CANADA

Department of Forestry

EFFECTIVENESS OF THREE CHEMICALS FOR KILLING DEFECTIVE SUGAR MAPLE AND ASSOCIATED SPECIES

by

D. C. F. Fayle

Forest Research Division
Technical Note No. 99
1961

Published under the authority of
The Honourable Hugh John Flemming, P.C., M.P.,
Minister of Forestry
Ottawa, 1961

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1961

CONTENTS

90383-1—2

PREFACE

The experiments described in this report were established mainly by Mr. J. M. Jarvis of the Department of Forestry, who also supervised remeasurements until 1956. The author continued the work in 1957 and 1958.

Effectiveness of Three Chemicals for Killing Defective Sugar Maple and Associated Species

by

D. C. F. FAYLE[1]

(Projects H-70, H-92, and H-94)

INTRODUCTION

A high proportion of the sugar maple[2] dominating most of the tolerant hardwood stands of Ontario and Quebec is defective and not utilized under present market conditions. As a result, only a small proportion of the merchantable-sized maple is cut, and the residual stands contain much defective material. In addition, these light cuts release few of the sugar maple in the understorey. Slow growth in young maple increases the chance that the future crop also will be largely defective, because wounds are slow to heal, and disease and stain can develop. Therefore, the gradual elimination of defective stems of all sizes is a necessary step in stand improvement. Removal of these trees will help also to provide sufficient light for the development of any established yellow birch regeneration.

The undesirable trees can be destroyed by felling, girdling or chemical treatment. As many of the trees to be removed have large diameters and crowns, felling, although the surest way of elimination, would be costly, and likely to result in damage to those trees which constitute the future growing stock. With girdling or poisoning, however, the crowns disintegrate slowly over a period of years causing little damage to the understorey, and the canopy is opened less abruptly, avoiding the dangers of sudden exposure.

The trunks of large sugar maple are often fluted and seamed, making complete girdling of a stem extremely difficult. If the cambium layer is not completely severed, trees are likely to recover. The recommended method is to notch girdle by cutting a gap about 4 inches wide and at least 2 inches deep into the sapwood all around the tree. Provided adequate care is taken in notch girdling, 80 per cent of the girdled trees may be dead after three years, and over 95 per cent dead by the end of eight years (Engle 1948, Stoeckeler and Arbogast 1947). If poisons are applied, however, less time-consuming techniques can be used to provide the same and often quicker and more certain results. At the same time, the risk of sprouting is decreased.

For those reasons, chemicals were used to kill defective sugar maple and associated species in various silvicultural experiments conducted by the Forestry Branch. The chemicals used were ammonium sulphamate, sodium arsenite, and a mixture of 2,4-D and 2,4,5-T in diesel oil. Differences in the species, number and size of trees treated, location, methods used, concentration of chemicals, and the quantity applied to the trees do not permit statistical analysis of the data. However, despite the various differences, trends are recognizable. By additional reference to results described in the literature, conclusions and recommendations concerning the effectiveness of treatment methods are presented.

---

[1] Forestry Officer, Forest Research Division, Ontario District Office, Ottawa.

[2] A list of species showing common name, abbreviation, and botanical name is given in the Appendix.

90383-1—2½

TREATMENT METHODS

All treatments were made after the leaves were fully out and after the period of main sap flow. The general consensus, in the literature, is that this period is the most favourable for the species treated, and that autumn and winter treatments produce less successful results. If treatment is made at the time of sap flow, the chemicals may be flushed out. This is especially liable to occur in sugar maple which produces an exceptionally strong flow of sap. (Rushmore 1956a).

No tally of the crown condition of the treated trees was made during the season in which the poison was applied, but for the subsequent three years the crown condition was recorded annually by one of the following classes:

(*a*) Healthy or apparently unaffected.
(*b*) Affected, but with less than half of the crown defoliated.
(*c*) More than half of the crown defoliated, but not completely.
(*d*) Dead.

Details concerning the individual treatments are given below.

1. Ammonium sulphamate

Ammonium sulphamate, also known as ammate, is a water-soluble contact poison which must be translocated in the tree to be effective (Sutton 1958). Death of the tree is achieved by the poison tending to precipitate the proteins of the protoplasm.

The ammate, which was used in crystal form, is non-toxic to animals generally, although some people are allergic to long contact with the chemical and may develop a skin rash. Ammate is highly corrosive to metals.

The area treated with ammate was located in Finlayson Township, Algonquin Park, Ontario. In the early part of July 1950, 98 defective sugar maple ranging in diameter from 5 to 25 inches, with an average d.b.h. of 12.4 inches, were treated by chopping cups in the base of each tree and placing 1 tablespoonful (about half an ounce) of dry ammate crystals into each cup, so that the crystals were in contact with the exposed sapwood. The cups were approximately 3 inches wide. The spacing between cups was varied and ranged from intervals of about 2 inches on some stems to over 30 inches on others. Eighteen beech and 26 yellow birch were treated also.

The trees were examined in early July 1951, and in mid-July of 1952 and 1953 to determine the effects of the poison.

2. Sodium arsenite

Like ammate, sodium arsenite is a water-soluble contact poison which must be translocated in the tree to be effective, but its effect is achieved by breaking down the structure of the cell nucleus.

Sodium arsenite, which was applied in the form of "Atlas A"[3], is toxic to animals and man. When arsenite is used, antidotes should be kept readily available—instructions and precautions are generally given on the label of arsenite containers. Protective clothing should be worn to prevent contact with the poison. Cook (1959) found that a protective grease cream was as efficient as gloves for protecting the hands, and was more comfortable to use. The poison should not be spilled needlessly, nor dregs poured on the ground, because of the danger to wildlife. The danger to wildlife can be reduced by applying the poison to frills, or in the form of treated tabs inserted into the wood (Swain 1954), rather than brushing the poison onto wood exposed by peeling. Animal repellents are sometimes incorporated into the liquid compound.

---

[3] "Atlas A" is a specially prepared liquid debarking compound containing 6 pounds of arsenite per gallon. Unless otherwise stated, the Imperial gallon has been used throughout this report.

The experiment was conducted on 20 acres of freehold land belonging to the Ontario Paper Company on Manitoulin Island, Ontario. A total of 582 defective sugar maple ranging in diameter from 4 to 30 inches, with an average d.b.h. of 13.2 inches, were treated in June 1955 using a method employed by the Company for debarking. A three-man crew girdled the trees with axes by chopping two lines about 4 inches apart around the trees at a height of 3 to 4 feet above ground, and then bumping the bark off between these lines with the back of the axe. No attempt was made to cut into the sapwood; the bark only was removed. A fourth man followed the axemen and applied sodium arsenite to the exposed wood. The poison was applied with a hollow-handled paint brush,[4] connected by a rubber hose to a pressure back-pack tank containing the poison. The flow of liquid to the brush was regulated by a valve assembly on the hose. The man applying the poison wore rubber gloves for protection; a supply of antidotes was kept readily available but was never used.

Peeling the bark off the large sugar maple was a tedious job. It is likely that similar results would have been obtained by the simpler procedure of applying the arsenite to a frill girdle, as described by Rushmore (1956b). In addition, frilling a tree would have taken only about one third the time of peeling (Baldwin 1939).

Treated at the same time as the sugar maple were 6 yellow birch, 3 white birch, 18 basswood, 40 ironwood, and 6 eastern cedar.

Tallies of the crown conditions were made in late July 1956, mid-July 1957, and early August 1958.

3. 2,4-D plus 2,4,5-T

Unlike the previous two chemicals, 2,4-D and 2,4,5-T are hormones or growth regulators, which disrupt the control of cell growth so that the cells enlarge beyond their normal size. Pressures are set up which crush and rupture the affected tissues.

A mixture of 2,4-D and 2,4,5-T was applied as a 3 per cent by volume solution in diesel oil. This 3 per cent solution was made by adding 5 fluid ounces of the liquid compound[5] to 1 gallon of diesel oil. Diesel oil is a somewhat more effective carrier than water, which is sometimes used (Arend and Coulter 1952). 2,4,5-T has more effect than 2,4-D on many woody stems, but a mixture of the two appears to be as effective as the 2,4,5-T alone (McQuilkin 1957). The advantage of using a proportion of 2,4-D is that it costs about half as much as 2,4,5-T. No special precautions are necessary in handling the liquid.

Two hundred and six maple, mostly sugar maple with some red maple, were treated in June 1955 on 8 acres of logged-over private land belonging to Hay and Company Limited in Haliburton County, Ontario. The diameters of the maple ranged from 4 to 22 inches, with an average d.b.h. of 10.6 inches. Eighteen ironwood and 5 hemlock were treated also.

One man chopped a frill 3 to 4 feet above ground around the stem of the trees to be removed. The axe cuts of the frill were made at an angle of 45 degrees, and care was taken to ensure that the girdle was complete. A second man filled the girdle with liquid using a Nelson paint gun of 1 quart capacity.

Reassessments of crown conditions were made in late August 1956, early September 1957, and early August 1958. Since sugar and red maple were not always separated in the tallies, they have been combined in the compilation.

---

[4] Paint brushes with ordinary bristles will not last long; brushes with Tampico or Nylon bristles, which are resistant to the chemical, should be used.

[5] The liquid compound used was "Esteron Brush Killer" which contains, in the form of propylene glycol butyl ether esters, 38.4 ounces of 2,4-D acid equivalent and 38.4 ounces of 2,4,5-T acid equivalent per gallon.

RESULTS

The results for each treatment are presented by species and by diameter classes as both of these have a marked influence on the effectiveness of treatment. A comparison of treatments regardless of tree size is not possible as the diameter distribution of trees within treatments is not the same for each.

1. Effectiveness of treatments

(*a*) *On sugar maple*

The effects of ammate were noticeable within a few weeks after application, and by the end of the first year most of the defoliation that was to occur had taken place. Only a few trees showed any recovery from the effects of the poison. Most of these were large-diameter trees with a large spacing between poison cups and they were only slightly affected by the poison in the first year.

An examination of Table 1 and Figure 1 shows that the application of ammate at a spacing of 6 inches or less around the stems has been more successful throughout the diameter range than applications at large spacings. The greatest success in killing trees was achieved in those stems under 10 inches in diameter which received 4 tablespoons of ammate crystals; applications of 2 tablespoons were less successful. All trees were affected by the close spacing between poison cups, but the majority were unaffected at the 16-inch and up spacing. Only one tree was killed at the large spacing.

The percentage of trees killed by sodium arsenite at the end of one year (Figure 2) was little different from that obtained by ammate at the 3 to 6 inch spacing, although about one third of the trees were apparently unaffected by the arsenite. By the second and third years, however, the arsenite had killed more trees throughout the diameter range, especially in the large diameter classes. A few trees in each diameter class still remained unaffected by the poison.

The most noticeable feature of the 2,4-D plus 2,4,5-T experiment was the very low kill in the first year (Figure 3). Although few trees were actually killed in the first year, a high proportion of those treated were partially defoliated, with only 16 per cent of the trees apparently unaffected. By the second and third years, however, the percentage of trees killed was much the same as that achieved by the arsenite, if not slightly better, because all trees under 16 inches in diameter were affected.

(*b*) *On other species*

The effectiveness of the chemcials in killing various other species treated at the same time as the sugar maple is illustrated in Figure 4. Unfortunately a comparison between the effectiveness of the different treatments is possible only with three species: ironwood, yellow birch, and beech. 2,4-D plus 2,4,5-T was more effective than sodium arsenite for killing ironwood, and the arsenite was apparently more effective than ammate at the 3 to 6 inch spacing for killing yellow birch. On both yellow birch and beech, ammate at the 3 to 6 inch spacing was more effective than at the larger spacings.

The decreasing effectiveness of the chemicals as the diameters of trees treated increased is evident in all treatments, except the 2,4-D plus 2,4,5-T on ironwood and the arsenite on cedar where the trees were killed before the first assessment of crown condition was made.

	PER CENT KILL AT END OF THIRD YEAR Diameter Class						
Cup Spacing	4-6"	7-9"	10-12"	13-15"	16-18"	19"+	No. of Cups
3"	(3✱⁑) 100	(3) 100	(2) 0	(4) 25	(4) 25	(2) 100	
4-6"	(2) 50	(5) 80	(6) 33	—	—	(1) 100	6
7-9"	(1) 100	(5) 25	(1) 0	(7) 14	—	—	
10-12"	—	(8) 50	(1) 0	—	(7) 14	(1) 0	
13-15"	—	—	(7) 14	—	—	(1) 100	4
16-18"	—	(1) 0	(3) 0	(4) 25	—	—	
19"+	—	(4) 0	—	(3) 0	(5) 0	(7) 0	
No. of Cups	1		2				

✱ Small figures give number of trees treated in each class.
⁑ The cup spacing on these 3 trees was less than 3 inches.

Table 1. Percentage kill by diameter classes and cup spacing at end of third year in sugar maple treated with ammonium sulphamate.

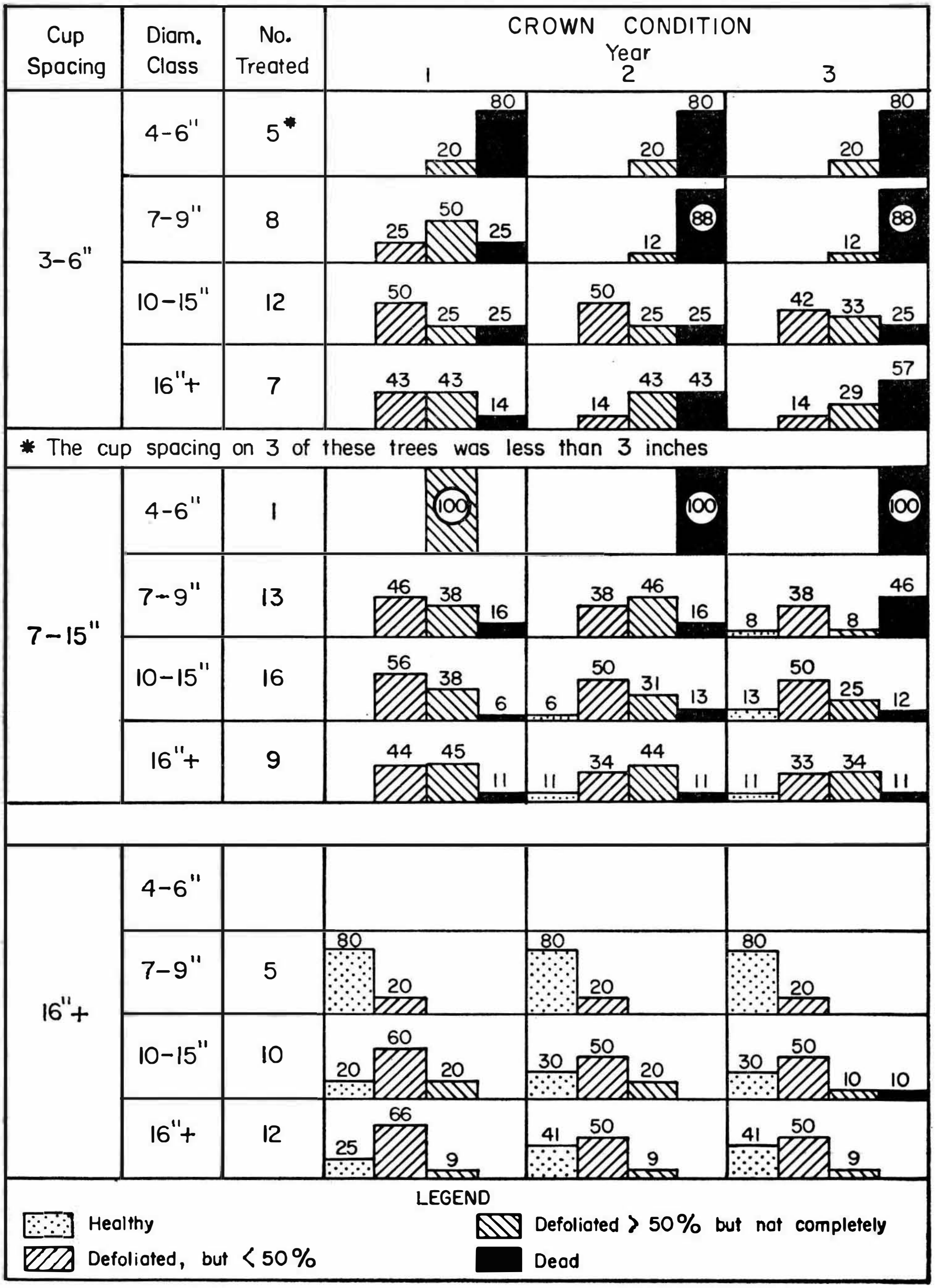

Figure 1. Percentage distribution by crown condition of sugar maple treated with ammonium sulphamate.

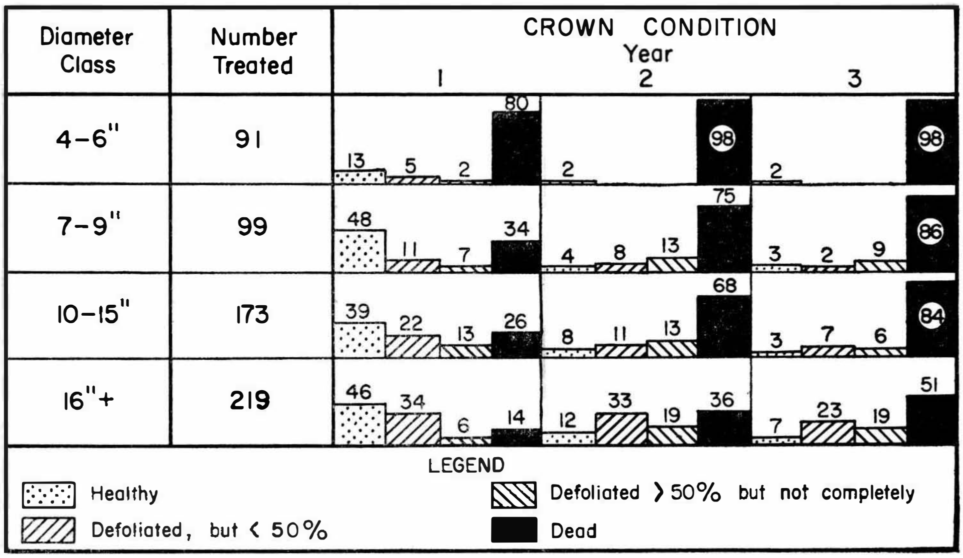

Figure 2. Percentage distribution by crown condition of sugar maple treated with sodium arsenite.

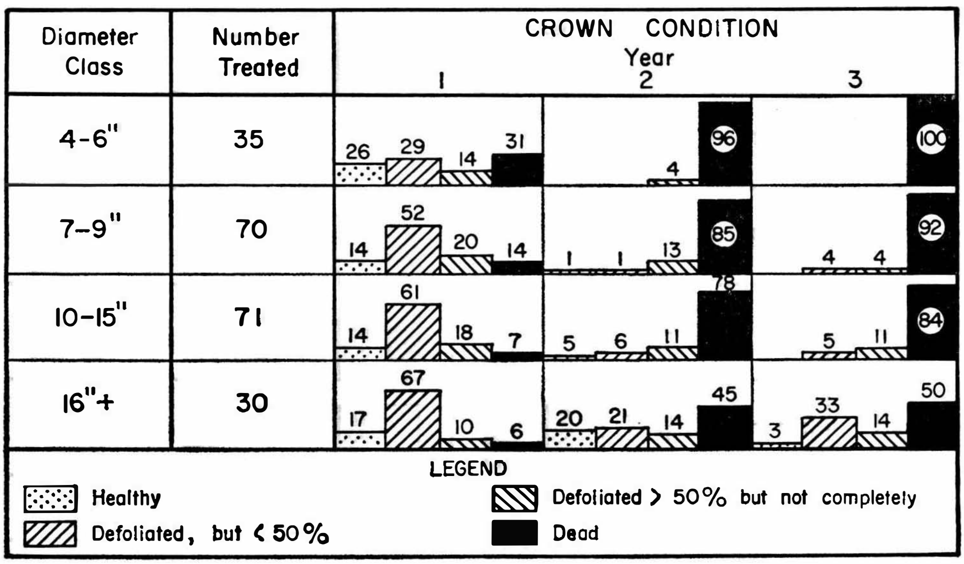

Figure 3. Percentage distribution by crown condition of sugar maple treated with 2,4-D plus 2,4,5-T.

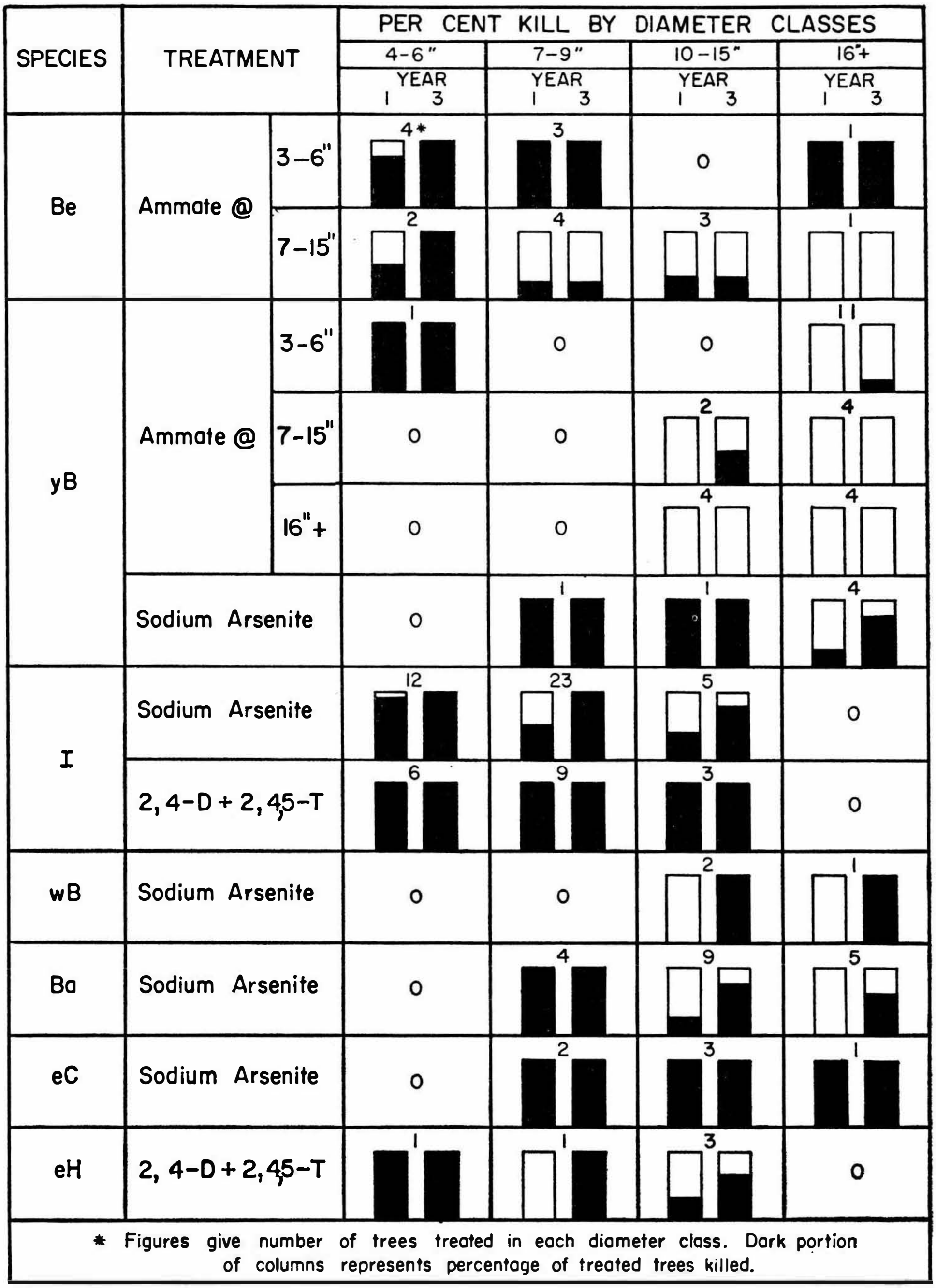

Figure 4. Percentage of other species treated dead after first and third years.

2. Influence of tree species

Some species are clearly more susceptible to the chemicals than others. Ironwood, hemlock and cedar are the least resistant of the species treated as most were killed within one year. After three years, only one ironwood and one hemlock, both of which had been incompletely girdled at the time of treatment, were still alive. Sugar maple is more resistant than the other species to all of the chemicals, while beech, yellow birch, white birch and basswood are intermediate.

These results are similar to those reported in the literature. Curry and Rushmore (1955), using 50 per cent by weight solutions of ammate and sodium arsenite, found sugar maple more resistant than yellow birch, with beech the least resistant. Cook (1944) using a 2-pound solution of sodium arsenite found sugar and red maple very resistant, white birch quite susceptible, with beech and yellow birch intermediate. After notch girdling without the use of chemicals, Engle (1948) found that hemlock were killed within two years, and ironwood and beech almost as soon. Yellow birch was a little more tenacious to life, while red and sugar maple were most tenacious. Westveld (1942) found that of yellow birch, beech, red and sugar maple trees which developed a bridge of callus tissue after axe girdling, yellow birch were the first to die, followed by beech. Few of the red maple died and none of the sugar maple were dead 11 years after girdling.

3. Influence of tree size and completeness of girdle

With all three chemicals used, the amount of defoliation and percentage of trees killed have decreased as the diameter of the tree treated increased. The effect was most noticeable on sugar maple (Figure 5), but was also noticeable on the beech, basswood and yellow birch treated. Generally, 80 per cent or more of the 4 to 6 inch diameter trees were killed within three years, but 50 per cent or less of the trees 16 inches and up were killed.

Few observers, according to McQuilkin (1957), have recognized the size of tree as an important factor. He suggests that this is the result of "the confounding effects of different species and conditions. With resistant species or under conditions that favour resistance, large trees may be expected to exhibit more resistance than small trees; whereas with sensitive species or conditions favouring susceptibility to treatment, effects of tree size may be masked by high per cents of kill among all sizes."

McQuilkin noted that vigour may be involved since the larger trees are usually in the dominant and co-dominant crown classes, whereas the smaller trees are generally in the intermediate or suppressed classes. Cook (1944) found that the effectiveness of a 2-pound solution of sodium arsenite on 13 species of northern hardwoods was reduced as the size and vigour of the trees increased. Wilcox *et al.* (1956), however, found that bark peeling after application of sodium arsenite was easier on healthy, vigorous trees than on trees of low vigour and those with defects. The difference was explained by the nature of the growth activity in the cambial region. Unfortunately, no mention was made of the rate of top kill in conjunction with the debarking.

It is possible that the lower kill in the large diameter trees is due in part to incomplete girdling, where this operation is carried out. An incomplete girdle is more liable to occur on large, defective trees with rough, thick bark, ingrown seams and fluted stems, than on the smoother stems of small trees. Bull and Chapman (1935) state that application of a poison is most effective in conjunction with a complete girdle. Cook (1959), using 4- and 6-pound solutions of sodium arsenite, found that on trees less than 4 inches in diameter, one or two unconnected hacks with application of arsenite was satisfactory, but on larger trees, an incomplete girdle delayed death considerably. Carnes and Walker (1956),

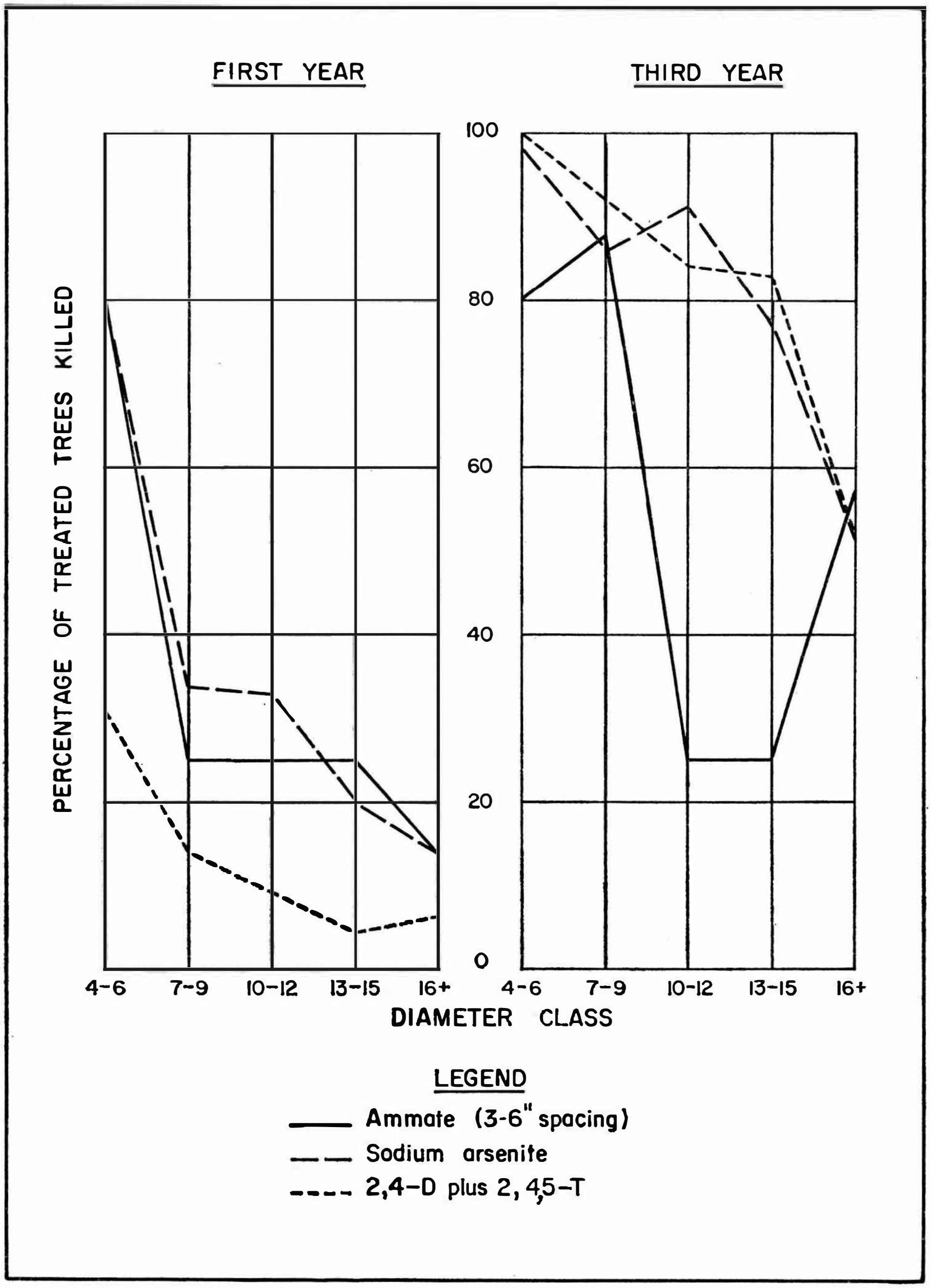

Figure 5. Influence of diameter on effectiveness of chemicals for killing sugar maple.

using a 2.5 per cent by volume solution in water of 2,4,5-T in the southern United States, found that applying the chemical to a complete frill girdle gave a 96 per cent kill, whereas a 90 per cent frill gave only a 38 per cent kill, and a 40 per cent frill resulted in a 2 per cent kill. Tree size, they noted, did not apparently influence mortality, aside from the completeness of the frill. Also in the southern States, Campbell and Peevy (1950) found that the application of ammate crystals in cups was suitable for trees under 12 inches in diameter, but for larger trees, the ammonium sulphamate should be applied in solution to a complete frill girdle.

A complete girdle, however, does not necessarily ensure death of a tree, nor does an incomplete girdle mean that the tree will survive. In the arsenite and 2,4-D plus 2,4,5-T experiments made by the Forestry Branch, some incompletely girdled trees were killed within one year and some completely girdled trees were still alive after three years.

4. Cost of treatment

No specific cost data were kept for the experiments; an indication of the cost of the chemicals is given below.

Ammate crystals retail at about 40 cents per pound. It has been estimated that there are about 30 tablespoons of crystals per pound, making a cost of 1.3 cents per tablespoon (Jarvis 1957). Assuming that each axe-cup is 3 inches wide, and that for small trees the spacing should not exceed 6 inches, a 10-inch tree would require a minimum of 4 cups, or a cost of 5.3 cents. Large trees require a closer spacing between cups: a spacing of 3 inches provided by 9 cups on an 18-inch tree would cost 12 cents, and a spacing of 2 inches provided by 15 cups on a 24-inch tree would cost 20 cents. These are similar to costs calculated by Chaiken (1951).

The cost of 2,4-D plus 2,4,5-T depends on the quantity purchased. The cost of a few fluid ounces of the liquid compound, which may be adequate for a small operation, will be two or three times greater than the purchase of a gallon or more. When mixed with diesel oil therefore, the cost per gallon of a 3 per cent by volume solution may vary from about 50 cents to just over one dollar. Applied to a frill girdle, one Imperial gallon will treat approximately 270 diameter-inches (Chaiken 1951). Probably less sodium arsenite, however, would be required on a peeled girdle, but the cost per gallon is greater. One gallon of sodium arsenite, containing 6 pounds of arsenite, costs about $2.00.

CONCLUSIONS AND RECOMMENDATIONS

The effectiveness of all three chemicals was reduced as the diameters of trees treated increased. This was especially noticeable on a species such as sugar maple, which is relatively hard to kill, but was not so apparent on less resistant species. On ironwood treated with sodium arsenite, for instance, the effect of diameter was just noticeable, but when treated with 2,4-D plus 2,4,5-T, all ironwood were killed within one year. Beech, yellow birch and basswood were intermediate in this regard.

Ammate was the least effective of the three chemicals used. To obtain results comparable to the other two chemicals, the spacing between cups, to which about half an ounce of crystals is applied, should not be more than 6 inches on trees up to 10 inches in diameter, and on larger trees not more than 3 inches. A rough guide is that on trees up to 10 inches in diameter the number of axe-cups, to which 1 tablespoonful of ammate crystals is added, should not be less than one third of the number of inches in the diameter, and on trees over 10 inches in diameter, the number of cups should not be less than one half of the number of inches in diameter. Although Curry and Rushmore (1955) used a different technique, the quantity of ammate they recommend is practically identical.

With the concentrations and methods used, there was practically no difference between 2,4-D plus 2,4,5-T and sodium arsenite in their effect on sugar maple, over a three-year period. Less kill, though, may be expected with the former during the first year, and a complete girdle is essential. However, if ease of handling and cost are considered, the 2,4-D plus 2,4,5-T solution is preferable to the sodium arsenite.

Reference to results described in the literature shows that there may be little difference over a three-year period between the effectiveness of chemical treatment and notch girdling without a chemical for killing sugar maple. However, notch girdling must be done carefully and thoroughly or a tree may remain alive by forming a bridge of callus tissue over the girdle. Even though the initial cost of chemical treatment may often be higher than notch girdling, with chemical treatment death of a tree is more certain and quicker, sprouting is reduced and a simpler, less tiring, and faster girdling technique can be used. If, on the other hand, immediate death of a tree is not required, labour is efficient, resprouting is not a problem, and the number of trees to be treated is relatively few, then notch girdling without a chemical may be adequate. Frill girdling alone may be satisfactory for a species such as ironwood that is not so hard to kill as sugar maple.

In order to obtain the lowest cost per tree killed, as opposed to cost per tree treated, the treatment method or quantity and type of chemical applied should be varied for trees of different size and species. To achieve this maximum efficiency in the use of chemicals, more information is required on the effect of quantity and concentration of different chemicals, taking into consideration the influences of season, location, tree species, size and vigour.

SUMMARY

The effectiveness of three chemicals in killing defective hardwoods, mainly sugar maple, over a period of three years has been discussed. The treatments used were: (1) ammonium sulphamate crystals applied at the rate of 1 tablespoon (half an ounce) to axe-cups spaced at varying intervals around the tree trunk; (2) sodium arsenite, used in the form of "Atlas A", a chemical debarking compound containing 6 pounds of arsenite per gallon, which was painted onto peeled girdles; and (3) a 3 per cent by volume solution in diesel oil of a 2,4-D plus 2,4,5-T compound ("Esteron Brush Killer") applied to frills. All treatments were made in late spring.

The effectiveness of the chemicals varied between tree species, and decreased as the diameters of the trees treated increased. Ammonium sulphamate was the least effective of the chemicals, but there was little difference between the effectiveness of 2,4-D plus 2,4,5-T and sodium arsenite over a period of three years. Sodium arsenite is a dangerous poison, however, and requires special precautions in handling.

Under certain circumstances, girdling without the addition of a chemical may be quite satisfactory for killing sugar maple and associated species.

REFERENCES

Arend, J. L., and L. L. Coulter. 1952. Frill girdle tests with 2,4,5-T in Lower Michigan. U.S. For. Serv., Lake States For. Expt. Sta., Tech. Note 385, 1 p.

Baldwin, H. I. 1939. Cost of girdling hardwoods. New Hampshire For. and Rec. Dept., Fox For. Note 16. 1 p.

Bull, H., and R. A. Chapman. 1935. Killing undesirable hardwoods in southern forests. U.S. For. Serv., Southern For. Expt. Sta., Occ. Paper 50. 21 pp.

Campbell, R. S., and F. A. Peevy. 1950. Chemical control of undesirable southern hardwoods. Jour. Range. Mgt. 3:118-124.

Carnes, E. T., and L. C. Walker. 1956. Complete frilling essential for hardwood control. J. For. 54(5):340.

Chaiken, L. E. 1951. The use of chemicals to control inferior trees in the management of loblolly pine. U.S. For. Serv., Southeast. For. Expt. Sta., Sta. Paper 10. 34 pp.

Cook, D. B. 1944. Sodium arsenite as a tree-killer. J. For. 42(2):141-143.

Cook, D. B. 1959. The hatchet and oil can technique for the application of sodium arsenite J. For. 57(11):845-847.

Curry, J. R., and F. M. Rushmore. 1955. Experiments in killing northern hardwoods with sodium arsenite and ammonium sulfamate. J. For. 53(8):575-580.

Engle, L. G. 1948. Girdling northern hardwood wolf trees. J. For. 46(12):925-926.

Jarvis, J. M. 1957. The effectiveness of ammonium sulphamate for killing defective tolerant hardwoods. For. Chron. 33(1):51-53.

McQuilkin, W. E. 1957. Frill treatment with 2,4,5-T and 2,4-D effective for killing northern hardwoods. U.S. For. Serv., Northeast. For. Expt. Sta., Sta. Paper 97. 18 pp.

Rushmore, F. M. 1956a. A small quantity of sodium arsenite will kill large cull hardwoods. U.S. For. Serv., Northeast. For. Expt. Sta. Sta. Paper 83. 6 pp.

Rushmore, F. M. 1956b. The frill: a new technique in chemical debarking. J. For. 54(5):329-331.

Stoeckeler, J. H., and C. F. Arbogast. 1947. Thinning and pruning of young second-growth hardwoods in Northeastern Wisconsin. Proc. Soc. Amer. Foresters' Meeting: 328-346.

Sutton, R. F. 1958. Chemical herbicides and their uses in the silviculture of forests of Eastern Canada. Canada, Dept. N.A. and N. R., For. Br., For. Res. Div., Tech. Note 68. 54 pp.

Swain, L. C. 1954. Economical tree girdling. University of New Hampshire, Agric. Expt.Sta., Sta. Bull. 408. 15 pp.

Westveld, M. 1942. Some effects of incomplete girdling of northern hardwoods. J.For. 40(1):42-44.

Wilcox, H., F. J. Czabator, G. Girolami, D. E. Moreland, and R. F. Smith. 1956. Chemical debarking of some pulpwood species. State Univ. of New York, College of For., Syracuse. Tech. Pub. 77. 43 pp.

APPENDIX

List of Species

Common Name	*Abbreviation*	*Botanical Name*
Basswood....................	Ba	*Tilia americana* L.
Beech........................	Be	*Fagus grandifolia* Ehrh.
Birch, white..................	wB	*Betula papyrifera* Marsh.
Birch, yellow.................	yB	*Betula alleghaniensis* Britt.
Cedar........................	eC	*Thuja occidentalis* L.
Hemlock, eastern.............	eH	*Tsuga canadensis* (L.) Carr.
Ironwood....................	I	*Ostrya virginiana* (Mill.) K. Koch
Maple, red...................	rM	*Acer rubrum* L.
Maple, sugar.................	sM	*Acer saccharum* Marsh.