments.

Fifty weeks following initial treatment a more complete analysis of the treatments could be made. Injection and treated stumps were the only treatments that had unanimous apparent kills of 100 percent. The control shown by girdle burn on small trees, untreated small stumps, large foliage spray, and small dessicate spray was zero.

The feathering on all other treatments was rated low, except for DNBP and spray foliage treatments, which were rated 4 or 5. Defoliation on these same treatments was low except for basal bark, which was rated between 60 and 90 percent. A leaf absence of 13 percent was determined for the girdle burn treated trees. Leaves were not absent from any localized area, but the absence was spread evenly though the crown. Checks were normal.

Untreated stumps had sprouted and sprouts were 15 inches long. Spray foliage and dessicate foliage had less than 25 percent apparent kill with slight to strong feathering.

Basal bark treatments were made on three trees which were not dead from the previous basal bark treatment. A foliage-stem treatment was applied on July 7, 1963, to every tree in both size ranges of girdle burn, spray foliage, dessicate foliage, and untreated stump (Table 1).

Again as in the spray foliage treatment before, all trees were rated 97.5 percent on defoliation two months after spraying. Trees that had girdle burn the first treatment had begun to feather. All basal bark trees were 100 percent defoliated with no feathering.

Twenty-three months, or during the third growing season after the first treatment, and eleven months after retreatment, the kill appeared good. Injection, basal bark, treated stumps, and large untreated stumps were rated 100 percent. Small girdle burn was rated 98.8 percent and large was 100 percent defoliated with feathering of .87 and 4.0 on the small and large trees respectively.

Defoliation was rated high on trees that received a treatment, and feathering was low on all but the large girdle burn and large dessicate foliage.

All trees that received a treatment or a retreatment were defoliated over 88 percent 27 months post treatment. However, the treatments of girdle burn, untreated stump, spray foliage and dessicate foliage had permitted the trees to feather.

It should be pointed out that after 1962 these trees were growing under extremely adverse conditions. The long term average annual precipitation for the area was 40 to 45 inches. During 1963 only about one-half the average moisture was received. The first seven months of 1964 were extremely dry too.

The average temperatures in the summers of 1962 and 1963 in the field were approximately 4°F warmer than the long term average. One the other hand, the winters for the same periods were about 4°F colder than the long term average.

The adverse conditions of drought and higher temperatures in the summer caused these winged elm trees that were studied to be in abnormal state of existence during the test.

It would appear that of the eight treatments, only the injection, basal bark, and treated stump treatments resulted in complete tree kill. However, the stem-foliage spray following the others also resulted in a good apparent kill.

Experiment 2 - Basal and foliar treatments of 2,4,5-T as they are affected by tree size.

Results of the foliage spray are quite similar on all sizes after 9 weeks (Table 2). All six tree sizes were rated between 71.5 and 97 percent defoliation. Each of the six sizes was showing some feathering. Feathering was rated from .1 to 1.9. Feather length ranged from .1 inch to 1.13 inches long.

The basal bark treatment, however, was more effective. Of the six sizes of trees treated, each size was completely defoliated and there was no feathering on any of the sizes treated. The check was completely normal and the basal bark check showed no response of any kind to the treatment they received.

Eleven months after treatment all trees that received a treatment were above 76 percent defoliation, except the basal bark check treated trees. In every tree size the feathering on foliage spray was higher than on the basal bark treated trees. The basal bark treatment on trees of 2 to 6 feet was the most effective treatment.

TABLE I

EFFECT OF DIFFERENT 2,4,5-T TREATMENTS ON WINGED ELM

		12.5 Months After 1st Treatment			11 Months After 2nd Treatment**		15 Months After 2nd Treatment		
Treatment	Size	% Defol.	Feather	FL*	% Defol.	Feather	% Defol.	Feather	FL*
Girdle Burn**	S	.0	0.25	0.8	98.8	0.87	99.0	0.8	0.0
	L	1.2	0.0	0.0	100.0	4.00	99.0	1.6	0.0
Injection	S	100.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0
	L	100.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0
Basal Bark	S	87.5	0.0	0.0	100.0	0.0	100.0	0.0	0.0
	L	62.5	0.5	0.5	100.0	0.0	100.0	0.0	0.0
Untreated Stump**	S		15.0[1]	18.0		2.5[1]	88.0	1.2[1]	2.0
	L		20.0[1]	14.0		0.0[1]	100.0	0.0[1]	0.0
Treated Stump	S		0.0	0.0		0.0	100.0	0.0	0.0
	L		0.0	0.0		0.0	100.0	0.0	0.0
Spray Foliage**	S	25.0	4.0	8.0	100.0	1.25	100.0	0.0	0.0
	L	0.0	5.0	11.0	96.3	0.62	95.0	0.5	0.0
Dessicate Foliage**	S	0.0	4.0	10.5	95.0	0.62	100.0	0.0	0.0
	L	12.5	5.0	9.0	95.0	5.50	99.0	1.0	1.0
Check	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Feathering Length in Inches

[1] Actual Number of feathers, the other feathering treatments are on a basis of 0=no feathering, 10=extensive feathering

**A second treatment of a foliage-stem spray of 2,4,5-T was applied to the girdle burn, spray foliage, dessicate foliage and untreated stump treatments.

There was only one tree with any feathering in the eight feet basal bark class. This tree was heavily shaded around the base by Smilax spp. There was also only one tree besides this one that wasn't completely defoliated in the eight foot basal bark category. This tree had no defoliation indicating that it was not treated or this was a new batch of spray in the sprayer and the diesel oil was not sprayed from the line. The base of the tree did appear to have been treated.

The untreated trees had no symptoms of any kind and appeared normal. The check basal bark oil treated trees were not affected by the diesel oil in any visable way.

Evaluations fifteen weeks after treatment, from the aspect of feathering and defoliation, showed basal bark to be better than the foliage spray on all sizes. There did not appear to be any general susceptibility trend with regard to tree size.

Experiment 3 - The effect of five herbicides compared on winged elm. (Table 3)

At nine weeks after treatment all trees that received a treatment were rated above 50 percent for defoliation except treatments Prometone 10 lb., Prometone 20 lb. + 2 lb. 2,4,5-T and TBA. No treated trees had any feathers.

Fenuron was rated at 10 earlier but four replications had 100 percent new leaves nine weeks post-treatment. Leaves were smaller than one-half the natural size. This regrowth was not due to feathering because new leaves have emerged from old buds that previously supported leaf growth.

TABLE II

AVERAGE DEFOLIATION AND FEATHERING OF WINGED ELM

THREE DATES AFTER THE APPLICATION OF 2,4,5-T

AS A FOLIAGE SPRAY (FS) OR BASAL BARK (BB)

	Nine weeks after treatment			11 months after treatment		15 months after treatment	
Height	% Def.	Feather	FL*	% Def.	Feather	% Def.	Feather
			Basal Bark				
2	100.0	0.0	0.0	100.0	0.0	100.0	0.0
4	100.0	0.0	0.0	100.0	0.0	90.0	0.0
6	100.0	0.0	0.0	100.0	0.0	100.0	0.0
8	80.0	0.0	0.0	81.0	1.0	84.0	0.0
10	97.0	0.0	0.0	98.0	0.6	97.0	0.5
12	71.0	0.0	0.0	76.0	1.0	72.0	0.2
Check	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Foliar Spray				
2	89.0	0.4	0.4	98.0	2.5	70.0	0.1
4	85.0	0.6	0.9	100.0	4.0	99.0	0.1
6	97.0	1.0	1.3	91.0	3.3	83.0	2.0
8	93.0	0.1	0.1	95.0	1.1	92.0	0.3
10	77.0	0.3	0.8	82.0	2.5	72.0	1.3
12	83.0	1.9	0.9	96.0	3.6	80.0	2.5
Check	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Feather Length in inches

Feathering 0 = no feathering 10 = extreme feathering

Trees treated with 2,3,6 TBA were defoliated to the extent of 42 percent. Untreated trees (check) showed no abnormalities.

The amount of control had changed drastically 48 weeks later. Results among the treatments varied widely in defoliation from 0 to 100 percent. Only four treatments appear to show any promise for the control of winged elm.

The treatment causing the best control was picloram granular at 10 pounds per acre. Apparent kill was 100 percent for this treatment. The control with dicamba liquid at eight pounds, picloram liquid at one pound, and picloram granular at 5 pounds were rated above 92 percent for defoliation.

The rest of the treatments showed less control, and trees treated with prometone showed no defoliation at any time during the study. Fifteen months post-treatment most trees chemically treated had large defoliation percentages. All of the treatments except one showed evidence of feathering. Control was normal throughout the investigation.

Experiment 4 - The injection of 2,4,5-T in winged elm with different diluents.

The results of this study clearly indicate the superiority of the injection method of treatment over other methods for the control of winged elm. All nine injection treatments showed excellent defoliation 21 weeks after treatment (Table IV). The only treatment that may be less effective as far as defoliation was concerned was the 2,4,5-T ester in water at the rate of 1:27. Nine trees in this group have a 100 percent rating for defoliation. The remaining tree had only 20 percent defoliation. There is reasonable doubt as to whether this tree was treated exactly as the rest of the trees receiving this treatment.

TABLE III

EFFECT OF TREATMENTS ON WINGED ELM ONE TO ONE AND ONE-HALF INCHES DBH

			9 weeks post treatment		48 weeks post treatment		15 months post treatment	
Chemical		Tmt. No.	% Defol.	Feather	% Defol.	Feather	% Defol.	Feather
Dicamba Granular	Soil	1	71	0	69	2.0	84	1.5
Dicamba Liquid	"	2	74	0	87	3.5	75	1.8
Dicamba Liquid	"	3	77	0	100	1.0	97	0.6
Picloram Liquid	Foliar	4	81	0	98	4.2	88	1.1
Picloram Liquid	"	5	69	0	100	0.9	92	0.8
Picloram Granular	Soil	6	90	0	90	0.4	99	0.2
Picloram Granular	"	7	100	0	100	0.0	100	0.0
Fenuron Granular	"	8	80	0	79	4.7	86	0.3
Prometone Liquid	Foliar	9	0	0	11	0.6	14	1.4
Prometone Liquid	"	10	55	0	0	0.0	36	0.7
Prometone 2,4,5-T Liquid	"	11	29	0	57	0.3	42	1.3
TBA Liquid	"	12	42	0	97	3.0	72	1.8
Control		13	0	0	0	0	0	0

*Chemical still acting.

Feathering scale 0=no feathering 10=severe feathering

Thirty-two weeks after treatment the dependability of the injection method was more clearly indicated. The 2,4,5-T in water treatment at the ratio of 1:27 was still rated at 92 percent on defoliation; one tree was still rated 20 percent and all other trees treated with this rate maintained their individual ratings of 100 percent. The ten trees that received 2,4,5-T in base oil at the ratio of 1:9 were rated 100 percent, with the exception of one which had 90 percent. This group of trees had an average defoliation of 99 percent. All other treated trees were rated 100 percent apparent kill. There was no resprouting.

Seventy-two weeks post treatment all treatments were 100 percent defoliation with no feathering except treatment 7 which was rated 0.5 for feathering.

The treated trees 21 months post-treatment demonstrated the dependability of the injection treatment. All treated trees were completely defoliated except checks which were normal.

Experiment 5 - The injection of 2,4,5-T in American Elm (*Ulmus americana*) (Table 5)

All the treated American elm trees in this study show very little defoliation seventeen weeks after treatment. However, the chemicals still showed some activity in the leaves. The standard treatment 1:9 ratio of 2,4,5-T ester is diesel oil appeared the best one year after treatment.

TABLE IV

EFFECT OF 2,4,5-T ESTER WITH DIFFERENT DILUENTS AND DILUTIONS ON DEFOLIATION OF WINGED ELM (as percent)

			Weeks Post Treatment 21	32	72	84
Diluent	Dilution	Tmt. No.	Defol	Defol	Defol	Defol
Water	1:9	1	100	100	100	100
Water	1:18	2	99	100	100	100
Water	1:27	3	92	92	100	100
Diesel Oil	1:9	4	100	100	100	100
Diesel Oil	1:18	5	100	100	100	100
Diesel Oil	1:27	6	100	100	100	100
Base Oil	1:9	7	100	99	100	100
Base Oil	1:18	8	100	100	100	100
Base Oil	1:27	9	100	100	100	100
Control		10	0	0	0	0

TABLE V

EFFECT OF 2,4,5-T ESTER IN DIFFERENT

DILUENTS AND DILUTIONS ON AMERICAN ELM

			Weeks Post Treatment 17			65	
Diluent	Dilution	Tmt. No.	% Defol	CSA[1]	AL[2]	% Defol	Feather
Water	1:9	1	50	1.0	27	70	.1
Water	1:18	2	16	.8	19	41	.0
Water	1:27	3	24	2.2	22.5	50	.1
Diesel Oil	1:9	4	60	3.8	13.5	100	.1
Diesel Oil	1:18	5	50	1.6	25	95.5	.6
Diesel Oil	1:27	6	26	1.0	15	40	.0
Base Oil	1:9	7	80	1.4	9.5	88	.7
Base Oil	1:18	8	60	1.8	25.5	86	.2
Base Oil	1:27	9	20	1.6	31.5	72	.1
Check		10	0	.0	0	0	.0

[1]CSA = Chemical still active in the leaves
0 = no activity   10 = extreme activity

[2]AL = Percent of remaining leaves that are affected by the chemical

Experiment 6 - Comparison of different chemicals injected and basally applied on winged elm.

All the injection treatments received a rating of 98.5 percent or better 25 weeks after treatment. The basal spray treatments were quite heterogenic as far as results were concerned. Ratings ranged from 3.5 percent for 2,4-D ester to 96 percent for silvex.

Thirty-four weeks after treatment the results were similar to the 25 week readings. The injection treatments were rated 100 percent and basal bark treatments ranged from .5 to 99 percent with the same two treatments being the high and low.

Sixty-eight weeks after treatment the injection and basal bark treatments were 95 percent or more defoliation and feathering was below 3.3.

Five of the eight chemical treatments that were applied to the trees had caused complete defoliation. The three remaining treatments had not caused complete defoliation and the three treatments had allowed the treated trees to feather.

Experiment 7 - Comparison of different chemicals injected and basally applied on American elm.

Neither method of application nor chemical was effective in this study 18 weeks after treatment. There was still some chemical activity in the leaves but it was not enough for control. The following growing season was about the same as before, except most defoliation ratings increased about 25 or 30 percent.

TABLE VI

EFFECT OF VARIOUS CHEMICALS INJECTED (I) OR

BASALLY (BB) APPLIED TO CONTROL WINGED ELM

			Weeks Post Treatment 34	68		84	
Treatments		Tmt. No.	% Defol	% Defol	Feath	% Defol	Feath
2,4,5-T(ester)	I	1	100.0	100.0	.0	100.0	.0
2,4,5-T(ester)	BB	2	81.0	99.0	.5	97.0	.4
2,4,5-T(amine)	I	3	100.0	100.0	.1	100.0	.0
2,4,5-T(amine)	BB	4	.5	100.0	3.3	49.0	4.1
Silvex	I	5	100.0	100.0	.0	100.0	.0
Silvex	BB	6	99.0	100.0	.0	100.0	.0
2,4-D (ester)	I	7	100.0	100.0	.0	100.0	.0
2,4-D (ester)	BB	8	5.0	95.0	3.2	31.0	3.3
Control		9	0.0	0.0	.0	0.0	.0

TABLE VII

EFFECT OF VARIOUS CHEMICALS INJECTED (I) OR BASALLY (BB) APPLIED TO CONTROL WINGED ELM

			Weeks Post Treatment				
			18			65	
Treatments		Tmt. No.	Defol	CSA[1]	AL[2]	Defol	Feath
2,4,5-T (ester)	I	1	50	.7	15.5	62	1.2
2,4,5-T (ester)	BB	2	30	2.3	24.5	56	.4
2,4,5-T (amine)	I	3	70	2.3	21.5	99	1.4
2,4,5-T (amine)	BB	4	0	.9	24.5	0	0
Silvex	I	5	35	.5	25.0	72	1.1
Silvex	BB	6	50	1.3	35.0	76	2.0
2,4-D (ester)	I	7	85	1.5	58.0	100	1.1
2,4-D (ester)	BB	8	25	.5	77.0	67	1.0
Check		9	0	.0	.0	0	.0
Silvex (dacamine)	BB	10	9	1.1	41.0	35	.2
Silvex (dacamine)	I	11	88	2.2	2.5	100	.0

I = Injection BB = Basal bark

[1]CSA = Chemical still active in the leaves
0 = no activity 10 = extreme activity

[2]AL = Percent of remaining leaves affected by the treatment

Experiment 8 - Natural mortality of winged elm seedlings in nature. (Table 8)

The purpose of this study was to determine the percent natural mortality of winged elm seedlings. Readings were taken during two growing seasons. The plots had an average of 118 plants per 9 square feet or 571,120 seedlings per acre. There was a steady decline with time in the number of seedlings that survived. The percent mortality increased as the number of seedlings decreased.

TABLE VIII

NATURAL MORTALITY OF WINGED ELM SEEDLINGS IN NATURE

	Replications						% Mortality
Date	1	2	3	4	5	Average	Average
6/13/62	32	86	171	174	126	118	0
8/3/62	28	59	147	118	98	90	24.8
9/26/62	15	40	107	63	37	53	55.4
6/7/63		17	84	19		40	73.6
8/15/63		15	52	17	26	27.5	80.5

Experiment 9 - The effect of water extract from winged elm seed on germination.

Some of the species tested were more tolerant to the water extract than others. In both tests tomatoes were more sensative. In one test, the alfalfa in the 264 hour extract only germinated 4.0 percent, but the germination dishes were heavily infested by fungus. Also, in both tests the percent germination of crabgrass was increased. In the second test the crabgrass seeds produced that current season germinated 2.4 percent when exposed to the 264 hour soaked extract.

As the number of hours that the elm seeds were in contact with the water increased, so did the total growth and germination of the species tested, except tomato and alfalfa.

TABLE IX

AVERAGE TOTAL LENGTH OF SEEDLINGS (IN MM) WHEN A WATER EXTRACT OF WINGED ELM SEED WAS USED AS A MOISTENING AGENT

Experiment A

	SPECIES			
No. Hrs.[1]	Alfalfa	Crabgrass	Tomatoes	Cucumber
0	17.0	13.4	19.9	63.2
24	21.1	25.2	19.8	72.6
144	24.6	29.1	25.4	101.5
264	12.1	21.4	8.7	115.7

Experiment B

	SPECIES					
No. Hrs.[1]	Crabgrass[2]	Alfalfa[4]	Tomato[4]	Millet[4]	Crabgrass[4]	Elm[4]
0	---	14.5	10.9	55.7	21.4	19.4
24	---	19.7	16.9	80.1	27.5	17.4
264	27.5[3]	12.3	11.1	86.5	31.9	27.2

[1]Number of hours elm seeds had soaked in the water.

[2]Current seasons crabgrass seed.

[3]Average of six seedlings.

[4]Average of 25 seedlings.

TABLE X

PERCENT GERMINATION OF SPECIES EXPOSED TO

WATER EXTRACT OF WINGED ELM SEED

Experiment A

	SPECIES			
No. Hrs.[3]	Alfalfa[1]	Crabgrass[1]	Tomatoes[1]	Cucumber[2]
0	66.8	22.0	56.0	80.4
24	62.0	82.8	22.8	77.6
144	59.2	84.4	27.2	92.0
264	4.0[4]	76.4	10.0	83.2

Experiment B

	SPECIES					
No. Hrs.[3]	Crabgrass[5]	Alfalfa[1]	Tomato[1]	Millet[1]	Crabgrass[1]	Elm[2]
0	.0[1]	69.6	84.0	68.0	64.0	66.4
24	.0[1]	41.6	12.8	64.8	54.8	85.5
264	2.4[1]	40.8	6.0	67.2	84.4	95.2

[1]Average of 250 seeds

[2]Average of 125 seeds

[3]Number of hours elm seeds had been in the water

[4]Heavily infested with fungus

[5]Current seasons crabgrass seed

Experiment 10 - The effect of shade on the growth and development of winged elm.

The intensity of shade drastically influenced the vigor and development of the seedlings. At the initiation of the study, all plants averaged three inches of stem growth above the soil with five leaves per stem. Growth of all parts of the seedlings appears to be decreased by shading. At the end of the growing season the seedlings under the 75 percent shade had 3.3 times as much total dry weight as did the seedlings under the 88° percent shade. At the same time the seedlings under the 50 percent shade had 1.7 times the dry weight the ones under 75 percent shade, or a six-fold increase over the seedlings grown under 88 percent shade.

TABLE XI

EFFECTS OF SHADE ON THE LEAF, ROOT AND STEM DEVELOPMENT OF WINGED ELM

Degree Shade	Fresh Weight gms/plant	Dry Weight gms/plant	No. of Leaves/plant	Length mm./plant
		Leaf Development		
88	.158	.069	11.05	
75	.428	.183	17.97	
50	.649	.281	20.10	
		Root Development		
88	.220	.070		133
75	.963	.263		185
50	1.645	.506		231
		Stem Development		
88	.089	.044		110
75	.357	.162		145
50	.545	.271		171
		Total Plant Measurements		
88	.467	.183		243
75	1.748	.608		330
50	2.839	1.058		402

DISCUSSION

Experiments were conducted in the laboratory and in the field to determine the effect of foliar and basal treatments on the control of winged elm. Also, the effects of the various ecological circumstances on the germination, development and growth of the winged elm were determined.

The leachate from winged elm seed had very little detrimental effect on the germination or development of species tested, except tomato and alfalfa. The development of the tomatoes and alfalfa was drastically reduced, particularly by the 264 hour extract.

The natural mortality of winged elm seedlings was found to be as high as 80.5 percent fourteen months after the beginning of the second growing season. The seedlings that survived were affected by the vegetational competition, particularly the degree of shading. It had been noted that the removal of an overstory from the seedlings resulted in a rapid increase of size and vigor. Where the degree of shade was the only noticeable factor restricting the development of winged elm seedlings, the more dense the shade, the less the seedling development. Seedlings that grew under 50 percent shade averaged 1.05 gms. dry weight per plant while 88 percent shade only produced a total of .183 gms. dry weight per plant.

In basal bark treatments elm trees responded differently to various concentrations of 2,4,5-T ester and carrier. A difference in the response of tree size up to 12 feet tall was not uniform. The 2 and 6 ft. trees were killed and the 10 feet trees were 97 percent defoliated, while the 4 and 8 feet trees were rated 90 and 83 percent defoliation respectively. A standard ratio of one part 2,4,5-T in 28 parts diesel oil did not give 100 percent kill of trees between 2.5 and 3.5 inches DBH. Winged elm trees from 2 to 5 inches DBH required a foliar treatment of 16 pounds 2,4,5-T ester AIHG diesel oil in addition to the standard basal bark treatment to give 100 percent kill. A single basal bark treatment of the standard ratio of silvex in diesel oil caused 100 percent kill in winged elm trees 2.5 to 3.5 inches DBH.

The standard basal bark treatment on American elm trees 2.5 to 3.5 inches DBH was inferior to the same treatment on winged elm trees. Four pounds 2,4,5-T amine, silves ester, the oil soluble amine of silvex, and 2,4-D ester AIHG diesel oil was inferior to the same ratio of 2,4,5-T ester applied as a basal spray on similar sizes of winged and American elm. However, the same concentration of silvex in diesel oil was more effective on both species than other materials tested when applied as a basal spray.

Injection of 2,4,5-T ester, 2,4,5-T amine, 2,4-D ester or silvex in diesel oil at the ratio of 1:9 killed 100 percent of the winged elm trees. The 2,4,5-T ester in base oil, diesel oil, or water at the ratio of 1:9, 1:18, or 1:27 resulted in 100 percent kill of winged elm trees 2.5 to 3.5 inches DBH. None of these chemicals diluted in diesel oil at the ratio of 1:9 resulted in 100 percent kill on American elm trees. American elm trees injected with silvex (oil soluble amine) in diesel oil at the ratio of 1:9 was completely killed however.

Foliar sprays of DNBP in diesel oil at the ratio of 1:40 or three pounds of 2,4,5-T ester in 100 gallons water was not totally effective on winged elm trees 2 to 5 inches DBH. Neither was four pounds of 2,4,5-T ester AIHG water applied as a foliage spray. Picloram at one or two quarts, or 2,3,6-TBA at two gallons per 100 gallons diesel oil, did not control the winged elm trees 12 feet tall. Liquid dicamba in water at the rate of 4 and 8 pounds AIHG water was sprayed on the soil around 12 feet tall trees resulted in 75 and 97 percent defoliation respectively.

The recommended rates of dicamba or fenuron when applied in a granular form resulted in only 84 and 86 percent defoliation respectively. Two of the most effective granular applications were 5 and 10 pounds a.i. per acre of picloram, which resulted in 99 and 100 percent defoliation respectively.

A very effective but difficult to apply treatment on winged elm was the chemical treatment of a freshly cut stump. Kill from this treatment was 100 percent while untreated stumps had regrowth until they were sprayed with a solution that contained 16 pounds 2,4,5-T ester AIHG diesel oil. The spraying of the untreated stumps after regrowth was present gave 100 percent apparent kill of stumps from trees that were 3 to 5 inches DBH. Smaller stumps were controlled 88 percent.

Of the treatments tested it appeared that the injection, treated stump, basal spray and granular applications had the best promise for the control of winged elm. Each of these treatments will be slow to apply on a large acreage basis with the possible exception of the granular forms.

SUMMARY AND CONCLUSIONS

Injection and stump treatments for the control of winged elm were by far better than other types of treatments, followed very closely by basal bark. It was clearly shown that the injection treatment had a wider range of adaptability and effectiveness than any other type of treatment.

Fenuron and dicamba lack effectiveness when compared to 2,4,5-T for winged elm control, but picloram was effective. American elm was somewhat resistant to the normally effective treatments for the control of winged elm. Treatments that were rated 100 percent kill on winged elm only defoliated American elm 40 to 50 percent. American elm was effectively controlled with silvex dacamine in diesel oil injected into the trunk.

Natural mortality of winged elm seedlings was extremely high in nature and the reduction in number was primarily due to vegetational competition. Water extract from winged elm seed stimulated both germination and growth of some species tested. There was a definite increase in the number of leaves, root and stem development, and dry weight of plants grown in 50 percent shade over plants grown under 88 percent shade.

LITERATURE CITED

1. Basler, Eddie, G. Todd and R. Meyer. 1961. Effects of moisture stress on absorption. Plant Physiol. 36:573-576.

2. Behrens, R., H. M. Elwell, W. A. Gentner, H. M. Hull, D. L. Klingman, F. A. Peevy, F. L. Timmons and F. H. Tschirley. 1961. Chemical control of brush and trees. U. S. D. A. Farmers Bul. 2158

3. Bullock, W. R. 1961. From the axe to the injector. Proc. S. Weed Conf. 14:237-240.

4. ____________. 1963. A faster and cheaper approach to the aerial application of 2,4,5-T. Proc. S. Weed Conf. 16:252-256.

5. Bunch, C. E. 1963. Report on conclusions from eastern Oklahoma brush and timber tour. Extension Service. Oklahoma State University, Stillwater, Oklahoma.

6. Dalrymple, R. L. 1962. Vegetation responses following winged elm (<u>Ulmus alata</u> Michx.) and oak (<u>Quercus</u> spp.) control, winged elm browse and winged elm understory growth. M.S. Thesis. Okla. State Univ. Stillwater, Okla.

7. Darrow, R. A. 1960. Aerial application of herbicides for brush and weed control. Texas Agr. Progress. Vol. 6 2:19-23.

8. ____________ and R. H. Haas. 1961. Use of granular herbicides for rangeland woody plant control in Texas. Proc. S. Weed Conf. 14:202.

9. ____________ and W. G. McCully. 1959. Brush control and range improvement in post-oak and blackjack oak areas of Texas. Texas Agr. Exp. Sta. Bul. 942:1-16.

10. Elwell, H. E. 1962. Control of hardwoods with 2,4,5-T in aerial application for pine release and native grass improvement. Proc. S. Weed Conf. 15:161.

11. ____________. 1963. An evaluation of oils as diluents for 2,4,5-T aerially applied for oak control. Proc. S. Weed Conf. 16:271-272.

12. ____________. 1963. Brush and weed control research for native grassland improvement in Oklahoma Annual Report. U. S. D. A., A. R. S., Stillwater, Oklahoma

13. ____________ and W. C. Elder. 1954. Aerial application of herbicides on post-oak and blackjack brush in Oklahoma Progress Report. Circular M 258. Stillwater, Oklahoma.

14. Fisher, C. E., C. H. Meadors and R. Behrens. 1956. Some factors that influence the effectiveness of 2,4,5-T Trichlorophenoxyacetic acid in killing mesquite. Weeds 4:139-147.

15. Gould, F. W. 1962. Texas plants, a check list and ecological summary. Texas Agr. Exp. Sta. College Station, Texas. Bul. MP 585.

16. Haas, R. H. and R. A. Darrow. 1963. Aerial applications of standard and invert emulsions of phenoxy herbicides for the control of post-oak and associated hardwoods. Proc. S. Weed Conf. 16:278.

17. ________, ____________ and S. K. Lehman. 1964. Evaluation of herbicides for the control of common persimmon. Proc. S. Weed Conf. 17:263-268.

18. Harrar, E. S. and J. G. Harrar. 1946. Guide to southern trees. McGraw-Hill Book Co., N.Y., N.Y. pp. 239-242.

19. Hill, H. J. 1962. Use of herbicides in industrial forest. Proc. S. Weed Conf. 15:150.

20. Hoffman, G. O. and B. J. Ragsdale. No date. Brush control with 2,4,5-T. Est. Ser., Tex. Agr. Exp. Sta. College Station, Texas. Leaflet 414.

21. ______________ and ______________. No date. Chemical brush control. Ext. Ser. Tex. Agr. Exp. Sta. College Station, Texas. Leaflet 415.

22. Holstun Jr., J. T. 1962. Woody plant control. Proc. S. Weed Conf. 15:96.

23. Keaton, J. A. and R. P. Upchruch. 1964. The influence of 2,4,5-Trichlorophenoxyacetic acid on (Queris laevis). Proc. S. Weed Conf. 17:284.

24. Kirby, B. W. and P. W. Santelmann. 1964. Germination and emergence of winged elm seed. Weeds 12(4).

25. Klingman, D. L. and W. E. Shaw. 1962. Using phenoxy herbicides effectively. U. S. Dept. Agr. Farmers Bul. 2183:1-24

26. Lecrone, Fred, F. B. Cross, H. B. Cordner, F. A. Romshe, R. P. Ealy, W. R. Kays, and E. R. Houston. 1951. General horticulture. Semco Color/Press. Oklahoma City, Oklahoma. p. 308.

27. Little, R. W. 1963. Reclaiming native grass from brush and tree infestation. Proc. S. Weed Conf. 16:199.

28. Mann, R. A. 1963. Stump treatment after initial clearing of rights of ways of newly constructed lines. Proc. S. Weed Conf. 16:318-325.

29. Miller, W. F. and J. W. Starr. 1963. The role of moisture regime in pine of hardwood kill. Proc. S. Weed Conf. 16:176.

30. __________ and __________. 1962. The relation between soil moisture and hardwood kill. Proc. S. Weed Conf. 15:223-231.

31. Nation, H. A. and C. T. Lichy. 1964. Tlordon herbicide for brush control in Southern U. S. Proc. S. Weed Conf. 17:287.

32. Peevy, F. A. 1964. Reducing hardwood control costs by injecting undiluted 2,4-D amine. Proc. S. Weed Conf. 17:232-239

33. __________. 1962. Injecting undiluted silvicides for control of woody plants. Proc. S. Weed Conf. 15:163.

34. __________. 1961. Killing woody plants with herbicides. Proc. S. Weed Conf. 14:208.

35. Putnam, J. A. No date. Management of bottom land hardwoods. U. S. Forest Ser. S. Forest Exp. Sta. Occasional Paper 116.

36. Ray, H. C. 1958. Aerial chemical reduction of hardwoods brush as a range improvement practice in Ark. Jour. of Range Management. 11 (6):284-290.

37. Robinson, E. D. 1963. Chemical brush control in west Texas. Texas Agr. Progress. Tex. Agr. Exp. Sta. College Station, Texas. 9:(3)3-5.

38. Sargent, C. S. No date. Manual of the trees of North America (Exclusive of Mexico). Ed. 2, reprinted with corrections. Houghton Mifflin Co., Boston and N. Y. p. 910.

39. Scott, W. O. and F. W. Slife. 1955. Chemical control of weeds and brush. Ill. Agr. Exp. Sta. Urbana, Ill. Agr. Ext. Circ. 771:1-19.

40. Shipman, R. D. 1963. Chemical pellets and their use in controlling unwanted hardwoods in South Carolina. Proc. S. Weed Conf. 16:204-208.

41. Smiley, W. L. and P. Y. Burns. 1962. Use of tractor mounted mist blower as a silviculture tool in the south. Proc. S. Weed Conf. 15:170.

42. Spurrier, E. C. 1957. Chemical control of weeds and brush. Ill. Agr. Ext. Urbana, Illinois.

43. Starr, J. W. 1961. Mistblower - Injection combination for forest weed control. Proc. S. Weed Conf. 14:228-235.

44. Upchurch, R. P. and J. A. Keaton. 1961. Woody plant control research - Techniques and results. Proc. S. Weed Conf. 14:272

45. U. S. D. A. Yearbook. 1941. Climate and man. pp. 700-750.

46. U. S. D. A. Yearbook. 1949. Trees. p. 63.

47. Walker, L. C. 1959. Brush control in the Georgia Piedmont. Jour. Range Management 12(1):16-18.

48. Williston, H. L. 1962. Hardwood brush control with foliar sprays. Miss. Agr. Exp. Farm Research. Miss. State College. Starkville, Mississippi.

49. Wiltse, M. G. 1964. Down to Earth. 19(4):3-6.

APPENDICES

TABLE VII

DAILY PRECIPITATION IN INCHES AT THE STUDY AREA,
QUINTON, OKLAHOMA, APRIL 1 TO DECEMBER 31, 1962

Day	Apr.[1]	May[1]	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1		0.04							
2			0.11						
3			0.86						
4						0.52			
5									
6	0.05								
7			0.61					2.00	
8			0.25			1.20			
9			0.42				1.70		
10			0.09				4.90		
11									
12									
13									
14							1.70		
15				0.35					
16					0.29				
17	0.35								
18			0.23	0.02					
19			0.14			1.45			
20			0.23	0.03					
21									
22									1.89
23	3.45		0.03			1.00			
24		0.01	0.06	3.29	0.67			1.60	
25		0.70	0.09	0.71					
26		0.15							
27	0.10	0.22					0.40		
28	0.18								
29		1.02	0.29						
30						0.80			
31					3.20				
TOTALS	4.13	2.14	3.41	4.40	4.16	4.97	8.70	3.60	1.89
Normal[2]	4.09	5.72	5.92	2.80	3.04	3.82	3.64	3.08	2.30
Departure	0.04	-3.58	-2.51	1.60	1.12	1.15	5.06	0.52	-0.41

[1]From Climatological Data, Oklahoma, 1962.
[2]From Climatic Summary of the U. S. 1931-1952. Normal was for McAlister, Oklahoma

TABLE VII, (CONTINUED)

DAILY PRECIPITATION IN INCHES AT THE STUDY AREA, QUINTON, OKLAHOMA, JANUARY 1 TO AUGUST 6, 1963

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1									0.21
2					0.24		0.59		
3									
4			0.33						
5	0.88								
6							0.07		
7									
8							0.08		
9			0.25						
10			0.26						0.53
11						0.34	1.11		
12						0.68			
13									
14							0.94		
15									
16						1.90			
17									
18						0.12			
19				0.33		0.03			
20									
21									
22									
23									
24			0.70						
25		0.18			0.27				
26				2.80	1.28	0.43			
27									
28				0.15					
29		0.40					0.58		
30			0.52				1.40	0.22	
31									
TOTALS	0.88	0.58	2.06	3.28	1.79	3.50	4.77	0.75	
Normal[1]	2.63	2.95	3.21	4.43	5.32	5.92	2.80	3.04	
Departure	-1.75	-2.73	-1.15	-1.15	-3.53	-2.42	1.97	-2.29	

[1]From Climatic Summary of the U. S. 1931-1952. Normal for McAlister, Oklahoma.

TABLE VIII

DAILY MAXIMUM AND MINIMUM AIR TEMPERATURE (°F) AT THE STUDY
QUINTON, OKLAHOMA, JUNE 7 TO DECEMBER 31, 1962

	July		August		Sept.		Oct.		Nov.	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1			84	70	82	68	88	66	60	40
2			88	72	92	68	86	74	55	41
3			94	68	93	69	78	63	80	34
4					80	67	80	60	70	36
5			96	78	79	63	100	68	72	40
6			98	84	92	64	100	70	65	40
7	98	74	104	80	80	60	80	60	70	46
8	102	86	106	74	90	85	89	69	76	50
9	102	78	104	74	89	72	88	70	79	52
10	94	72	106	74	84	76	86	65	78	50
11	102	76	108	74	80	65	102	72	81	56
12	106	88	98	80	87	70	90	70	80	50
13	102	76	88	66	100	85	96	71	82	42
14	102	76	98	66	90	87	100	80	86	68
15	98	72	97	67	84	67	102	72	67	45
16	94	70	90	70	84	66	88	64	60	40
17	96	70	97	76	86	68	92	66	54	39
18	94	70	99	79	106	66	84	72	49	34
19	98	72	98	80	100	65	78	62	48	32
20	102	72	96	78	89	55	72	56	60	40
21	100	72	98	80	90	65	70	52	67	45
22	104	74	104	72	86	60	80	64	84	40
23	100	73	104	72	84	64	79	52		
24	98	70	98	70	86	60	72	48		
25	78	70	94	68	84	56	72	44		
26	88	68			90	54	65	40	60	40
27	88	66	94	58	89	60	70	64	59	39
28	88	68	96	66	94	64	96	70	62	40
29	94	72			93	60	80	52	68	38
30	98	74	100	70	94	58	84	40	56	40
31	94	72	90	68			70	45		
Average			91	73	89	66	84	62	68	43
Normal[1]			95	70	89	63	77	51	55	42
Departure			-4	3	0	3	7	11	13	1

[1]From Climatic Summary of the U. S. 1931-1952. Normal for McAlister, Oklahoma.

TABLE VIII, (CONTINUED)

DAILY MAXIMUM AND MINIMUM AIR TEMPERATURE (°F) AT THE STUDY QUINTON, OKLAHOMA, DECEMBER 1, 1962 TO APRIL 30, 1963

	Dec.		Jan.		Feb.		Mar.		Apr.	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	60	45	60	40	50	30	50	40	80	68
2	80	60	68	38	50	30	54	40	76	60
3	79	60	56	20	30	20	52	42	78	68
4	65	45	58	40	64	40	56	30	82	64
5	55	34	54	40	50	30	58	32	80	58
6	60	39	52	42	50	30	60	40	84	60
7	50	34	54	28	58	42	67	50	84	62
8	45	32	68	32	52	42	68	50	78	68
9	40	30	68	44	50	40	60	52	78	68
10	41	32	68	42	60	30	62	54	76	64
11	30	20	50	20	60	36	64	52	74	52
12	30	8	20	2	50	32	78	30	72	66
13	20	8	28	1	60	10	60	40	86	68
14	40	35	40	10	60	36	68	44	90	70
15	50	40	28	1	55	40	70	40	84	60
16	60	45	52	22	60	30	82	42	80	70
17	70	34	58	30	50	20	72	42	90	70
18	56	56	52	30	40	30	84	60	92	70
19	62	42	44	10	50	40	68	48	88	76
20	64	46	52	20	20	18	62	32	98	70
21	64	48	62	34	19	17	68	42	80	72
22	60	30	10	2	40	21	70	50	82	72
23	62	34	28	28	70	10	72	58	65	60
24	62	30	29	10	40	27	70	40	60	50
25	60	28	38	0	58	48	76	38	70	70
26	60	22	34	20	48	12	80	44	84	70
27	62	20	40	4	56	46	78	50	86	74
28	60	32	40	4	58	40	72	48	88	74
29	46	42	42	30			76	52	80	70
30	58	40	40	30			76	50	62	42
31	60	24	40	20			70	50		
Average	55	35	46	22	50	30	68	45	80	66
Normal[1]	53	32	51	30	56	33	66	42	74	51
Departure	2	3	-5	-8	-6	-3	2	3	6	15

[1]From Climatic Summary of the U. S. 1931-1952. Normal for McAlister, Oklahoma.

TABLE VIII, (CONTINUED)

DAILY MAXIMUM AND MINIMUM AIR TEMPERATURE (^{o}F) AT THE STUDY QUINTON, OKLAHOMA, MAY 1 TO AUGUST 31, 1963

	May		June		July		August	
Day	Max	Min	Max	Min	Max	Min	Max	Min
1	70	60	82	64	100	70	110	76
2	80	70	90	70	110	70	108	70
3	85	74	102	72	100	70	108	72
4	87	70	100	80	102	80	110	72
5	80	74	90	70	104	79	112	70
6	80	70	92	75	106	80	110	72
7	80	68	96	75	100	74	100	70
8	86	70	100	80	100	72	99	70
9	87	69	102	80	104	76	100	72
10	90	70	100	68	98	68	104	80
11	89	74	100	72	96	66	101	78
12	87	70	90	72	100	68	80	70
13	90	80	100	80	89	69	81	70
14	90	70	98	80	97	70	80	60
15	90	78	89	70	104	64	86	64
16	90	80	80	70	99	70	85	60
17	92	84	80	68	90	74	89	61
18	90	80	90	70	110	72	92	66
19	80	76	89	70	99	80	80	65
20	66	54	90	74	106	80	81	69
21	70	50	89	70	118	80	100	60
22	60	45	79	60	112	82	102	60
23	80	56	84	62	120	80	100	66
24	84	70	92	66	122	70	92	68
25	82	68	90	70	104	70	104	70
26	80	70	90	70	96	72	108	75
27	81	70	94	70	84	70	110	76
28	78	67	108	82	92	72	98	70
29	82	68	98	78	92	72	92	72
30	80	70	99	76	80	68	86	70
31	72	66			112	70	98	70
Average	82	69	93	72	98	73	97	69
Normal[1]	81	59	89	67	94	71	95	70
Departure	1	10	4	5	4	2	2	-1

[1]From Climatic Summary of the U. S. 1931-1952. Normal for McAlister, Oklahoma.

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