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HAZEL FOLIAGE TREATMENTS TO REDUCE SUPPRESSION OF WHITE SPRUCE REPRODUCTION

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(Project M.S. 147)
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INTRODUCTION

Shrub competition is one of the main factors affecting the survival and growth of white spruce reproduction (Rowe 1955, Shirley 1945). Fernow (1916) observed this fact in Manitoba as early as 1916. The most important shrub species present in many of the white spruce-aspen (*Picea glauca* (Moench) Voss, *Populus tremuloides* Michx.) stands of Manitoba and Saskatchewan is hazel (*Corylus cornuta* Marsh.). As these mixedwood stands reach maturity, the logging of spruce and the mortality of decadent aspen increase the amount of light reaching the forest floor. This in turn results in vegetative increase and rapid expansion of hazel colonies (Hsiung 1951).

Figure 1. A 20-year-old white spruce seedling under a dense cover of hazel. Pole intervals equal one foot.

The effect that hazel cover may have on the amount of light reaching an understorey of white spruce reproduction was suggested by the results of foliage sampling, done on the experimental area described below, which showed that on a one-acre plot the area of leaf surface totalled approximately seven acres.

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An experiment carried out at the Dunbar Forest Experiment Station in upper Michigan suggested that herbicides are more effective than cutting as a means of controlling shrub competition. Day (1948) found in this study that there was less sprouting of shrubs after spraying than after cutting.

In 1950 an experiment was started at the Riding Mountain Forest Experimental Area in Manitoba to study the use of herbicides as a means of reducing the suppression by dense hazel of natural white spruce reproduction.[2] Three herbicides (2,4-D, 2,4,5-T and ammate) were applied as foliage sprays in different concentrations. In 1954 the experiment was expanded to study the effect of spraying hazel on the survival and growth of planted white spruce.

DESCRIPTION OF EXPERIMENTAL AREA

The Riding Mountain Forest Experimental Area is located in the extreme southeastern portion of the B.18 forest section as defined by Halliday (1937). Its soils are characterized by upland tills on which mature and overmature mixedwood and hardwood stands have developed. Owing primarily to natural mortality of the hardwoods, extensive areas containing large scattered aspen and a luxuriant growth of hazel have resulted.

An area containing dense hazel, scattered mature white spruce and overmature aspen was chosen for the experiment. Table 1 gives the percentage representation of hazel and associated shrub species and their approximate heights.

TABLE 1.—HAZEL AND ASSOCIATED SHRUB SPECIES OCCURRING ON THE EXPERIMENTAL AREA

Species	Per Cent of Total Stems	Approximate Height (feet)
Corylus cornuta Marsh.	88	4
Rosa acicularis Lindl.	6	3
Rubus idaeus L.	2	3
Prunus virginiana L.	1	5
Others*	3	1–4
Total number of stems per acre	41,900	

*Others include: *Viburnum* spp., *Acer spicatum* Lam., *Symphoricarpos albus* (L) Blake, and *Amelanchier alnifolia* Nutt.

METHODS

In August of 1950 eight 1/10-acre plots and one 1/100-acre plot were established. After a total count of shrub stems by species was made the plots were sprayed with herbicides, applied on a per acre basis, in mixture with water in different concentrations as shown in Table 2. Spraying was done with an ordinary garden pressure sprayer of about two-gallon capacity. All spraying was carried out during the first week of August. The weather was clear and sunny with temperatures ranging from 72°F. to 78°F. Annual counts of residual living stems and new stems were made at the end of each growing season from 1951 to 1954 inclusive, and again in 1956.

2 The planning and early work on the experiment were done by V. H. Phelps and R. T. Pike, both formerly on the staff of the Manitoba-Saskatchewan District Office.

TABLE 2. TREATMENTS AND RESULTS — HERBICIDES USED AS FOLIAGE SPRAYS ON HAZEL IN 1950

Plot Number	Original Number of Hazel Stems (M/ac.)	Chemical[2]	Quantity and Concentration				Percentage of Stems Killed by Herbicides 1 Year after Treatment	Cost per Acre[4] (chemical only) $
			Chemical Only		Aqueous Solution			
			(oz./M stems)[3]	(oz./ac.)	(p.p.m.)	(gal./ac.)		
1	40	2,4-D	(1.5)	60	3,000	50	100	3.00
2	29	"	(1.0)	30	1,500	50	97	1.50
3	34	"	(0.9)	30	750	100	96	1.50
4	35	2,4,5-T	(1.7)	60	3,000	50	96	8.00
5	41	"	(0.7)	30	1,500	50	95	4.00
6	37	"	(0.8)	30	750	100	74	4.00
7	39	2,4-D plus 2,4,5-T	(1.5(.75 ea.))	60(30 ea.)	3,000	50	99	5.50
8[1]	38	Ammate	(42.1)	1,600	80,000	100	91	35.00
9	39	"	(20.5)	800	80,000	50	88	17.50

[1] 1/100-acre plot.
[2] Ammate—ammonium sulfamate 80% acid equivalent.
2,4-D—herbate ester.....40% acid equivalent.
2,4,5-T—ester.....40% acid equivalent.
[3] Oz./M stems computed from data in column headed "oz./ac."
[4] 1958 costs.

In May 1954, six 1/40-acre plots were established and each planted with 49 white spruce (3-2 stock). In August, three plots were sprayed with an aqueous solution of 2,4-D at a concentration of 1,875 p.p.m. (0.75 ounces of chemical per 1,000 shrub stems), and three plots were retained as controls. The survival and height of the spruce on the six plots were recorded in the spring of 1958.

In the autumn of 1956 twenty-five height measurements were taken at six-foot spacings on each of the eight 1/10-acre plots. The average height of the hazel within a 1½-foot radius of each sampling point was measured and recorded.

Heights and annual height growth of white spruce reproduction present on the plots were measured in 1958. Similar records for spruce reproduction on the surrounding untreated area were taken.

RESULTS

Effects of Treatment on Hazel

Although all treatments were highly effective (Table 2), ammate and the lower concentration of 2,4,5-T were less effective than the others. Hansen and Ahlgren (1950) and Atkins (1956) also reported good results with 2,4-D and 2,4,5-T.

The increase in the number of stems from 1951 to 1956 (Figure 2) was due mainly to sprouting from the roots. To permit direct comparisons, numbers of living stems were expressed as percentages of numbers found before treatment. The values obtained were plotted over years of measurement.

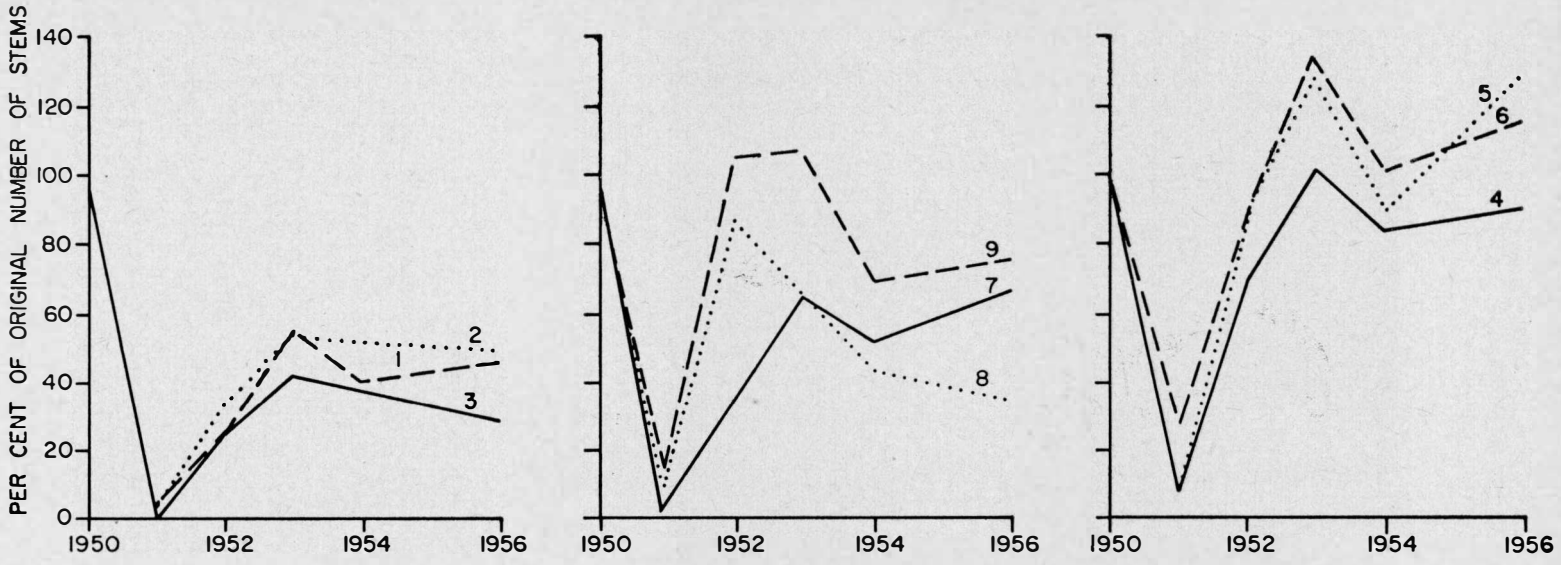
Sprouting did not occur until the second season after treatment. Except when ammate at 80,000 p.p.m. (plot 8) was used, a peak in number of stems per acre was reached three years after treatment. Six years after treatment plots sprayed with 2,4-D had proportionally the least number of stems and plots with 2,4,5-T the greatest. The heavier ammate treatment gave results approximating those for 2,4-D. The lighter ammate and the mixed chemicals yielded intermediate results.

The results of the height data taken for hazel in 1956 are presented in Table 3.

TABLE 3.—HEIGHT OF SPRAYED HAZEL SIX YEARS AFTER TREATMENT

Chemical	Approximate Average Height of Hazel (feet)
2,4-D	3.0
2,4-D plus 2,4,5-T	3.1
Ammate	3.5
2,4,5-T	3.9
Untreated	5.2

During the six growing seasons after treatment, untreated hazel made an average height growth of 1.4 feet, from 3.8 to 5.2 feet. During the same period treated hazel, the original stems of which were almost entirely replaced by sprouts appearing after 1951, grew to average heights of from three to four feet depending upon treatment, and in 1956 was from one to two feet shorter than untreated hazel (Figure 3).



1. 2,4-D 3,000 p.p.m.
2. 2,4-D 1,500 p.p.m.
3. 2,4-D 750 p.p.m.
7. 2,4-D plus 2,4,5-T 3,000 p.p.m.
8. Ammate 80,000 p.p.m. (100 gals./ac.)
9. Ammate 80,000 p.p.m. (50 gals./ac.)
4. 2,4,5-T 3,000 p.p.m.
5. 2,4,5-T 1,500 p.p.m.
6. 2,4,5-T 750 p.p.m.

Figure 2. Effects of treatment on hazel. Living stems per acre expressed as a percentage of original number in 1950. Most living stems after 1951 were new sprouts.

The effects on height growth and on numbers of stems suggest that the best treatment was from 2,4-D, but the results do not indicate the minimum dosage to produce adequate results, as the lightest dosage used appeared to be highly effective.

Figure 3. Hazel six years after treatment with 2,4-D plus 2,4,5-T (plot 4). Stems behind sheet were untreated. The pole is six feet high and marked in one-foot intervals.

As shown in the cost column of Table 2, treatment with 2,4-D required the least outlay for chemicals. However, the addition of application cost would tend to even out the total costs of treatment.

Effects of Treatment on All Shrub Species

Table 4 shows the numbers of shrub stems for all species, expressed as percentages of the original numbers in 1950, from 1951 to 1956. All treatments resulted in high percentage mortality. Their effect on other shrubs was less than on hazel—2,4-D treatments, 23 per cent; 2,4,5-T treatments, 13 per cent; ammate treatments, 42 per cent; and 2,4-D plus 2,4,5-T treatments, 38 per cent. This might be attributed to the hazel overstorey which shielded the shorter other shrubs from the spray, and also, to the difference in susceptibility to different herbicides that exist amongst shrub species (Anon, 1955).

After treatment, the number of stems of both hazel and other species increased until a peak was reached in 1953, and then the number declined. Response to all treatments is similar and is shown graphically in Figure 4. After the heavy mortality of the aerial portion of hazel in 1951, the areas were invaded by such species as *Lonicera dioica* L., *Ribes triste* Pall. and *Ribes hirtellum* Michx., and the number of stems of the shrubs that were less affected by the spray increased. These shrubs accounted for a large proportion of the stems present from 1952 to 1954.

TABLE 4.—TREATMENTS AND RESULTS—HERBICIDES USED AS FOLIAGE SPRAYS ON ALL SHRUBS IN 1950

Plot Number	Original Number of Stems (M/ac.)	Chemical	Per Cent of Original Number of Stems at End of Growing Season in Various Years After Treatment				
			1951	1952	1953	1954	1956
1	45	2,4-D	10	80	145	85	67
2	40	"	21	87	170	117	78
3	38	"	13	80	205	110	85
4	39	2,4,5-T	13	105	179	107	116
5	45	"	14	128	225	119	140
6	39	"	29	135	242	152	132
7	41	2,4-D plus 2,4,5-T	5	72	172	95	95
8	42	Ammate	16	124	157	89	61
9	47	"	18	139	204	105	88

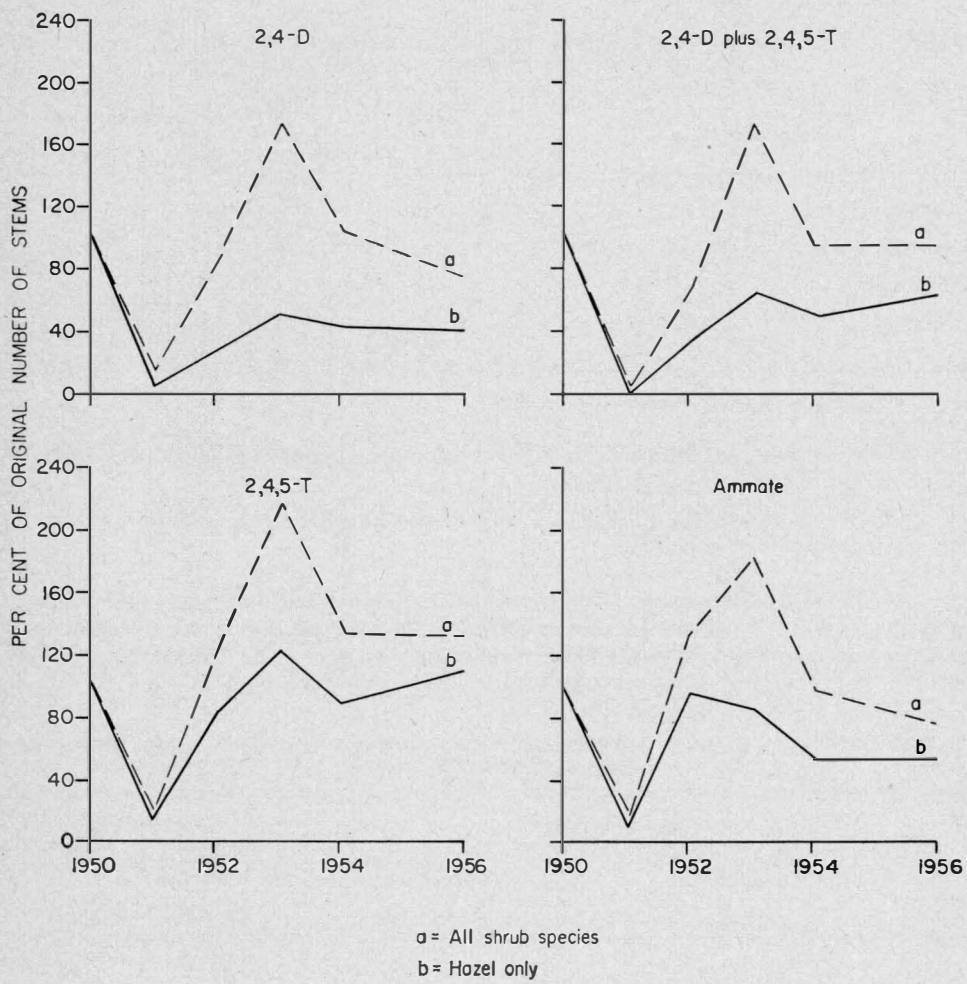


Figure 4. Effects of treatment (data averaged for each herbicide) on all shrub species and on hazel only. Living stems per acre expressed as a percentage of original number in 1950.

The decrease in numbers in 1954 was probably due to the hazel again becoming the major canopy, thereby killing by suppression the new species which had invaded the areas and reducing the numbers of those whose representation had increased.

Effects of Treatment on White Spruce Reproduction

Natural Reproduction: During the seven years after treatment, height growth of white spruce on the treated plots was greater than that on the untreated area. The increased height growth did not take place until 1954, four years after treatment (Figure 5).

Slightly over 50 per cent of the spruce present on the treated plots in 1950 were taller than the surrounding hazel sprouts in 1956 (Table 5). It seemed likely that this height advantage would be maintained and these plants would not be suppressed, and that possibly many of the others would outgrow shrub suppression. On the untreated area the hazel was still taller than most of the spruce reproduction.

TABLE 5.—RELATIONSHIP OF WHITE SPRUCE REPRODUCTION TO SURROUNDING HAZEL ON TREATED AND UNTREATED AREAS, 1956

Position of Seedling	Number*		Average Height (feet)	
	Treated	Untreated	Treated	Untreated
Above hazel	19	—	4.6	—
Even with hazel	8	9	3.8	4.9
Below hazel	7	26	2.7	2.9
Hazel			3.4	5.2

*All seedlings were below hazel in 1950.

White spruce reproduction on the treated plots appeared much more vigorous than on adjacent untreated areas.

There was no visible damage on any of the natural white spruce that could be attributed to the herbicides.

Artificial Reproduction: The percentage survival and average height in the spring of 1958, of the white spruce which were planted under dense hazel and subsequently sprayed with 2,4-D in August of the same year (1954), and of the spruce which were planted on untreated plots, are shown in Table 6.

TABLE 6.—SURVIVAL AND HEIGHT OF WHITE SPRUCE GROWN UNDER TREATED AND UNTREATED HAZEL.

Treatment 1954		Survival 1958	Height 1958
Chemical	Concentration (in mixture with water)		
	(p.p.m.)	(per cent)	(inches)
2,4-D	1,875	57.1	16.6
Untreated	—	28.6	11.1

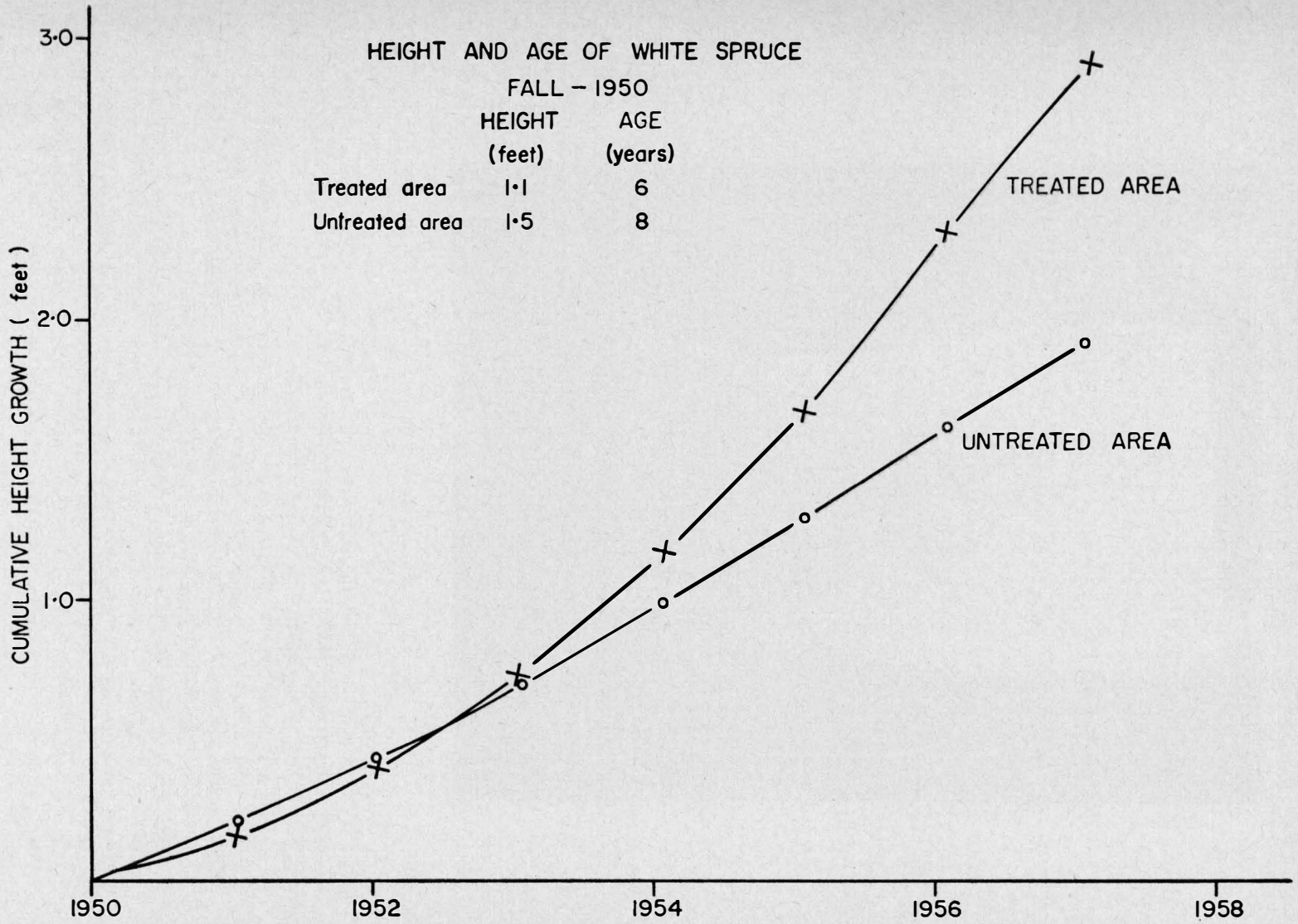


Figure 5. Cumulative height growth of white spruce seedlings on treated and untreated areas from the autumn of 1950 to the autumn of 1957.

Figure 6. A 10-year-old, six-foot white spruce seedling released from hazel (plot 1). Height growth between the spring of 1951 and the autumn of 1956 was 4½ feet. Pole intervals equal one foot.

A "t" test showed that the differences in survival and height between the treated and untreated plots were highly significant ($p<.01$). There is no doubt about the practical significance of the differences.

The cumulative height growth of the white spruce transplants for the period 1954 to 1957 was much better on the treated plots than on the untreated ones. The average growth of the ten best transplants on the untreated plots was less than the average of all plants on the treated plots (Figure 7).

It was apparent in the spring of 1955 that the chemical had caused some injury to the planted stock. The observable damage, which took the form of twisted leaders and blackened needles, was confined to the terminal shoots. Approximately 55 per cent of the white spruce that survived to the spring of 1958 had been affected. It was not possible to determine whether any transplants died as a result of the injury, although it was apparent that some loss of height growth resulted.

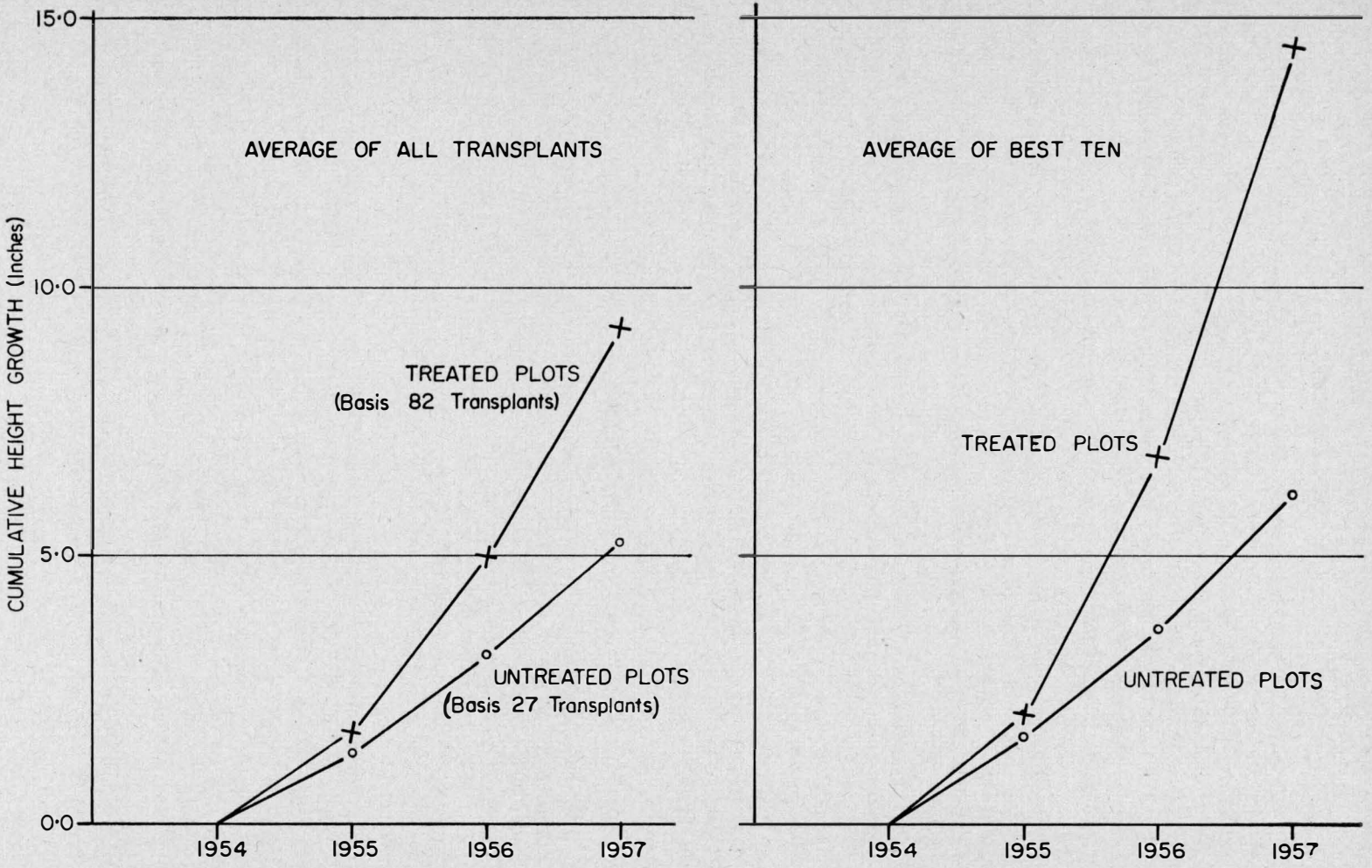


Figure 7. Cumulative height growth of white spruce transplants on treated and untreated plots from the autumn of 1954 to the autumn of 1957.

DISCUSSION

Results of the experiment suggest the eventual practical use of hazel foliage treatments for releasing suppressed white spruce reproduction from conditions similar to those encountered on the experimental area. More needs to be learned about optimum quantities and concentrations of sprays, re-occurrence of hazel and other shrubs after treatments, susceptibility of white spruce reproduction to damage by herbicides, timing of treatments, and to what extent site differences must be considered when planning treatments.

Lighter dosages than were used in this experiment might be adequate under some conditions. Spraying at a later date and with less herbicide would decrease the danger of damage to reproduction, although possibly it would be less effective for the control of hazel. Roe (1953), experimenting with weekly treatments of 2,4-D from mid-May to late August, determined that hazel sprouts were fewest in number and least vigorous when treatment was applied during the third week of July.

Determination of optimum dosages and the best time for spraying would lessen the need for more than one application; however, there may be occasions when it is necessary to spray more than once to obtain the degree of release required. Sparse stocking and small seedlings at the time of treatment would increase the likelihood of further treatment being necessary.

Investigations are in progress at the Riding Mountain Forest Experimental Area to study the influence of different densities of hazel overstoreys on various sizes of planted white spruce seedlings. Preliminary results from this study will be available soon.

SUMMARY

During 1950, nine plots were established in an area of dense hazel under scattered white spruce and aspen on the Riding Mountain Forest Experimental Area, to study the use of herbicides for the control of hazel and the subsequent release of white spruce reproduction. Each plot was sprayed with an aqueous solution of one of the following chemicals: 2,4-D, 2,4,5-T, ammate, or a 50-50 mixture of 2,4-D and 2,4,5-T. These chemicals were applied to the hazel as foliage sprays in varying dosages and concentrations during the first week of August.

All chemicals and spray concentrations tested in this experiment produced a fairly complete kill of the above-ground portions of hazel. Subsequent sprouting was high, but less after 2,4-D treatments than after the others. The associated shrub species reacted variously to the different herbicides tested.

Treatment resulted in an increased growth rate of natural white spruce reproduction under hazel. It is believed that a high percentage of the spruce which were released in this way will not again be overtopped by the hazel.

In 1954, six plots were established in dense hazel to determine the effect of controlling hazel on the survival and growth of planted white spruce. Each plot was planted with 49 white spruce (3-2 stock). Three plots were sprayed in early August with 2,4-D at 1,875 p.p.m., and three were retained as controls.

The spruce on the treated plots had better survival and a higher rate of growth, although there was some damage to the terminal shoots.

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