AN INVESTIGATION INTO THE EFFECT OF SEASON UPON THE EFFECTIVENESS OF FOUR METHODS OF HARDWOOD CONTROL FOR RED PINE PLANTATIONS IN LOWER MICHIGAN

Thesis for the Degree of M. S.

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AN INVESTIGATION INTO THE EFFECT OF SEASON UPON THE EFFECTIVENESS OF FOUR METHODS OF HARDWOOD CONTROL FOR RED PINE PLANTATIONS IN LOWER MICHIGAN

by

William Carl Siegel

AN ABSTRACT

Submitted to the College of Agriculture
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ABSTRACT

The problem of how to release pine plantations from competing hardwoods, both effectively and inexpensively, has become an important factor in recent years. Thus a study was initiated by the Lower Peninsula Forest Research Center of the Lake States Forest Experiment Station to test the effect of season of application on four methods of pine release treatment. The four methods used were as follows: cutting and girdling, ammate, 2,4-D and 2,4,5-T. The ammate was applied in crystalline form to cut stumps, frills or cups; while the 2,4-D and 2,4,5-T were applied as basal sprays. Two typical red pine plantations in Lower Michigan which were in need of release from oak, aspen and red maple were selected for the study. Sixteen half-acre plots, one for each season-treatment combination, were established in each plantation. From fifteen to nineteen each of oak, red maple and aspen were selected on each plot for testing purposes. These hardwoods were treated in 1950 according to the specifications of the designated treatments. Measurement of the number and heights of resulting sprouts for each treated tree was made in 1952. The same information was recorded per killed tree in 1955, for those species-treatment combinations where all treated trees were not dead.

The average number and average height of sprouts were computed per treated tree by species and by species combined, and per killed tree by species alone. This provided twenty combinations for which season effect on number and height of sprouts was compared by analysis of variance. Fall treatment or summer treatment or both resulted

in significantly fewer sprouts than did winter treatment or spring treatment or both in twelve of these combinations. Fall treatment or summer treatment or both also resulted in significantly smaller sprout heights than did winter treatment or spring treatment or both in twelve of the combinations, although not in all cases the same twelve as for sprout number. There was no significance between seasons for sprout number or for sprout height in the eight combinations remaining for each.

For the range of conditions characterizing the study, fall or summer seems to be the best time of the year to apply any of the four release methods for control of at least one, and in some cases two, of the three hardwood species studied. However more intensive studies need to be made on a number of variable factors which may have influenced the results of the study.

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PART I -- INTRODUCTION

HISTORICAL BACKGROUND

During the past forty years nearly one half million acres of plantations, consisting mainly of red, white, and jack pine, have been successfully established in the northern half of the lower peninsula of Michigan. Many of these plantations were planted on areas that supported understocked, scrub hardwoods. In recent years these hardwoods have begun to crowd and suppress many of the planted pines. Other pine were planted on what appeared to be open land at the time of planting, but now many hardwood species such as oak, aspen, and red maple have sprouted up and overtopped many of the pine. During the Civilian Conservation Corps period, when manpower was plentiful and comparatively inexpensive, the hardwoods were cut on many thousands of acres of plantations in order to release the pine. In the majority of cases this release work was beneficial. Now, however, sprouts from the cut hardwood stumps have again overtopped many of the pine on these areas and additional release work is needed.

STATEMENT OF THE PROBLEM

The problem of how to release plantations from competing hardwoods, both effectively and inexpensively, has become an exceedingly important factor in plantation management. At the present time manpower is expensive. The average woods worker receives from $10 to $12 a day. Recent release work, where the smaller trees have been cut and the larger ones girdled, has been averaging about one man day per acre. This does not include technical supervision and transportation.

Therefore, not only is initial plantation release work expensive, but follow-up releases are very expensive. The conventional axe method of girdling the larger hardwoods and cutting the smaller ones can be successfully used if the treatment is applied when the pines are sufficiently tall to keep ahead of the resultant hardwood sprouts. This is especially true when the treatment is applied during the growing season.

In recent years many herbicides and chemicals have been developed to kill herbaceous and woody plants. A few of these have been found to kill the tops of woody plants with subsequent sprouting. Some of the variables that seem to influence the effect of these silvicides are tree species, season of year applied, time of day applied, method and concentration of application, temperature, relative humidity, age of the tree, and size of the tree. The initial costs of these chemicals are comparatively high. Because of their cost, and the general lack of information on their effectiveness, they have not been used extensively for pine plantation release in Lower Michigan.

There is a necessity, therefore, for more information concerning the possible methods of releasing plantations from hardwoods, with direct comparisons of cost and effectiveness of release.

SCOPE AND OBJECTIVES OF THE STUDY

The primary objective of the study in question is to investigate the effectiveness of four methods of pine release treatment in removing overtopping oak, aspen, and red maple competition from pine plantations during the four seasons of the year. The study was initiated by the

Lower Peninsula Forest Research Center of the Lake States Forest Experiment Station and field work was carried out by station personnel in cooperation with administrative personnel of the Lower Michigan National Forest. Analysis of field data and determination of results were accomplished by the writer. The main criteria used to establish effectiveness of treatment by season were: number and height of resultant sprouts per treated tree two years after treatment, and number and height of resultant sprouts per treated tree five years after treatment, in those cases where all treated trees were not killed.

The four methods of treatment used were as follows: 1. Conventional axe treatment--cutting small trees and girdling large trees. 2. Ammate applied on cut stumps of small trees and in notches or cups at the bases of larger trees. 3. H-978 (2,4-D) in a 2% solution of diesel oil applied as a basal stem spray without mechanical injury, and 4. H-9124 (2,4,5-T) in a 2% solution of diesel oil applied as a stem spray without mechanical injury.

The three chemicals used are those which have been found to be most effective in killing woody plants. The treatments were applied during the 1. dormant season. 2. early growing season when the buds were breaking. 3. after full leaf development, and 4. late growing season before the first frost.

The experimental design of the study was set up in order to provide for statistical evaluation and demonstration of the many variables involved. Specifically it was desired to obtain information on: 1. the relative sprouting abilities of oak, aspen, and red maple when cut and girdled in February, May, July, and early September, and the relative costs of this treatment, and 2. the effects of ammate crystals and ester formulations H-978 (2,4-D) and H-9124 (2,4,5-T) on the sprouting of these three species by season of the year, and the relative costs of these applications.

REVIEW OF PREVIOUS WORK

Much experimental effort has been expended over the past years in testing the uses and effects of various chemical silvicides and axe girdling on unwanted hardwoods. All aspects of the problem have been emphasized, some more than others, and certain definite conclusions have been obtained. One of the weaker areas, however, in which considerable more work remains to be done, is the effect of season upon the effectiveness of the various chemical and mechanical methods of hardwood elimination.

Stoeckler (1947) in Wisconsin has found that summer cutting and girdling of aspen and oak, immediately after full leaf development, is most effective in order to reduce subsequent sprouting. He also found that fall is the next most effective season in reducing the number of resultant sprouts from these species and that stump height had no effect on sprouting. Further tests by Stoeckler indicate that the vigor and height of aspen and oak sprouts are much lower after summer and fall cutting and girdling as compared to after winter and spring treatment. He has found that a single cutting and girdling of aspen in the period from late June to early August will usually suffice to release a coniferous plantation. If the treatment is made during the winter, however, the aspen will resprout with maximum vigor and in large numbers; at least two and sometimes three releases are then needed, greatly increasing the cost.

Liming, in unpublished experimental work on plantation release in Missouri, has also found that summer is the most effective season to cut and girdle aspen and oak in order to reduce sprouting. He, too, found that stump height had no effect on sprouting. Liming also determined that girdled oak trees larger than ten inchs D.B.H. seldom sprout and the sprouts that are found are not vigorous in growth.

Greth (1957), in recent tests in southern Illinois with various species of oak, has found that season of girdling did not affect the number of sprouts produced by girdled trees. All sprouting trees averaged four sprouts each regardless of time of girdling. He did find, however, that season affected the length of sprouts produced. Sprouts from trees girdled during the summer and fall averaged one foot smaller than those from trees treated during the winter.

Grano (1955), during the past eight years in Arkansas, has conducted experiments on the seasonal effects of girdling oak. He found that girdling applied from April 15 through June on red and post oak resulted in the largest percentage of dead trees without sprouts. May girdling resulted in the maximum sprout-free proportion of dead trees--an average of 68 percent red oak and 58 percent post oak one year after girdling. Although this period of time is chronologically spring, it is physiologically the first half of the growing season in southern Arkansas since it coincides with the emergence and the attainment of full leaf for both post and red oak. It would correspond with early and middle summer in areas farther north. Grano found that season of girdling had no effect on the number or size of sprouts per dead sprouting tree.

Experimental work with ammate in Arkansas on oak, red maple, and sassafras has shown that the dormant season does not appear to be the best time to apply ammate crystals for effective reduction of sprouting. Several thousand small trees of these three species were cut and the stumps treated with ammate crystals in February. Eighteen months later 70 percent of the oak had sprouted while all the red maple and sassafras had sprouted. Treatment during the late growing season, specifically August, gave the best results. Of sassafras treated during this period only 10 percent showed evidence of sprouting one year later.

Experiments conducted at the Harvard Forest (1954) have indicated that 2,4-D and 2,4,5-T are both much more effective than cutting or girdling in reducing the number of sprouts and sprout heights of treated northeastern hardwoods in white pine plantations. Hackett (1952), in further tests at the Harvard Forest, has found that 2, 4-D and 2,4,5-T treatments made on oak and red maple during the summer are more effective in reducing subsequent sprouting than are such treatments made during the winter.

Worley, Bramble and Byrnes (1954) and Worley, Bramble and Chisman (1952) in Pennsylvania have found that the growing season (June through August) is the most effective time to apply 2,4,5-T to aspen in order to reduce root suckering. Treatment during the winter (dormant season) was effective in killing the aspen, but resulted in vigorous sprouting so that several follow-up treatments were needed in order to gain adequate control of root suckers. These same men also found that dormant spraying of 2,4,5-T on scrub oak was least effective in preventing subsequent sprouting, but that summer treatment was most effective in this respect.

Arend (1953) has reported that using 2,4,5-T during the summer on young aspen in lower Michigan shows promise of control with little or no subsequent sprouting for at least three years, as compared to vigorous sprouting for winter treatment. The tests in this case were made on four to five inch trees.

Morrow (1953) has found that aspen of 6 to 12 inches D.B.H. that have been treated with 2,4,5-T during the dormant season exhibit little or no sprouting. Results of tests in Pennsylvania have paralleled Arend's and Morrow's findings--that young and middle-aged aspen treated with 2,4,5-T are best controlled by growing season treatments and that mature aspen may be effectively controlled by 2,4,5-T applied during any season.

Shipman (1955), in South Carolina, has reported that 2,4,5-T was very successful in killing sweetgum when applied during the spring and early summer (growing season). In contrast, rather poor results were obtained from applications made at other times of the year.

Grano (1957), in experimenting with 2,4,5-T in Arkansas, has concluded that spring treatments are most effective in controlling subsequent sprouting of southern red oak. These spring treatments were conducted in May which falls within the growing season in Arkansas and corresponds to summer in more northern areas.

In upper Michigan, Day (1948, 1950, 1951, 1952) has tested various chemicals on hardwoods, namely aspen and red maple. However, he has done no work with the effect of season on such treatments and no such work has been reported in the Upper Peninsula of Michigan. Until the study with which this thesis is concerned, no formal experimental work with chemical silvicides had been reported in lower Michigan. Certain tests have been made by the Dow Chemical Company but they were not concerned with methods, seasonal effect on, and cost of plantation release.

PART II -- PROCEDURES

INTRODUCTION AND BACKGROUND

Two typical red pine plantations in need of release from oak, aspen and red maple were selected for study on the Manistee National Forest, which is now the Lower Michigan National Forest. They are located on the Cadillac Ranger District near Wellston in Wexford County. The experimental areas were readily accessible, thus reducing travel time for subsequent inspections. The study was initiated in 1950; at this time the red pine were between four and six feet tall, overtopped by oak, aspen and red maple.

The first plantation is specifically located one-fourth mile west of the junction of Highways M-55 and M-37 on the south side of M-55. The legal description is NWNW Section 17, T21N, R12W. When the study was initiated the stand was composed of ten-year old red pine overtopped by aspen, oak and red maple. The pine that were not suppressed and which were growing in natural openings were six to eight feet high, whereas those that were suppressed by the overstory were three to five feet high. The hardwoods ranged from twenty to thirty years old with a few large oak from sixty to seventy years old. Most of the oak and maple were of sprout origin.

The second plantation is specifically located 1½ miles south of Hodenpyle Dam along a Forest Service road near Harrietta. The legal description is SWSW Section 31, T23N, R12W. The area was planted to red pine in 1935 and replanted in 1937. When the study was initiated the pine were fairly uniform in height, varying from four to six feet. The overstory consisted of oak, aspen, red maple, and some cherry and

juneberry. These hardwoods were from thirty to forty years old with some scattered large oak from fifty to sixty years old. Nearly all the oak and maple were of sprout origin.

EXPERIMENTAL DESIGN

The four methods of release and four seasons of the year provided a factorial combination of 16 treatments on the three hardwood species selected for study--oak,[1] aspen and red maple. To provide for statistical testing of the variables involved, a randomized block design was set up with one replication. The two blocks, one in each plantation, were divided into four equal compartments and the four seasons assigned at random. Each compartment was then subdivided into four equal plots to which the four treatments were randomly assigned. The two blocks were laid out in close proximity to a road for both accessibility and demonstration. Each block measured twelve square acres; each plot was ½ acre in size. The number of trees to be tagged for case study had to be kept within the limits of available time and personnel. Therefore, from 15 to 19 trees of each of the three designated species were selected for remeasurement in each of the 16 replicated plots. The total number of selected trees was 1506.

FIELD PROCEDURES

The 16 plots laid out in each test block were made as uniform as possible in regard to site and stocking. Their shape was decided

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[1] Includes both red oak and white oak.

on the basis of topography and other ground factors encountered.

All hardwoods on each plot were treated in 1950 according to the specifications of the designated treatment for that plot.[2] The first 15 to 19 each of oak, aspen and red maple were identified with aluminum tags. A white stake was driven into the ground near each tagged tree, and also at the corner of each block, to facilitate future location. Five to ten tagged trees of each species would probably have been sufficient if all the trees were of the same age. Since, however, the hardwoods treated ranged from one to about twelve inches in diameter, 15 to 19 trees were tagged in order to learn as much as possible about the effects of age and size of the treated trees in relation to sprouting.

Winter operations in Block I were carried out on February 7 and 8, 1950. The temperature during this time ranged from thirty to forty degrees Fahrenheit, with southwest winds of three to five miles per hour. Skies were cloudy to clear with no snowfall. The ground was nearly bare of snow. Winter treatments on Block II were installed on February 21, 1950. The temperature ranged from ten to twenty degrees Fahrenheit; winds from the west blew at eight to ten miles per hour; and snowfall was light to heavy. The ground was covered with snow from eight to twelve inches deep. The sub-freezing temperatures and snowfall greatly hindered the work on this block.

Spring operations on Block I were carried out on May 15 and 16,

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[2] See Section E, Part II, "Detailed Description of Treatments."

1950. The temperature at this time was from fifty to sixty-five degrees Fahrenheit with westerly winds of three to twelve miles per hour. Skies were clear and the ground was dry with very little green vegetation. Spring treatments on Block II were accomplished on May 18 and 19, 1950. The temperature ranged from fifty to seventy degrees Fahrenheit with winds from three to ten miles per hour. Skies were clear to slightly cloudy and the ground was dry with little green vegetation. The efficiency of the crew applying the spray treatments was below average, with the result that the stem sprays were not applied as uniformly as could be done with a more alert crew.

Summer operations on Block I were carried out on July 11 and 13, 1950. The temperature on these days was from sixty to eighty degrees Fahrenheit with westerly winds of three to ten miles per hour. Skies were cloudy to clear and the ground was covered with green herbage in full foliage. Summer treatments on Block II were installed on July 12 and 14, 1950. The temperature ranged from sixty to seventy-five degrees Fahrenheit. Winds were from the southwest at four to fifteen miles per hour. Skies were cloudy to clear and the ground was covered with green herbage in full foliage. There was an abundance of small aspen suckers and cherry seedlings, less than one inch D.B.H. on Block II. These required full treatment to preclude their being included in the subsequent tally of sprout growth. Thus total man hours and cost were higher than usual on Block II. The laborers employed for the summer treatments were exceptionally efficient and industrious as compared to the men used for the winter and spring treatments.

Fall operations on Block I were carried out on September 20 and 21,

1950. The temperature at this time ranged from sixty to sixty-five degrees Fahrenheit with westerly winds of five to eight miles per hour. Skies were cloudy to clear and the ground was covered with green herbage which had started to harden after the growing season before the first frost. The fall treatments on Block II were installed on September 19 and 20, 1950. The temperature ranged from seventy to seventy-five degrees Fahrenheit with south and southwesterly winds up to three miles per hour. Skies were cloudy to clear and the ground was covered with green herbage which had begun to harden off following the summer's growth.

Follow-up inspections were made at subsequent intervals of one and two years to determine the number and growth of the resulting sprouts per treated tree. A follow-up inspection was also made five years later to determine the degree of kill per treated tree.

DATA COLLECTED

The total number of hardwood trees on each plot was tallied by species and one-inch diameter classes at the time of treatment. Weather conditions at time of treatment were also recorded, to include degree of cloudiness, air temperature and wind velocity.

The following initial data at time of treatment were collected by tree number for those trees selected for recurrent observation and measurement: 1. species. 2. D.B.H. to the nearest inch. 3. Height. 4. Crown spread (diameter in feet), and 5. Tree class according to the Lake States Classification System. A record was made of the number of suckers within the vicinity of the treated aspen trees for a distance of 37 feet in order to compare suckering before and after treatment.

The recurrent measurements made in 1952 (two years after the initial treatments) were recorded separately for each tagged tree. They consisted of the number of sprouts, height in inches of each sprout, and vigor of the sprouts. In 1955 (five years after the initial treatments) degree of kill was recorded separately for each treated tree. The man-hours of labor and costs of the chemicals were also recorded for each plot.

DETAILED DESCRIPTION OF TREATMENTS

Treatment number one consisted of the ordinary axe method. Trees less than four inches D.B.H. which were difficult to girdle were cut at stump height. Trees ranging from four to eight inches D.B.H. were peel-girdled (the bark stripped off without cutting through the cambium layer). Trees larger than eight inches D.B.H. were notched- or frill-girdled. The height of the girdling was optional, but averaged about three feet above the ground.

Treatment number two embodied the axe method plus an application of ammate crystals to cups, frills, or cut stumps. The crystalline of ammate was used in this study because previous investigations have found it to be more effective than the various liquid preparations. Trees less than four inches D.B.H. were cut and the sapwood portion of the stump covered with crystals. Wherever possible this operation was simplified by cutting the small trees in such a way as to leave a V-shaped stump and then applying one level tablespoon of ammate per inch of diameter in the V. On trees four to six inches D.B.H. two frills or cups were cut near the base and ammate crystals were placed in them at the rate of one tablespoon per inch of diameter. An extra cup was cut for every two inch increase in diameter on trees larger than six inches.

Treatment number three consisted of a basal spray without mechanical injury to the tree. A 2% solution of Dow Chemical H-978[1] was sprayed on the entire base of each tree to a height of four feet. Great care was exercised to keep the spray off the pines which were to be released.

Treatment number four also entailed a basal spray without mechanical injury to the tree. A 2% solution of Dow Chemical H-9124[2] was sprayed on the entire base of each tree to a height of four feet. The spray was successfully kept off the pines.

PERSONNEL AND AGENCIES PARTICIPATING AND COOPERATING IN THE STUDY

The study was conducted by the Lower Peninsula Forest Research Center of the Lake States Forest Experiment Station in cooperation with the Lower Michigan National Forest, and as part of the regular plantation release work of the forest. The experimental areas, ammate,

[1] An ester of 2,4-D at the rate of four pounds acid equivalent per gallon of diesel oil.

[2] An ester of 2,4,5-T at the rate of four pounds acid equivalent per gallon of diesel oil.

and labor were furnished by the National Forest. The Dow Chemical Company supplied the 2,4-D and the 2,4,5-T. The work plan and technical supervision were furnished by the Research Center.

PART III -- ANALYSIS OF DATA

BASIC INFORMATION OBTAINED

Most of the trees that were treated during the growing season and which subsequently sprouted did so during the same growing season. However, sprouting occurred early in the following growing season on some of the trees treated late in the growing season and on all those treated during the dormant season. Generally, a tree that had not sprouted by the end of the second year following treatment did not sprout at all.

Most of the oak and red maple sprouts originated near the bases or on the stumps of the treated trees; a small percentage appeared as root suckers. Aspen sprouts, however, occurred in equal numbers from both sources.

STATISTICAL METHODS USED IN ANALYSIS

The "F" test was used for each species-treatment combination and if significance resulted studentized ranges were then applied to test for significant differences between seasons in both sprout number and sprout height. The studentized ranges encompass a 5% level and a 1% level new multiple range test, using special protection levels based on degrees of freedom. They were developed by Dr. William D. Baten of Michigan State University.

ANALYSIS OF THE AXE TREATMENT

The average number of sprouts and the average sprout height per treated tree, two years after treatment, diameter classes combined, were computed by species and seasons (Table 1). The same information was computed for the three species combined (Table 2). Since all treated trees died, there is no separate analysis for killed trees only.

Effect of Season on Number of Sprouts Produced by Species. The seasonal differences in the average numbers of oak and red maple sprouts which developed per tree were not significant. However the average numbers of aspen suckers produced per tree after the summer, fall and spring treatments were significantly fewer at the 1% level as compared to the winter treatment.

Effect of Season on Height of Sprouts Produced by Species. The two year average heights of oak sprouts which resulted from the winter and spring treatments were significantly larger (1% level) than those which developed from the summer and fall treatments. The average fall height for oak sprouts was also significantly larger, at 5%, than the summer height. The two year average heights of red maple sprouts which resulted from the winter treatment were significantly larger at the 1% level than those which developed from the summer and fall treatments, while the average height of maple sprouts resulting from spring treatment was significantly larger (1%) than the summer height only. The average height of aspen suckers developed from the summer treatment was significantly smaller at 1% than the winter treatment average height. The spring and fall heights fell between these two extremes and were not significantly different from each other or from summer and winter.

The height growth of the maple sprouts averaged twice that of the oak sprouts. The former ranged from 3.2 feet as the result of summer treatment to 6.8 feet from winter treatment and the latter from 1.9 feet (summer) to 3.0 feet (winter). The height growth of the aspen suckers fell about halfway between that of the oak and maple, being larger than the former and smaller than the latter.

Effect of Season on Number and Height of Sprouts Produced by the Three Species Combined. The average numbers and heights of sprouts developed after the axe treatment in different seasons followed the same pattern for all three species combined as for each species separately. Summer and fall produced fewer sprouts and smaller sprout heights as opposed to winter and spring.[1] The summer and fall sprout numbers were significantly fewer than winter at the 1% level, and summer sprouts were also significantly fewer than spring at the 5% level. In addition, the number of spring sprouts was significantly fewer at 5% than the number for winter. The average height of summer sprouts for the three species combined was significantly smaller at 1% than the winter height only.

Influence of Diameter Range on Sprouting. For the range of diameters included under the axe treatment (1-12 inches) there were no marked differences in the percentages of treated trees which sprouted, due to either size of the tree or to whether it was cut or girdled. Trees of large diameters sprouted as readily as those of small diameters. This was true for all three species and for treatment in each of the four seasons.[2]

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[1] See Table 2.

[2] See Tables 35, 41, 47, and 52 in Appendix.

TABLE 1

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE AXE TREATMENT, BY SPECIES AND SEASON, ALL DIAMETER CLASSES COMBINED, TWO YEARS AFTER TREATMENT

Species	Winter		Spring		Summer		Fall		Seasons Combined	
	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S.E.* (No.)	S.E. (Ht.)
Oak	21	3.0	23	3.0	22	1.9	19	2.1	2.93	.06
Red Maple	10	6.8	9	5.4	9	3.2	10	3.9	1.10	.52
Aspen	24	3.6	9	3.0	4	2.4	5	3.2	1.41	.29

*S.E. = Standard Error = Standard deviation of a season average. S.E. will be defined the same wherever it appears in the text hereafter.

TABLE 2

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE AXE TREATMENT, BY SEASON, DIAMETER CLASSES AND SPECIES COMBINED, TWO YEARS AFTER TREATMENT

Winter		Spring		Summer		Fall		Seasons Combined	
No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S.E. (No.)	S.E. (Ht.)
18	3.8	14	3.5	9	2.3	11	2.7	1.41	.22

Likewise there was no marked difference due to range in diameters in the average number of sprouts produced per treated tree. This is applicable to all species and seasons except oak during each season.[1] However there was a marked difference due to diameter range in the average height of the sprouts which were produced.[2] Height, on the average, decreased with parent tree diameter increase. This held true for treatments during each of the four seasons and for those species which had enough of a diameter range to show a difference, except for oak treated during the fall. Liming[3] obtained similar results in Missouri with oak. He found that sprouts produced by axe-treated trees in the larger diameter classes were smaller and less vigorous than those produced by trees in the smaller diameter classes.

Cost. The average number of man-hours expended per acre for the axe treatment, and thus cost, varied on a wide basis between seasons. It was lowest in the summer and highest in the spring.[4] Typical winter conditions encountered during the operations in that season undoubtedly contributed to the slower productivity experienced at that time.

ANALYSIS OF THE AMMATE TREATMENT

The average number of sprouts and the average sprout height per treated tree, two years after treatment, diameter classes combined,

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[1]See Tables 15, 21, 27, and 31 in Appendix.

[2]Ibid.

[3]Unpublished experimental work during the past ten years on plantation release in Missouri.

[4]See Table 57 in Appendix.

were computed by species and seasons (Table 3). The same information was computed for the three species combined (Table 4). Since all treated trees died, there is no separate analysis for killed trees only.

Effect of Season on Number of Sprouts Produced by Species. The seasonal differences in the average numbers of oak sprouts which developed per tree were not significant. However the average number of red maple sprouts produced per tree after the summer treatment was significantly fewer at 5% than the average number produced after winter treatment. Spring and fall average sprout numbers for red maple fell between these two extremes and were not significantly different from each other or from winter and summer. The average number of aspen suckers produced per tree after both winter and summer treatments was significantly fewer at the 5% level as compared to spring and significantly fewer at the 1% level as compared to fall. There was no significant difference between winter and summer or between spring and fall.

Effect of Season on Height of Sprouts Produced by Species. The seasonal differences in the average heights of oak sprouts which developed per tree were not significant. For red maple, however, the winter average sprout height was significantly larger at the 1% level than the spring, summer and fall heights, and the spring and summer heights were significantly larger than the fall height at 1% and 5% respectively. The seasonal differences in the average heights of aspen suckers which developed were not significant.

As was the case with the axe treatment, the maple sprouts averaged twice the height growth of the oak sprouts. The former ranged from

1.1 feet as the result of fall treatment to 4.0 feet from winter treatment and the latter from 0.9 feet (summer) to 2.0 feet (spring). The average aspen sprout heights were about $2\frac{1}{2}$ and $1\frac{1}{2}$ times the heights of the oak and maple sprouts respectively.

Effect of Season on Number and Height of Sprouts Produced by the Three Species Combined. For all three species combined, the average number of sprouts for each season was significantly different from the average number for each of the other seasons. Fall treatment resulted in the largest average number of sprouts per tree, followed by spring, winter and summer in that order. These differences were at the 1% level except between summer and winter, spring and winter, and fall and spring, which were at the 5% level. For the three species combined there was no significance in the seasonal differences of average sprout height per tree.

Influence of Diameter Range on Sprouting. For the range of diameters included under the ammate treatment (1-12 inches) there were several definite trends, depending upon species, in the percentage of treated trees which sprouted.[1] Oak had the smallest percentages of trees which sprouted and aspen the largest. This was true, on an average, for all diameter classes and seasons. Oak of the larger diameter classes (10 inches D.B.H. and up) did not sprout at all, regardless of season of treatment. Red maple was almost entirely represented by trees in the two and four inch diameter classes. For three of the four seasons, a much greater percentage of the four inch trees sprouted than

[1] See Tables 36, 42, 48 and 53 in Appendix.

TABLE 3

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE AMMATE TREATMENT, BY SPECIES AND SEASON, ALL DIAMETER CLASSES COMBINED, TWO YEARS AFTER TREATMENT

Species	Winter		Spring		Summer		Fall		Seasons Combined	
	No.	(Ft.)	No.	(Ft.)	No.	(Ft.)	No.	(Ft.)	S. E. (No.)	S. E. (Ht.)
Oak	2	1.0	2	2.0	3	0.9	3	1.2	1.19	.01
Red Maple	8	4.0	7	2.7	3	2.2	4	1.1	1.56	.23
Aspen	7	3.1	12	3.6	7	2.5	15	2.8	1.50	.30

TABLE 4

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE AMMATE TREATMENT, BY SEASON, DIAMETER CLASSES AND SPECIES COMBINED, TWO YEARS AFTER TREATMENT

Winter		Spring		Summer		Fall		Seasons Combined	
No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S.E. (No.)	S.E. (Ht.)
5	4.4	6	3.5	4	2.0	7	2.2	.28	.15

did the two inch trees. On an average, aspen of larger diameter classes sprouted more than did those of smaller diameter classes.

There was no marked trend, due to range in diameters, in the average number of sprouts produced per treated tree. This applied to all species and seasons.[1] Some combinations produced more sprouts at larger diameters, some produced more at lower diameters, and some produced fairly equal numbers throughout the entire diameter range.

There was a noticeable difference due to diameter range, although not so definite as with the axe treatment, in the average height of the sprouts which were produced by red maple and aspen, but not with oak.[2] Sprout height, on the average, decreased for aspen and maple as parent tree diameter increased. This was true for most of the season combinations of these two species.

Cost. The number of man-hours expended and the amount of chemical used for the ammate treatment, and thus cost, varied on a rather narrow basis between seasons.[3] The number of man-hours was lowest in the summer and equally highest in the spring and fall while amount of chemical was lowest in the fall and highest in the winter.

ANALYSIS OF THE 2,4-D TREATMENT

The average number of sprouts and the average sprout height per treated tree, two years after treatment, diameter classes combined,

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[1] See Tables 16, 22, 28 and 32 in Appendix.

[2] See Tables 16, 22, 28, and 32 in Appendix.

[3] See Table 57 in Appendix.

were computed by species and seasons (Table 5). The same information was computed for the three species combined (Table 6). Since the 2,4-D treatment did not kill all treated oak and red maple, a separate analysis was done for the individuals of these two species which were dead five years after treatment. Information was computed in the same manner as for treated trees (Table 7).

Effect of Season on Number of Sprouts Produced per Treated Tree. Significantly fewer sprouts were produced per treated oak after fall treatment as compared to summer and spring treatments, at the 5% and 1% levels respectively. The average number of oak sprouts resulting from winter treatment was also significantly smaller at the 1% level than the average number resulting from spring treatment. Fall, spring and summer treatments for red maple each produced significantly fewer sprouts per treated tree (1% level) than did winter treatment. There was no significance in seasonal differences for the average numbers of sprouts produced per treated aspen.

Effect of Season on Height of Sprouts Produced per Treated Tree. There was no significance between the seasonal differences in sprout height for treated oak. As regards average sprout heights for treated maple, the fall and summer heights were each significantly smaller at 1% and the spring height significantly smaller at 5% than the winter height. The summer height for maple was also significantly smaller than the spring height, at the 1% level. The average heights of fall and summer sprouts for aspen were significantly smaller at the 1% level than the heights of winter and spring sprouts. Also, winter height was significantly smaller at 1% than spring height.

Effect of Season on Number and Height of Sprouts Produced by the Three Species Combined. For the three species combined (treated trees) there were no significant differences between the average numbers of sprouts produced after the four seasonal treatments. However, the summer and fall average sprout heights were significantly smaller at 1% than the winter and spring heights.

Influence of Diameter Range on Sprouting of Treated Trees. For the range of diameters included under the 2,4-D treatment there were no definite differences in the percentages of treated trees which sprouted. Trees of larger diameters sprouted as readily as those of smaller diameters.[1] This was true for all three species and for treatment in each of the four seasons.

Likewise, there was no marked trend, due to diameter range, in the average numbers of sprouts produced per treated tree or in the average sprout heights. This applies to all species and seasons.[2]

Effect of Season on Number of Sprouts Produced per Killed Tree. For killed oak the seasonal differences in average number of sprouts per tree was not significant. For killed red maple, however, summer and fall treatments produced significantly fewer sprouts (1% level) and spring significantly fewer sprouts (5% level) than did winter treatment.

Effect of Season on Height of Sprouts Produced per Killed Tree. For both killed oak and killed red maple the seasonal differences in average sprout height per tree were not significant.

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[1]See Tables 37, 43, 49 and 54 in Appendix.

[2]See Tables 17, 23, 29 and 33 in Appendix.

TABLE 5

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE 2, 4-D TREATMENT, BY SPECIES AND SEASON, ALL DIAMETER CLASSES COMBINED, TWO YEARS AFTER TREATMENT

Species	Winter		Spring		Summer		Fall		Seasons Combined	
	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S. E. (No.)	S. E. (Ht.)
Oak	2	1.2	8	2.5	6	1.8	1	2.0	1.45	.55
Red Maple	6	3.7	2	2.8	1	1.7	1	2.3	.54	.20
Aspen	4	3.0	4	4.0	1	2.2	4	1.9	.70	.25

TABLE 6

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE 2, 4-D TREATMENT, BY SEASON, DIAMETER CLASSES AND SPECIES COMBINED, TWO YEARS AFTER TREATMENT

Winter		Spring		Summer		Fall		Seasons Combined	
No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S. E. (No.)	S. E. (Ht.)
4	3.0	5	3.0	3	1.8	2	2.0	2.01	.14

TABLE 7

AVERAGE NUMBER AND HEIGHT OF SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON, ALL DIAMETER CLASSES COMBINED, PER OAK AND RED MAPLE KILLED BY THE 2, 4-D TREATMENT

Species	Winter		Spring		Summer		Fall		Seasons Combined	
	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S. E. (No.)	S. E. (Ht.)
Oak	2	2.3	3	4.0	1	4.2	2	3.3	.97	.11
Red Maple	4	5.6	2	5.9	1	4.5	1	4.6	.63	.60

Influence of Diameter Range on Sprouting of Killed Trees. Diameter range of parent trees had some influence on the number of oak killed by the 2,4-D treatment which subsequently sprouted. Generally a smaller percentage of oak in the larger diameter classes sprouted than did those in the lower diameter classes.[1] Red maple was almost entirely represented by trees in the two and four inch diameter classes; each class sprouted about equally.[2]

There was no marked difference due to diameter range in the average number of red maple sprouts produced per killed tree, but average height of the sprouts from winter and spring treatments increased with diameter increase of parent trees.[3] The average number of oak sprouts produced per killed tree decreased with diameter increase, but there was no definite trend in the average heights of these sprouts due to diameter difference in parent trees.[4]

Cost. The number of man-hours expended varied on a narrow basis between seasons while the amount of chemical used varied on a wide basis.[5] The number of man-hours was lowest in the fall and highest in the spring. Amount of chemical used was lowest in the winter and highest in the summer.

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[1]See Table 38 in Appendix.

[2]See Table 44 in Appendix.

[3]See Table 24 in Appendix.

[4]See Table 18 in Appendix.

[5]See Table 57 in Appendix.

ANALYSIS OF THE 2,4,5-T TREATMENT

The average number of sprouts and the average sprout height per treated tree, two years after treatment, diameter classes combined, were computed by species and seasons (Table 8). The same information was computed for the three species combined (Table 9). Since the 2,4,5-T treatment did not kill all treated oak and red maple, a separate analysis was done for the individuals of these two species which were dead five years after treatment. Information was computed in the same manner as for treated trees (Table 10).

Effect of Season on Number of Sprouts Produced per Treated Tree. There was no significance between the seasonal differences in average number of sprouts produced per treated oak. For red maple, however, fall treatment produced significantly fewer sprouts than did winter treatment (5% level). The average number of sprouts produced per treated aspen after the spring treatment was significantly greater at the 1% level than the average numbers of fall, summer and winter sprouts. In addition, fall and summer treatments produced significantly fewer sprouts per tree at 5% than did winter.

Effect of Season on Height of Sprouts Produced per Treated Tree. For both oak and red maple the average heights of sprouts produced after fall, summer and winter treatments were significantly smaller at 1% than the average height of sprouts resulting from spring treatment. In addition, for maple only, the average fall height was significantly smaller at 1% than the average summer and winter heights. The average heights of aspen sprouts produced after the summer and fall treatments were significantly smaller at the 5% level than the average winter height.

Also, the average fall height was significantly smaller at 5% and the average summer height at 1% than the average spring height.

<u>Effect of Season on Number and Height of Sprouts Produced by the Three Species Combined</u>. For the three species combined the average number of fall sprouts was significantly smaller at the 1% level than the average numbers for summer, winter and spring, and the average numbers for summer and winter were significantly smaller at 1% than the average number for spring. As concerns average sprout height for the three species combined, summer was significantly smaller at 1% than fall, winter and spring; winter was significantly smaller at 1% than fall and spring; and fall was significantly smaller than spring at 5%.

<u>Influence of Diameter Range on Sprouting of Treated Trees</u>. For the range of diameters included under the 2,4,5-T treatment there were a few trends in the percentages of treated trees which sprouted.[1] Fall percentages throughout the diameter ranges for each of the three species were generally smaller than the percentages for the other three seasons. Oak treated during the fall and winter did not sprout at all in the higher diameter classes, and no red maple treated during the fall sprouted. Otherwise, trees of larger diameter classes generally sprouted as readily as those of smaller diameter classes.

There were no marked differences due to diameter range in the average numbers of sprouts produced per treated tree or in the average sprout heights. This applies to all species and seasons.[2]

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[1] See Tables 39, 45, 50 and 55 in Appendix.

[2] See Tables 19, 25, 30 and 34 in Appendix.

Effect of Season on Number of Sprouts Produced per Killed Tree. For killed oak, fall, summer and winter treatments produced significantly fewer sprouts at the 5% level than did spring treatment. For killed red maple the seasonal differences in average number of sprouts produced per tree were not significant.

Effect of Season on Height of Sprouts Produced per Killed Tree. For both killed oak and maple the seasonal differences in average sprout height per tree were not significant.

Influence of Diameter Range on Sprouting of Killed Trees. There were no definite trends due to diameter range in the percentages of oak and red maple which sprouted.[1] Likewise there were no definite trends due to diameter of parent trees in the numbers and average heights of sprouts produced by these two species.[2]

Cost. The number of man-hours expended for the 2,4,5-T treatment varied on a narrow basis between seasons, being lowest in the fall and highest in the spring, while the amount of chemical used varied on a rather wide basis, being equally lowest in the winter and fall and highest in the spring.[3]

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[1] See Tables 40 and 46 in Appendix.

[2] See Tables 20 and 26 in Appendix.

[3] See Table 57 in Appendix.

TABLE 8

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE 2, 4, 5-T TREATMENT, BY SPECIES AND SEASON, ALL DIAMETER CLASSES COMBINED, TWO YEARS AFTER TREATMENT

Species	Winter		Spring		Summer		Fall		Seasons Combined	
	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S. E. (No.)	S. E. (Ht.)
Oak	3	1.7	4	2.4	4	1.6	1	1.5	.91	.17
Red Maple	2	2.1	1	4.2	1	2.1	0	0	1.10	.25
Aspen	6	3.0	13	3.7	3	2.1	2	2.2	.45	.22

TABLE 9

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE RECEIVING THE 2, 4, 5-T TREATMENT, BY SEASON, DIAMETER CLASSES AND SPECIES COMBINED, TWO YEARS AFTER TREATMENT

Winter		Spring		Summer		Fall		Seasons Combined	
No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S. E. (No.)	S. E. (Ht.)
4	2.4	6	3.4	3	1.8	1	3.0	.51	.13

TABLE 10

AVERAGE NUMBER AND HEIGHT OF SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON, ALL DIAMETER CLASSES COMBINED, PER OAK AND RED MAPLE KILLED BY THE 2, 4, 5-T TREATMENT

Species	Winter		Spring		Summer		Fall		Seasons Combined	
	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	No.	Ht. (Ft.)	S. E. (No.)	S. E. (Ht.)
Oak	1	2.4	2	4.5	1	2.7	1	3.0	.28	.37
Red Maple	2	5.6	1	5.9	2	3.7	0	0	.62	.58

COMPARISON OF ALL TREATMENTS BY SEASON

Oak. The average numbers of sprouts and the average sprout heights per treated tree are shown for oak by season and treatment in Table 11. Of the sixteen treatment-season combinations, each of the twelve chemical combinations resulted in far less sprouts than each of the four axe combinations. 2,4-D and 2,4,5-T applied during the fall resulted in the fewest average numbers of sprouts (one sprout each) while the axe treatment during the spring resulted in the highest average number of sprouts (23). As regards average sprout height, eight of the chemical combinations resulted in lower averages than all of the four axe combinations and all of the chemical combinations resulted in lower averages than two of the axe combinations. Ammate applied during the summer resulted in the smallest average sprout height (0.9 feet) while the axe treatment during winter and spring resulted in the largest average sprout heights (3.0 feet each).

Red Maple. The average numbers of sprouts and the average sprout heights per treated tree are shown for red maple by season and treatment in Table 12. Of the sixteen season-treatment combinations, each of the twelve chemical combinations resulted in less sprouts than each of the four axe combinations. 2,4,5-T applied during the fall resulted in the fewest average number of sprouts (none) while the axe treatment during fall and winter resulted in the highest average number of sprouts (ten each). As regards average sprout height, nine of the chemical combinations resulted in lower averages than all of the four axe combinations and all of the chemical combinations resulted in lower averages than two of the axe combinations. 2,4,5-T applied during the fall resulted in the smallest average sprout height (none) while the axe treatment during the winter resulted in the largest average sprout height (6.8 feet).

Aspen. The average numbers of sprouts and the average sprout heights per treated tree are shown for aspen by season and treatment in Table 13. As regards average number of sprouts, the chemical combinations do not stand apart from the axe combinations, as was the case with oak and red maple. 2,4-D applied during the summer resulted in the fewest average number of sprouts (one) while the axe treatment in winter resulted in the highest average number of sprouts (24). The chemical combinations also do not stand apart from the axe combinations in average sprout height. 2,4-D applied during the fall resulted in the smallest average sprout height (1.9 feet) while 2,4-D applied during the spring resulted in the largest average sprout height (4.0 feet).

Oak, Red Maple, and Aspen Combined. The average numbers of sprouts and the average sprout heights are shown for the three species combined by season and treatment in Table 14. Of the sixteen treatment-season combinations, each of the twelve chemical combinations resulted in far less sprouts than each of the four axe combinations. 2,4,5-T applied during the fall resulted in the fewest average number of sprouts (one) while the axe treatment during the winter resulted in the highest average number of sprouts (18). As regards average sprout height, five of the chemical combinations resulted in lower averages than all of the four axe combinations and all of the chemical combinations except two resulted in lower averages than two of the axe combinations. 2,4,5-T and 2,4-D applied during the summer resulted in the smallest average sprout

TABLE 11

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND TREATMENT, ALL DIAMETER CLASSES COMBINED, FOR OAK TWO YEARS AFTER TREATMENT

Season	Treatment	No.	Season	Treatment	Ht.
Fall	2, 4-D	1	Summer	Ammate	0.9
Fall	2, 4, 5-T	1	Winter	Ammate	1.0
Winter	Ammate	2	Fall	Ammate	1.2
Winter	2,4-D	2	Winter	2, 4-D	1.2
Spring	Ammate	2	Fall	2, 4, 5-T	1.5
Winter	2, 4, 5-T	3	Summer	2, 4, 5-T	1.6
Fall	Ammate	3	Winter	2, 4, 5-T	1.7
Summer	Ammate	3	Summer	2, 4-D	1.8
Spring	2, 4, 5-T	4	Summer	Axe	1.9
Summer	2, 4, 5-T	4	Fall	2, 4-D	2.0
Summer	2, 4-D	6	Spring	Ammate	2.0
Spring	2, 4-D	8	Fall	Axe	2.1
Fall	Axe	19	Spring	2, 4, 5-T	2.4
Winter	Axe	21	Spring	2, 4-D	2.5
Summer	Axe	22	Winter	Axe	3.0
Spring	Axe	23	Spring	Axe	3.0

TABLE 12

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND TREATMENT, ALL DIAMETER CLASSES COMBINED, FOR RED MAPLE TWO YEARS AFTER TREATMENT

Season	Treatment	No.	Season	Treatment	Ht.
Fall	2, 4, 5-T	0	Fall	2, 4, 5-T	0
Summer	2, 4-D	1	Fall	Ammate	1.1
Summer	2, 4, 5-T	1	Summer	2, 4-D	1.7
Spring	2, 4, 5-T	1	Winter	2, 4, 5-T	2.1
Fall	2, 4-D	1	Summer	2, 4, 5-T	2.1
Winter	2, 4, 5-T	2	Summer	Ammate	2.2
Spring	2, 4-D	2	Fall	2, 4-D	2.3
Summer	Ammate	3	Spring	Ammate	2.7
Fall	Ammate	4	Spring	2, 4-D	2.8
Winter	2, 4-D	6	Summer	Axe	3.2
Spring	Ammate	7	Winter	2, 4-D	3.7
Winter	Ammate	8	Fall	Axe	3.9
Spring	Axe	9	Winter	Ammate	4.0
Summer	Axe	9	Spring	2, 4, 5-T	4.2
Winter	Axe	10	Spring	Axe	5.4
Fall	Axe	10	Winter	Axe	6.8

TABLE 13

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND TREATMENT, ALL DIAMETER CLASSES COMBINED, FOR ASPEN TWO YEARS AFTER TREATMENT

Season	Treatment	No.	Season	Treatment	Ht.
Summer	2, 4-D	1	Fall	2, 4-D	1.9
Fall	2, 4, 5-T	2	Summer	2, 4, 5-T	2.1
Summer	2, 4, 5-T	3	Fall	2, 4, 5-T	2.2
Fall	2, 4-D	4	Summer	2, 4-D	2.2
Winter	2, 4-D	4	Summer	Axe	2.4
Spring	2, 4-D	4	Summer	Ammate	2.5
Summer	Axe	4	Fall	Ammate	2.8
Fall	Axe	5	Winter	2, 4-D	3.0
Winter	2, 4, 5-T	6	Winter	2, 4, 5-T	3.0
Winter	Ammate	7	Spring	Axe	3.0
Summer	Ammate	7	Winter	Ammate	3.1
Spring	Axe	9	Fall	Axe	3.2
Spring	Ammate	12	Spring	Ammate	3.6
Spring	2, 4, 5-T	13	Winter	Axe	3.6
Fall	Ammate	15	Spring	2, 4, 5-T	3.7
Winter	Axe	24	Spring	2, 4-D	4.0

sprouts per tree than did spring treatment in one case and winter treatment in the other case.

Sprout Height. The analysis for treated trees by species was concerned with three species and four treatments, for a total of twelve combinations. For three of these combinations, namely oak and ammate, oak and 2,4-D, and aspen and ammate, there were no significant seasonal differences between average heights of sprouts produced per tree. Of the nine remaining combinations, however, either summer treatment or fall treatment or both resulted in a significantly smaller average sprout height per tree than did spring treatment or winter treatment or both.

The analysis for treated trees with the three species combined was concerned with four treatments, for a total of four combinations. For the ammate treatment there were no significant seasonal differences between average heights of sprouts produced per tree. Of the three remaining combinations, however, either summer treatment or fall treatment or both resulted in a significantly smaller average sprout height per tree than did spring treatment or winter treatment or both.

The analysis for killed trees was concerned with two species and two treatments, for a total of four combinations. Not any of these combinations had significant seasonal differences between average heights of sprouts produced per tree.

Influence of Diameter Range. With the exception of the ammate treatment, treated trees of larger diameter classes generally sprouted as readily as those of smaller diameter classes. As regards the ammate treatment, large oak did not sprout at all; more four-inch red maple

sprouted than did two-inch red maple; and more aspen of large diameter classes sprouted than did aspen of small diameter classes.

Diameter range of parent trees generally had no effect on the average number of sprouts produced per tree, but in some instances had an effect on the average height of sprouts produced per tree. The height of sprouts resulting from the axe and ammate treatments generally decreased with diameter increase of parent trees.

Conclusions. Under the range of conditions characterizing the study, season of application of the four hardwood release methods studied has a definite effect, for certain species-treatment combinations, on the number and height of sprouts which subsequently develop. Certain factors which may have influenced the results of the study must be taken into consideration, however.

Fall or summer would seem to be the best time of the year to apply any of the four release methods for control of at least one, and in some cases two, of the three hardwood species studied, which fall into the two- to twelve-inch D.B.H. class. The species for which fall and summer treatments seem to be the most effective are not the same for each release method, but vary between methods. In a situation where oak, aspen and red maple from two to twelve inches D.B.H. occur in equal numbers, and control by individual species is not desired, each treatment except 2,4-D would seem to be the most effective if applied during fall or summer. 2,4-D in such a case seems to be equally effective if applied during any season.

Some of the sprouts resulting from summer treatment which were produced during that same growing season may have been killed by adverse fall and winter weather conditions soon after they appeared. However sprouts resulting from fall treatment did not appear until the following growing season and they were generally as few in number as the summer produced sprouts.

Sprout height was measured two years after treatment. During these periods sprouts produced after treatment during one season may have had more favorable or more adverse growing seasons than sprouts produced after treatment during another season. Browsing by wildlife may have occurred on some sprouts and not on others. These and other factors may have influenced sprout height. Overhead shade was not an influencing factor, however, since the hardwoods selected for study were all in the open and not over-topped by other hardwoods.

Before it could definitely be concluded that summer and fall hardwood release is the most effective for certain treatment-species combinations in lower Michigan, more intensive studies would have to be made of the influence of the several variable factors involved. The importance of such work cannot be overemphasized; if a definite time of year can be absolutely established as being most effective for a certain combination of treatments, species, and conditions, much time and money can be saved by lessening the amount of re-release work.

PART IV -- APPENDIX

TABLE 15

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE AXE TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	17	3.0	11	2.9	21	2.2	24	2.2
4	25	3.1	22	2.4	23	1.8	18	2.3
6	28	3.5	32	2.7	11	1.9	11	1.8
8	14	0.9	31	4.7	20	2.1	16	2.8
10	9	4.1	13	1.3	20	0.9	20	2.8
12	7	1.5	9	1.2	10	1.6	29	3.3

TABLE 16

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE AMMATE TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	4	1.8	2	2.5	3	1.0	7	1.5
4	2	0.2	6	2.4	4	0.8	1	0.3
6	1	0.5	0	0	1	0.2	5	1.0
8	2	1.4	5	1.4	2	1.6	0	0
10	0	0	0	0	0	0	0	0
12	0	0	-	-	4	0.7	2	2.6

TABLE 17

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE 2, 4-D TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	6	1.3	12	2.2	9	1.6	2	0.9
4	1	0.8	6	2.3	5	1.4	1	1.2
6	1	0.1	15	2.7	3	2.6	1	2.0
8	0	0	0	0	9	2.3	0	0
10	0	0	1	0.9	20	1.9	5	2.6
12	0	0	-	-	0	0	0	0

TABLE 18

AVERAGE NUMBER AND HEIGHT OF SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, PER OAK KILLED BY THE 2, 4-D TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	4	1.5	6	3.3	5	1.2	9	2.4
4	2	2.3	5	3.3	1	0.9	8	3.1
6	-	-	5	2.2	2	2.1	3	2.2
8	0	0	0	0	0	0	-	-
10	-	-	-	-	0	0	3	2.0
12	-	-	-	-	-	-	-	-

TABLE 19

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE 2, 4, 5-T TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	4	1.6	4	1.5	6	1.3	1	0.8
4	5	1.7	4	2.6	4	1.6	1	2.6
6	0	0	4	2.9	4	1.6	1	0.6
8	0	0	3	2.5	1	0.7	1	1.0
10	0	0	1	0.5	5	2.2	0	0
12	0	0	3	2.0	0	0	0	0

TABLE 20

AVERAGE NUMBER AND HEIGHT OF SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, PER OAK KILLED BY THE 2, 4, 5-T TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	5	2.0	1	0.6	0	0	1	0.6
4	3	0.7	3	1.7	1	0.5	2	2.7
6	-	-	1	1.2	1	0.3	2	0.7
8	-	-	0	0	0	0	4	4.4
10	-	-	0	0	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 21

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE AXE TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	8	5.5	8	5.3	8	2.7	9	5.1
4	15	8.2	13	8.9	12	3.3	13	3.2
6	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 22

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE AMMATE TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	5	3.9	7	2.7	3	2.3	4	1.0
4	14	4.0	8	2.7	3	1.7	5	1.4
6	-	-	0	0	0	0	-	-
8	-	-	-	-	0	0	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 23

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE 2, 4-D TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	6	3.5	3	2.6	1	1.7	2	2.3
4	10	4.6	1	4.0	0	0	0	0
6	-	-	6	1.3	-	-	-	-
8	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 24

AVERAGE NUMBER AND HEIGHT OF SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, PER RED MAPLE KILLED BY THE 2, 4-D TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	4	5.1	2	3.1	1	1.7	1	1.8
4	12	7.6	2	4.1	1	1.2	0	0
6	-	-	4	7.9	-	-	-	-
8	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 25

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE 2, 4, 5-T TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	2	2.4	1	5.1	1	2.1	0	0
4	2	0.9	2	2.5	0	0	0	0
6	-	-	1	2.0	-	-	0	0
8	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 26

AVERAGE NUMBER AND HEIGHT OF SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, PER RED MAPLE KILLED BY THE 2, 4, 5-T TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	1	2.6	1	2.7	1	0.9	0	0
4	1	1.7	1	0.9	0	0	0	0
6	-	-	1	4.3	-	-	0	0
8	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 27

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE AXE TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	20	4.3	3	2.8	1	2.0	3	3.2
4	43	4.6	2	3.5	2	4.0	1	3.9
6	-	-	-	-	3	3.5	10	6.0
8	20	4.0	-	-	1	2.0	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 28

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE AMMATE TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	3	3.5	12	2.6	3	5.5	5	3.3
4	5	2.8	12	4.5	5	2.6	1	2.4
6	6	3.0	11	6.1	10	2.0	1	4.7
8	6	2.0	-	-	-	-	3	2.0
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 29

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE 2, 4-D TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	1	2.0	6	4.3	0	0	0	0
4	1	4.5	6	5.0	0	0	0	0
6	2	6.0	0	0	-	-	0	0
8	-	-	-	-	-	-	0	0
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 30

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE 2, 4, 5-T TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	1	2.1	7	4.9	0	0	0	0
4	1	3.0	19	3.7	0	0	0	0
6	-	-	10	4.4	0	0	-	-
8	-	-	-	-	0	0	-	-
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

TABLE 31

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ALL SPECIES COMBINED RECEIVING THE AXE TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	11	4.9	7	4.4	9	2.4	11	4.3
4	29	4.6	18	4.4	17	2.5	11	3.1
6	28	3.5	32	2.7	9	2.4	11	2.3
8	16	1.7	31	4.7	17	2.1	16	2.9
10	9	4.1	13	1.3	20	0.9	20	2.8
12	7	1.5	9	1.2	10	1.6	29	3.3

TABLE 32

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ALL SPECIES COMBINED RECEIVING THE AMMATE TREATMENT TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	4	3.5	7	2.7	3	2.6	5	1.3
4	7	3.3	9	2.0	4	1.6	2	1.2
6	2	1.6	11	6.1	2	1.3	3	1.6
8	3	1.6	5	1.4	2	1.6	3	2.0
10	0	0	0	0	0	0	0	0
12	0	0	0	0	4	0.7	2	2.6

TABLE 33

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ALL SPECIES COMBINED RECEIVING THE 2, 4-D TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	5	2.7	5	2.8	2	1.2	2	1.8
4	2	2.8	4	3.8	4	1.0	1	0.5
6	1	2.1	13	2.4	3	2.6	1	2.0
8	0	0	0	0	9	2.3	0	0
10	0	0	1	0.9	20	1.9	5	2.6
12	0	0	-	-	0	0	0	0

TABLE 34

AVERAGE NUMBER AND HEIGHT OF SPROUTS PER TREE, BY SEASON AND DIAMETER CLASS, FOR ALL SPECIES COMBINED RECEIVING THE 2, 4, 5-T TREATMENT, TWO YEARS AFTER TREATMENT

DBH Class	Winter		Spring		Summer		Fall	
	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)	No.	Ht.(Ft.)
2	2	2.2	3	4.5	1	1.6	0	0
4	3	2.0	6	2.8	2	0.8	1	1.0
6	0	0	5	2.1	4	1.5	1	0.5
8	0	0	3	2.5	1	0.7	1	1.0
10	0	0	1	0.5	5	2.2	0	0
12	0	0	3	2.0	0	0	0	0

TABLE 35

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE AXE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	100	100	100	100
4	92	100	100	100
6	88	100	100	100
8	33	100	84	100
10	100	50	100	100
12	100	100	66	100

TABLE 36

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE AMMATE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	17	17	21	60
4	15	60	25	9
6	13	7	17	20
8	13	17	20	0
10	0	0	0	0
12	0	-	-	0

TABLE 37

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE 2, 4-D TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	75	75	100	100
4	20	90	92	22
6	50	82	50	33
8	17	0	75	0
10	0	40	50	50
12	0	-	-	0

TABLE 38

PERCENTAGE OF TREES PRODUCING SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR OAK KILLED BY THE 2, 4-D TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	78	75	40	100
4	75	67	18	100
6	-	60	40	50
8	0	0	20	-
10	-	-	0	50
12	-	-	-	-

TABLE 39

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR OAK RECEIVING THE 2, 4, 5-T TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	71	67	50	20
4	53	86	67	36
6	20	50	50	29
8	0	57	33	33
10	0	50	67	0
12	0	100	0	0

TABLE 40

PERCENTAGE OF TREES PRODUCING SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR OAK KILLED BY THE 2, 4, 5-T TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	67	20	0	67
4	29	29	22	29
6	-	17	20	-
8	-	20	0	-
10	-	0	0	-
12	-	-	-	-

TABLE 41

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE AXE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	100	100	70	100
4	100	100	60	100
6	-	-	-	-
8	-	-	-	100
10	-	-	-	-
12	-	-	-	-

TABLE 42

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE AMMATE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	45	65	29	60
4	60	60	60	80
6	-	0	0	-
8	-	-	0	-
10	-	-	-	-
12	-	-	-	-

TABLE 43

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE 2, 4-D TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	85	75	33	33
4	100	36	0	0
6	-	66	-	-
8	-	-	-	-
10	-	-	-	-
12	-	-	-	-

TABLE 44

PERCENTAGE OF TREES PRODUCING SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE KILLED BY THE 2, 4-D TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	85	63	33	39
4	100	60	33	0
6	-	100	-	-
8	-	-	-	-
10	-	-	-	-
12	-	-	-	-

TABLE 45

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE RECEIVING THE 2, 4, 5-T TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	65	34	26	0
4	75	33	0	0
6	0	75	-	0
8	-	-	-	-
10	-	-	-	-
12	-	-	-	-

TABLE 46

PERCENTAGE OF TREES PRODUCING SPROUTS FIVE YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR RED MAPLE KILLED BY THE 2, 4, 5-T TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	53	42	24	0
4	50	33	0	0
6	-	100	-	0
8	-	-	-	-
10	-	-	-	-
12	-	-	-	-

TABLE 47

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE AXE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	100	75	78	80
4	100	100	100	67
6	-	0	100	0
8	100	-	100	100
10	-	-	-	-
12	-	-	-	-

TABLE 48

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE AMMATE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	60	40	40	100
4	100	80	100	60
6	100	75	100	63
8	100	-	-	100
10	-	-	-	-
12	-	-	-	-

TABLE 49

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE 2, 4-D TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	33	50	0	0
4	38	50	0	0
6	100	0	-	0
8	-	-	-	-
10	-	-	-	-
12	-	-	-	-

TABLE 50

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON AND DIAMETER CLASS, FOR ASPEN RECEIVING THE 2, 4, 5-T TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	67	50	0	0
4	67	100	0	13
6	-	40	0	-
8	-	-	-	-
10	-	-	-	-
12	-	-	-	-

TABLE 51

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT; BY SPECIES, TREATMENT, AND SEASON; ALL DIAMETER CLASSES COMBINED

Species	Treatment	Winter	Spring	Summer	Fall
Oak	Axe	88	97	94	97
Oak	Ammate	16	19	24	20
Oak	2,4-D	37	68	73	30
Oak	2,4,5-T	39	65	52	26
Red Maple	Axe	100	100	67	100
Red Maple	Ammate	48	63	28	63
Red Maple	2,4-D	87	59	26	27
Red Maple	2,4,5-T	66	60	28	0
Aspen	Axe	100	87	93	87
Aspen	Ammate	93	83	90	83
Aspen	2,4-D	70	69	50	54
Aspen	2,4,5-T	83	76	50	48

TABLE 52

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY DIAMETER CLASS AND SEASON, FOR ALL SPECIES COMBINED RECEIVING THE AXE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	100	79	91	97
4	100	86	100	88
6	92	100	93	100
8	67	92	100	100
10	100	83	50	100
12	100	-	100	100

TABLE 53

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT,
BY DIAMETER CLASS AND SEASON,
FOR ALL SPECIES COMBINED
RECEIVING THE AMMATE TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	46	24	50	63
4	50	46	52	32
6	23	25	26	40
8	15	17	10	10
10	0	-	0	0
12	0	100	0	0

TABLE 54

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY DIAMETER CLASS AND SEASON, FOR ALL SPECIES COMBINED RECEIVING THE 2, 4-D TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	77	36	75	31
4	36	69	57	10
6	33	47	84	30
8	17	50	0	0
10	0	25	42	50
12	0	-	-	0

TABLE 55

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY DIAMETER CLASS AND SEASON, FOR ALL SPECIES COMBINED RECEIVING THE 2, 4, 5-T TREATMENT

DBH Class	Winter	Spring	Summer	Fall
2	71	27	44	7
4	62	36	66	17
6	13	41	51	34
8	0	33	75	33
10	0	33	50	0
12	0	0	50	0

TABLE 56

PERCENTAGE OF TREES PRODUCING SPROUTS, TWO YEARS AFTER TREATMENT, BY SEASON, ALL SPECIES AND DIAMETER CLASSES COMBINED, FOR THE AXE, AMMATE, 2, 4-D, AND 2, 4, 5-T TREATMENTS

Treatment	Winter	Spring	Summer	Fall
Axe	96	94	85	95
Ammate	49	53	48	54
2, 4-D	63	65	53	36
2, 4, 5-T	61	62	43	26

TABLE 57

COSTS PER TREATMENT BY SEASON

(IN MAN HOURS AND AMOUNTS OF SILVICIDES)

Treat-ment	Winter		Spring		Summer		Fall	
	Man Hours	Chemical (Lbs.)	Man Hours	Chemical (Lbs.)	Man Hours	Chemical (Lbs.)	Man Hours	Chemical (Lbs.)
Axe	8.3	None	9.9	None	5.3	None	7.6	None
Ammate	10.3	27.1	11.2	24.8	9.2	25.0	11.2	23.8
2,4-D	6.3	94.0	6.4	165.6	5.3	178.1	4.3	137.5
2,4,5-T	4.5	125.0	5.8	189.1	4.8	143.8	4.2	125.0

A P P E N D I X

ANALYSIS OF VARIANCE

NUMBER OF SPROUTS -- OAK -- AXE TREATMENT

Source	DF	MS
Total	136	287.0
Seasons	3	93.0
Error	133	291.0

F = .32 = no significance

S.E. = 2.93

There was no significance between seasons.

NUMBER OF SPROUTS -- RED MAPLE -- AXE TREATMENT

Source	DF	MS
Total	119	38.9
Seasons	3	5.3
Error	116	39.8

F = .13 = no significance

S.E. = 1.10

There was no significance between seasons.

NUMBER OF SPROUTS -- ASPEN -- AXE TREATMENT

Source	DF	MS
Total	117	128.0
Seasons	3	2686.0
Error	114	61.0

F = 44.0 = 1% significance

S.E. = 1.41

By use of studentized ranges it was determined that summer, fall, and spring are significantly different at 1% from winter.

NUMBER OF SPROUTS -- OAK -- AMMATE TREATMENT

Source	DF	MS
Total	135	47.2
Seasons	3	7.7
Error	132	48.1

F = .16 =

no significance

S.E. = 1.19

There was no significance between seasons.

NUMBER OF SPROUTS -- RED MAPLE -- AMMATE TREATMENT

Source	DF	MS
Total	118	70.4
Seasons	3	186.5
Error	115	67.3

F = 2.77 =

5% significance

S.E. = 1.50

By use of studentized ranges it was determined that summer is significantly different at 5% from winter.

NUMBER OF SPROUTS -- ASPEN -- AMMATE TREATMENT

Source	DF	MS
Total	119	78.1
Seasons	3	399.7
Error	116	69.8

F = 5.73 =

1% significance

S.E. = 1.56

By use of studentized ranges it was determined that summer and winter are significantly different at 5% from spring and at 1% from fall.

NUMBER OF SPROUTS -- OAK -- 2, 4-D TREATMENT

Source	DF	MS
Total	138	79.7
Seasons	3	378.0
Error	135	73.0

F = 5.20 = 1% significance

S.E. = 1.45

By use of studentized ranges it was determined that fall is significantly different at 5% from summer and at 1% from spring and that winter is significantly different at 1% from spring.

NUMBER OF SPROUTS -- RED MAPLE -- 2, 4-D TREATMENT

Source	DF	MS
Total	117	18.0
Seasons	3	178.0
Error	114	14.0

F = 12.70 = 1% significance

S.E. = .70

By use of studentized ranges it was determined that fall, winter, and spring are significantly different at 1% from winter.

NUMBER OF SPROUTS -- ASPEN -- 2, 4-D TREATMENT

Source	DF	MS
Total	116	8.4
Seasons	3	11.4
Error	113	8.3

F = 1.38 = no significance

S.E. = 54

There was no significance between seasons.

NUMBER OF SPROUTS -- OAK -- 2, 4, 5-T TREATMENT

Source	DF	MS	
Total	136	29.2	F = 2.06 = no significance
Season	3	58.9	
Error	133	28.6	S.E. = .91

There was no significance between seasons.

NUMBER OF SPROUTS -- RED MAPLE -- 2, 4, 5-T TREATMENT

Source	DF	MS	
Total	117	6.3	F = 2.83 = 5% significance
Season	3	17.0	
Error	114	6.0	S.E. = .45

By use of studentized ranges it was determined that fall is significantly different at 5% from winter.

NUMBER OF SPROUTS -- ASPEN -- 2, 4, 5-T TREATMENT

Source	DF	MS	
Total	121	46.5	F = 35.80 = 1% significance
Season	3	894.0	
Error	118	25.0	S.E. = 1.10

By use of studentized ranges it was determined that fall, summer, and winter are significantly different at 1% from spring and that fall and summer are significantly different at 5% from winter.

NUMBER OF SPROUTS -- ALL SPECIES -- AXE TREATMENT

Source	DF	MS	
			F = 5.33 =
Total	374	195.6	1% significance
Seasons	3	1006.7	
Error	371	189.0	S.E. = 1.41

By use of studentized ranges it was determined that fall and summer are significantly different at 1% from winter; that spring is significantly different at 5% from winter; and that summer is significantly different at 5% from spring.

NUMBER OF SPROUTS -- ALL SPECIES -- AMMATE TREATMENT

Source	DF	MS	
			F = 2.91 =
Total	380	73.3	5% significance
Seasons	3	210.0	
Error	377	72.0	S.E. = .28

By use of studentized ranges it was determined that fall is significantly different from spring at 5% and from winter and summer at 1%; that spring is significantly different from winter at 5% and from summer at 1%; and that winter is significantly different from summer at 5%.

NUMBER OF SPROUTS -- ALL SPECIES -- 2, 4-D TREATMENT

Source	DF	MS
Total	373	39
Seasons	3	159
Error	370	38

F = 4.10 =

1% significance

S.E. = 2.01

There was no significance between seasons.

NUMBER OF SPROUTS -- ALL SPECIES -- 2, 4, 5-T TREATMENT

Source	DF	MS
Total	375	30.9
Seasons	3	772.0
Error	372	25.0

F = 30.90 =

1% significance

S.E. = .51

By use of studentized ranges it was determined that fall is significantly different at 1% from summer, winter, and spring and that summer and winter are significantly different at 1% from spring.

NUMBER OF SPROUTS -- KILLED OAK -- 2, 4-D TREATMENT

Source	DF	MS
Total	72	18.6
Seasons	3	51.0
Error	69	17.2

F = 3.0 = 5% significance

S.E. = .97

By use of studentized ranges it was determined that there was no significance between seasons.

NUMBER OF SPROUTS -- KILLED OAK -- 2, 4, 5-T TREATMENT

Source	DF	MS
Total	66	5.1
Seasons	3	27.7
Error	63	1.3

F = 21.3 = 1% significance

S.E. = .28

By use of studentized ranges it was determined that fall, summer and winter are significantly different at 5% from spring.

NUMBER OF SPROUTS -- KILLED RED MAPLE -- 2, 4-D TREATMENT

Source	DF	MS
Total	81	11.3
Seasons	3	98.0
Error	78	8.0

F = 12.3 = 1% significance

S.E. = .63

By use of studentized ranges it was determined that fall and summer are significantly different at 1% from winter and that spring is significantly different at 5% from winter.

NUMBER OF SPROUTS -- KILLED RED MAPLE -- 2, 4, 5-T TREATMENT

Source	DF	MS	
			F = 1.4 =
Total	84	8.1	no significance
Seasons	3	11.3	
Error	81	8.0	
			S.E. = .62

There was no significance between seasons.

SPROUT HEIGHT -- OAK -- AXE TREATMENT

Source	DF	MS	
			F = 3.7 =
Total	138	1.2	1% significance
Seasons	3	4.1	
Error	135	1.1	
			S.E. = 0.6

By use of studentized ranges it was determined that fall and summer are significantly different at 1% from winter and spring and that fall is significantly different at 5% from summer.

SPROUT HEIGHT -- RED MAPLE -- AXE TREATMENT

Source	DF	MS	
			F = 11.1 =
Total	119	7.8	1% significance
Seasons	3	89.8	
Error	116	8.1	
			S.E. = .52

By use of studentized ranges it was determined that winter is significantly different at 1% from fall and summer and that spring is significantly different at 1% from summer.

SPROUT HEIGHT -- ASPEN -- AXE TREATMENT

Source	DF	MS
Total	117	2.8
Seasons	3	12.8
Error	114	2.5

F = 5.1 =

1% significance

S.E. = .29

By use of studentized ranges it was determined that winter is significantly different at 1% from summer.

SPROUT HEIGHT -- OAK -- AMMATE TREATMENT

Source	DF	MS
Total	138	.3
Seasons	3	.2
Error	135	.3

F = .54 =

no significance

S.E. = .009

There was no significance between seasons.

SPROUT HEIGHT -- RED MAPLE -- AMMATE TREATMENT

Source	DF	MS
Total	119	3.0
Seasons	3	11.6
Error	116	2.7

F = 4.3 =

1% significance

S.E. = .30

By use of studentized ranges it was determined that winter is significantly different at 1% from spring, summer, and fall; that spring is significantly different at 1% from fall, and that summer is significantly different at 5% from fall.

SPROUT HEIGHT -- ASPEN -- AMMATE TREATMENT

Source	DF	MS
Total	119	.2
Seasons	3	1.7
Error	116	1.6

F = 1.08 = no significance

S.E. = .23

There was no significance between seasons.

SPROUT HEIGHT -- OAK -- 2, 4-D TREATMENT

Source	DF	MS
Total	140	1.2
Seasons	3	57.0
Error	137	1.0

F = 57.0 = 1% significance

S.E. = .55

By use of studentized ranges it was determined that there was no significance between seasons.

SPROUT HEIGHT -- RED MAPLE -- 2, 4-D TREATMENT

Source	DF	MS
Total	119	2.6
Seasons	3	30.0
Error	116	1.9

F = 15.9 = 1% significance

S.E. = .25

By use of studentized ranges it was determined that winter is significantly different at 5% from spring and at 1% from fall and summer; and that spring is significantly different at 1% from summer.

SPROUT HEIGHT -- ASPEN -- 2, 4-D TREATMENT

Source	DF	MS	
Total	119	1.3	F = 2.7 = 5% significance
Seasons	3	3.1	
Error	116	1.2	S.E. = .20

By use of studentized ranges it was determined that fall and summer are significantly different at 1% from winter and spring and that winter is significantly different at 1% from spring.

SPROUT HEIGHT -- OAK -- 2, 4, 5-T TREATMENT

Source	DF	MS	
Total	137	1.1	F = 5.94 = 1% significance
Seasons	3	5.7	
Error	134	1.0	S.E. = .17

By use of studentized ranges it was determined that fall, summer and winter are significantly different at 1% from spring.

SPROUT HEIGHT -- RED MAPLE -- 2, 4, 5-T TREATMENT

Source	DF	MS	
Total	118	1.7	F = 9.2 = 1% significance
Seasons	3	13.0	
Error	115	1.4	S.E. = .22

By use of studentized ranges it was determined that fall is significantly different at 1% from spring, winter and summer and that summer and winter are significantly different at 1% from spring.

SPROUT HEIGHT -- ASPEN -- 2, 4, 5-T TREATMENT

Source	DF	MS	
			F = 15.0 =
Total	119	2.4	1% significance
Seasons	3	27.0	
Error	116	1.8	
			S.E. = .25

By use of studentized ranges it was determined that summer is significantly different at 5% from winter and at 1% from spring and that fall is significantly different at 5% from winter and spring.

SPROUT HEIGHT -- ALL SPECIES -- AME TREATMENT

Source	DF	MS	
			F = 11.1 =
Total	374	5.1	1% significance
Seasons	3	52.0	
Error	371	4.7	
			S.E. = .22

By use of studentized ranges it was determined that summer is significantly different at 1% from spring and winter and that fall is significantly different at 1% from winter.

SPROUT HEIGHT -- ALL SPECIES -- AMMATE TREATMENT

Source	DF	MS	
			F = 2.2 =
Total	378	2.3	no significance
Seasons	3	5.0	
Error	375	2.3	
			S.E. = .15

There was no significance between seasons.

SPROUT HEIGHT -- ALL SPECIES -- 2, 4-D TREATMENT

Source	DF	MS
Total	380	2.4
Seasons	3	72.0
Error	377	1.9

F = 38.5 =

1% significance

S.E. = .14

By use of studentized ranges it was determined that summer and fall are significantly different at 1% from spring and winter.

SPROUT HEIGHT -- ALL SPECIES -- 2, 4, 5-T TREATMENT

Source	DF	MS
Total	375	1.9
Seasons	3	30.0
Error	372	1.7

F = 17.6 =

1% significance

S.E. = .13

By use of studentized ranges it was determined that summer is significantly different at 1% from winter, fall and spring; that winter is significantly different at 1% from fall and spring; and that fall is significantly different at 5% from spring.

SPROUT HEIGHT -- KILLED OAK -- 2, 4-D TREATMENT

Source	DF	MS
Total	72	55.5
Seasons	3	7.7
Error	69	5.5

F = 1.4 =

no significance

S.E. = .11

There was no significance between seasons.

SPROUT HEIGHT -- KILLED OAK -- 2, 4, 5-T TREATMENT

Source	DF	MS	
Total	66	3.1	F = 1.4 = no significance
Seasons	3	5.0	
Error	63	3.5	S.E. = .37

There was no significance between seasons.

SPROUT HEIGHT -- KILLED RED MAPLE -- 2, 4-D TREATMENT

Source	DF	MS	
Total	81	10.0	F = 11.5 = 1% significance
Seasons	3	83.0	
Error	78	7.2	S.E. = .60

By use of studentized ranges it was determined that there was no significance between seasons.

SPROUT HEIGHT -- KILLED RED MAPLE -- 2, 4, 5-T TREATMENT

Source	DF	MS	
Total	84	7.1	F = .80 = no significance
Seasons	3	5.7	
Error	81	7.1	S.E. - .58

There was no significance between seasons.

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