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CROWN RELEASE OF YOUNG SUGAR MAPLE

by

M. H. Drinkwater

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Summary in French

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by

M. H. Drinkwater[1]

INTRODUCTION

This report presents some preliminary results of releasing sapling sugar maple in 1951 near Nuttby, Colchester County, Nova Scotia[2]. The experiment was established with the co-operation of the provincial Department of Lands and Forests to determine the response of young sugar maple to several degrees of crown release, to provide some basic data on growth of the released trees, and to evaluate the influence of such factors as diameter at breast height, total height, crown diameter, length of live crown, and inter-crown distance on such growth.

There are over half a million acres of tolerant hardwood (i.e. sugar maple, sugar maple-beech and sugar maple-beech-yellow birch associations) in northern Nova Scotia. Heavy cutting and the incidence of insects and disease have so degraded the stands and reduced the amount and quality of saw timber that there is not enough left to support an industry. At the same time, the volume of small low-quality hardwood has continued to increase. If these stands are to produce saw timber, cultural treatments and thinnings are needed to improve the growth rate and quality of the trees that remain.

Most operations in the tolerant hardwoods of Canada and the United States are carried out in old-growth timber. Consequently silviculture has been directed mainly towards methods of harvest cuttings and obtaining reproduction. Relatively few studies of the effects of stand improvement in the second-growth forests have been made. Although the results from the latter are difficult to synthesize, because of variations in treatment, species composition, site and sampling methods, some general conclusions can be given.

Investigations in the Lake States (Anon, 1940) showed that it was not desirable to apply cultural treatments in 10- to 20-year-old hardwoods, except to remove wolf trees. Sugar maple and yellow birch responded with large numbers of epicormic branches; the exposed trees were often sun-scalded.

Downs (1942, 1946) and Church (1955) working with hardwoods in the Appalachian region reported that release definitely increased the rate of diameter growth of sugar maple. Provided the crop trees were vigorous, all crown classes responded well to treatment.

From treating 11-year-old tolerant hardwoods in northern Wisconsin, Stoeckeler and Arbogast (1947) concluded after considering growth response, epicormic branching, and rate of crown closure, that the best thinning radius was about four feet. They thought it practical to remove wolf trees, but favoured delaying thinning until the trees were merchantable.

In Quebec, MacLean (1950) reported that an improvement felling that removed 50 per cent of the total volume effected good response in young sugar maple, yellow birch, white birch and red oak.

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[1] Forestry Officer, Forestry Branch, Maritimes District Office, Fredericton, N.B.

[2] Botanical names of trees are given in the Appendix.

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Nearly all the literature indicates that young hardwood are tolerant to release cuttings. Application of the results, however, is limited because the different methods are not compared in the same stands; the crop tree method of thinning is not considered and the possible limits of release are not clearly defined.

METHODS

Experimental Area

The study area is in the Cobequid Mountains (latitude 45°34′ north, longitude 63°15′ west) on a gentle west slope at an elevation of 900 feet. The mean annual temperature is 42°F. with a normal of 64°F. in July and 18°F. in February. Annual precipitation is about 42 inches, a third of which falls between June and September. The soil is a well-drained, sandy loam that developed from a gravelly till.

The stand became established about 1925 beneath a mature hardwood overstorey. It was released in 1930 when the area was clear-felled. In 1951 there were approximately 3,200 saplings per acre of which 38 per cent were sugar maple, 32 per cent beech, 25 per cent mountain maple, 3 per cent yellow birch, and 2 per cent balsam fir. Nearly all the mountain maple were overtopped. Residual trees from the 1930 cut, with a basal area of about 20 square feet per acre, formed a ragged overstorey.

Although this type of stand is fully stocked, there are relatively few well-formed, sound, thrifty trees. The beech scale and nectria canker have reduced beech almost to a weed. Yellow birch is the most desirable hardwood, but it is too scarce to be promising for the near future. Attention, therefore, must be given to the sugar maple.

Treatments

Four intensities of complete crown release were applied to selected dominant and co-dominant sugar maple saplings. The treatments were designated as:

1. light release—crown allowed 3 to 4 feet for expansion
2. moderate release—crown allowed 5 to 6 feet for expansion
3. heavy release—crown allowed 8 to 10 feet for expansion
4. control—crown not released.

The selection of the crop trees was based upon their apparent quality and growth potential; spacing was a secondary consideration to ensure protection from outside influences. The felling was done in late August, 1951. A sugar maple with a 3- to 4-foot crown release is shown in Figure 1.

Design of Experiment

This study of crown release is based on analysis of growth of individual trees. Twenty potential sugar maple crop trees were chosen on each of ten small areas. The selected trees were numbered and then assigned to the different treatments at random. Thus on each area five trees were allocated to a light release, five to a moderate release, five to a heavy release and five were left untreated for control.

Figure 1. Sugar maple sapling with 3- to 4-foot crown release. A portion of the untreated stand appears in the background.

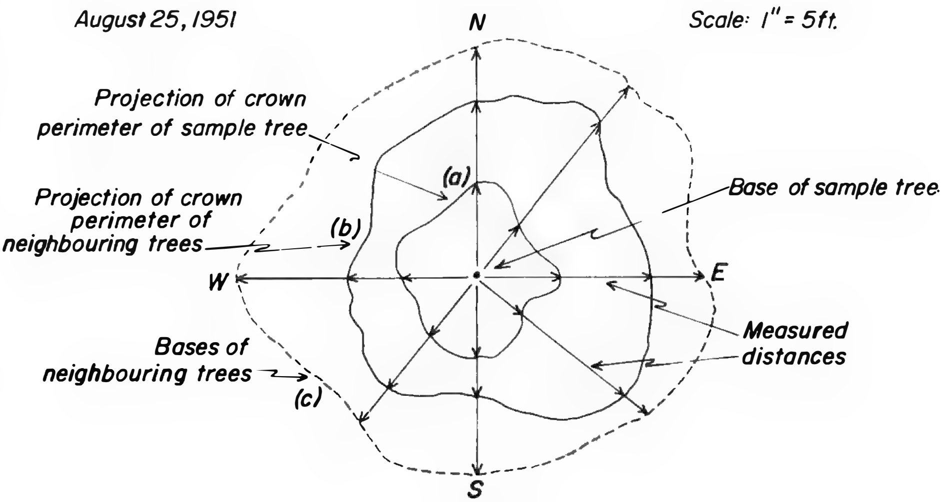

Figure 2. Crown projection of a sample tree released 3 to 4 feet and the crown projections of its neighbours.

Measurements

The sample trees were measured first in August, 1951. Diameter at breast height was recorded to the nearest tenth-inch, and total height and length of live crown to the nearest foot. The crown projections were mapped to determine crown widths and inter-crown distances between sample trees and their neighbours. This is illustrated in Figure 2. All measurements, except those of inter-base distances, were repeated in August, 1954, and in June, 1957.

The areas of the crown projections were determined with a planimeter, then by converting each area to a circle with the same area, the average crown diameter, inter-crown distance and inter-base distance were determined for each sample tree.

Some trees had been thinned too lightly. Those in the light release were affected least; 46 out of 50 were within the required range if a tolerance of half a foot is allowed at the lower end. With the same tolerance, 37 of the 50 moderately released trees and 32 of the heavily released trees were within their respective ranges. By allowing the degrees of release to read 2.5 to 4 feet for the light treatment, 4.5 to 6 feet for the moderate treatment and 6.5 to 9 feet for the heavy treatment, 97 per cent of the treated trees were within the prescribed limits.

The analysis of response to release is based on basal area increment computed for the periods 1951-54, 1954-57, and 1951-57. It must be noted that because of the dates of the measurements (August 1951, August 1954, and June 1957), there are only two growing seasons in the period 1954-57 and five for the period 1951-57. Because of missing data only 48 control trees were used in the analysis of basal area increment and 49 elsewhere.

RESULTS AND DISCUSSION

Basal Area Increment From Crown Release

The amount of basal area growth is summarized in Table 1 by time since treatment, and degree of release. The data show a progressive increase in the amount of basal area growth from the untreated control to the heavy crown release, though for the first three-year period the pattern is not as neat as it is for the periods 1954-57 and 1951-57.

TABLE 1.—AVERAGE PERIODIC BASAL AREA INCREMENT IN SQUARE FEET PER TREE BY TIME SINCE TREATMENT AND DEGREE OF RELEASE

Period	Treatment						
	Degree of Release						
	Control	Light		Moderate		Heavy	
	Basal area increment	B.A. inc.	Per cent of control	B.A. inc.	Per cent of control	B.A. inc.	Per cent of control
1951-54	.0094	.0094	100	.0117	124	.0115	122
1954-57	.0056	.0077	137	.0097	173	.0106	189
1951-57	.0150	.0171	114	.0214	143	.0221	147

The basal area data for all trees within each period were assembled by the ten blocks and four treatments and the two sources of variation were separated from the total by an analysis of variance. Neither treatment nor block variance is significant for the period 1951-54. But for the periods 1954-57 and 1951-57 some treatment variances were highly significant though the block variances were not.

The differences between the treatment means and their significance are given in Table 2.

TABLE 2.—DIFFERENCES BETWEEN TREATMENT MEANS OF BASAL AREA GROWTH (IN SQUARE FEET) PER TREE FOR THE PERIODS 1954-57 AND 1951-57

Treatments	Period	
	1954-57	1951-57
Control—Light	.0021	.0021
Control—Moderate	.0042**	.0064**
Control—Heavy	.0050**	.0071**
Light—Moderate	.0020	.0043*
Light—Heavy	.0029**	.0044*
Moderate—Heavy	.0009	.0007
	Critical difference 5% level = .0022 1% level = .0029	Critical difference 5% level = .0041 1% level = .0054

*Significant
**Highly significant

It can be concluded that for the experimental period 1951-57, the heavy and moderate crown releases have given significantly better results as compared with the light release and the control. While the difference between the light release and the control is not significant, it is close to being so for the period 1954-57. The difference between the heavy and moderate releases is not significant.

In a supplementary analysis, the data were pooled for each treatment and multiple regressions were used to estimate the dependence of basal area increment for 1951-57 on diameter at breast height, per cent live crown, and crown diameter as of 1951. The analysis of variance for these partial regressions is given in Table 3.

The combined effect of the three variates is highly significant in each treatment including the control. However, the analysis indicates that in the presence of diameter, per cent live crown and crown diameter are not significant for the control and the light and heavy thinnings. For the moderate thinning, the order of importance is reversed and crown diameter is the significant factor. This apparent contradiction cannot be accounted for at this time.

In a further analysis it was assumed that the various degrees of crown release formed a continuum ranging from about 2 to 9 feet. The data for the 150 treated trees were pooled and a fourth variate inter-crown distance was included with the three other items. The analysis of variance of this partial regression is given in Table 4.

In this instance, the combined effect and the effect of each individual item was significant. The initial diameter at breast height had by far the greatest influence upon subsequent growth in basal area; the initial per cent of live crown, crown diameter, and inter-crown distance each influenced subsequent growth to a similar degree, but individually they were of much less importance than the initial stem size.

TABLE 3.—ANALYSIS OF VARIANCE OF BASAL AREA INCREMENT OF SUGAR MAPLE FOR 1951–57 BY TREATMENTS

Source of variation	Degrees freedom	Sum squares	Mean squares
	Control (48 trees)		
Combined effect of bi's[1]	3	.003420	.001140**
Effect of b_1	1	.001017	.001017**
Effect of b_2	1	.000116	.000116
Effect of b_3	1	.000004	.000004
Error	44	.002460	.000056
Total	47	.005880	R^2 = .5616

B.a. increment = a + .1096 d.b.h. + .0168 p.l.c. − .0163 c.d.

Source of variation	Degrees freedom	Sum squares	Mean squares
	Light Thinning (50 trees)		
Combined effect of bi's	3	.002025	.000675**
Effect of b_1	1	.000239	.000239*
Effect of b_2	1	.000176	.000176
Effect of b_3	1	.000016	.000016
Error	46	.002046	.000046
Total	49	.004071	R^2 = .3544

B.a. increment = a + .1202 d.b.h. + .0187 p.l.c. − .0047 c.d.

Source of variation	Degrees freedom	Sum squares	Mean squares
	Moderate Thinning (50 trees)		
Combined effect of bi's	3	.001958	.000653**
Effect of b_1	1	.000018	.000018
Effect of b_2	1	.000107	.000107
Effect of b_3	1	.000671	.000671**
Error	46	.003566	.000077
Total	49	.005524	R^2 = .3544

B.a. increment = a + .0189 d.b.h. + .0137 p.l.c. + 035.d c2..

Source of variation	Degrees freedom	Sum squares	Mean squares
	Heavy Thinning (50 trees)		
Combined effect of bi's	3	.001387	.000462**
Effect of b_1	1	.000406	.000406*
Effect of b_2	1	.000231	.000231
Effect of b_3	1	.000035	.000035
Error	46	.004543	.000099
Total	49	.005930	R^2 = .2339

B.a. increment = a + .0803 d.b.h. + .0197 p.l.c. + .0067 c.d.

[1]bi's = $b_1 + b_2 + b_3$ where b_1 = diameter at breast height, 1951; b_2 = per cent live crown, 1951; and b_3 = crown diameter, 1951.

Diameter and Height Growth

The effect of release on diameter growth at breast height and total height of the crop trees is summarized in Table 5. The trends of response of diameter growth for the various treatments are similar to that of basal area increment.

The heavily and moderately released trees are growing at an average rate of 1.6 inches in diameter per decade, the lightly thinned trees at 1.4 inches per decade, and the control trees at 1.0 inch per decade.

The weighted average for annual height increment is small and practically the same for each treatment. The effect of release on height growth cannot be determined easily because it is difficult to measure height accurately. At Nuttby, difficulties also arose because some terminals had been broken by sleet.

TABLE 4.—ANALYSIS OF VARIANCE OF BASAL AREA INCREMENT FOR THE PERIOD 1951–57 OF 150 TREATED SUGAR MAPLE SAPLINGS

Source of variation	Degrees freedom	Sum squares	Mean squares
Combined effect of bi's[1]	4	.005395	.001348**
Effect of b_1	1	.001072	.001072**
Effect of b_2	1	.000436	.000436*
Effect of b_3	1	.000467	.000467*
Effect of b_4	1	.000400	.000400*
Error	145	.010550	.000073
Total	149	.015945	R^2 = .3383

B.a. increment = a + .072 d.b.h. + .014 c.d. + .016 p.l.c. + .009 i.c.d.

[1]bi's — $b_1 + b_2 + b_3 + b_4$ where b_1 = diameter at breast height, 1951; b_2 = per cent live crown, 1951; b_3 = crown diameter, 1951; and b_4 = inter-crown distance, 1951.

Crown Development

Some effects of release on crown size of young sugar maple are given in Tables 6 and 7. Increase in crown diameter was greatest on the heavily released trees and almost negligible on the controls. Expansion of the crown and the resulting addition of leaf area is one reason why stem diameter increment is stimulated when trees are released. The increase in crown width even at the greatest release is not excessive and does not indicate that this treatment would promote wolf trees.

Crown length of the crop trees increased about four feet between 1951 and 1957 and there was no marked difference among the treatments. Natural pruning did not occur and the ratio of live crown length to total height increased.

Against the advantages of thinning may be set the disadvantage of increased limb size which will continue at least until the crowns close. By that time the lower limbs will probably be so heavy that natural pruning will be hindered. Certainly the lower branches on the released trees continued to grow, but they also remained alive on the control trees. This suggests that while natural pruning on sugar maple may be hindered by thinning it probably depends more on the species' natural characteristics than to any degree of release.

Crown Closure

A summary of changes in inter-crown distances for the treated sugar maple between 1951 and 1957 is given in Table 8. The rate of closure for the various degrees of release expressed in feet per year is not equal. For the light thinning, the weighted average is 0.4 foot per year; for the moderate crown release, 0.6 foot per year; and for the heavy release, almost 1.0 foot per year. In other words, the inter-crown distance for the heavy release closed 2.3 times faster than in the light release and 1.6 times faster than in the moderate release. It must be noted, however, that the inter-crown distance for some light and moderately thinned trees increased when neighbouring trees died.

In spite of the different rates of closure, it is obvious that the smaller openings will close first. About 80 per cent of the lightly released trees were either closed or nearly so in 1957 (inter-crown distance of 1.5 feet and less). This is to be compared with 38 per cent for trees with moderate crown release and 12 per cent for those with heavy crown release. It was expected that the canopies surrounding most trees with moderate crown release would have closed in 1959 and that 90 per cent of those with heavy release will have closed by 1960.

TABLE 5.—AVERAGE DIAMETER AND TOTAL HEIGHT INCREMENT PER YEAR ON CROP TREES

Treatment	No. trees	Diameter at breast height		Diameter increment		Total height		Total increment	
		1951	1957	5 yrs.	Annual	1951	1957	5 yrs.	Annual
		(inches)		(inches)		(feet)		(feet)	
Control	49	2.2	2.7	.5	.10	23	27	4	.8
Light crown release	50	2.0	2.7	.7	.14	23	26	3	.6
Moderate crown release	50	2.0	2.8	.8	.16	22	26	4	.8
Heavy crown release	50	2.1	2.9	.8	.16	23	27	4	.8

Epicormic Branching

The incidence of epicormic branches five growing seasons after treatment is given in Table 9.

Indications are that epicormic branching is associated with, but not necessarily restricted to trees that have been released. The heavily thinned group has the largest number of trees with epicormic branches and the number is slightly more than for the light and moderate thinnings, but the differences are not enough to be significant.

If the branches continue to grow they will reduce the clear length and the quality of the stems, but definite conclusions cannot be drawn now. The branches may wither and drop when the canopies close. Stoeckeler and Arbogast (1947) reported that nearly all the epicormic sprouts had disappeared eight years after thinning and no apparent loss in quality had occurred.

Extent of Release

The regression of inter-base distance on inter-crown distance for the released sugar maple is shown in Figure 3. For an inter-crown distance of five feet in this uniform stand it is necessary to remove all stems within a radius of 10 feet from the base of the favoured tree.

These data are not given to derive a standard of stocking for the average area. They indicate only the work necessary to release individual trees.

The density of a stand that should be left depends upon the site and upon the number of good stems in the stand. From studies of young stands in the Nuttby region it seems that the average stocking to desirable sugar maple is about 100 stems per acre. Because there is little, if any, market for the trees removed it is assumed that any treatment will be limited to the release of the crop trees.

SUMMARY

A preliminary assessment is made of a crown release experiment with young sugar maple near Nuttby, Colchester County, Nova Scotia. Beginning in 1951, four intensities of complete crown release were applied to 20 selected crop trees on each of 10 small areas. The release treatments were:

1. light—crown allowed 3 to 4 feet for expansion
2. moderate—crown allowed 5 to 6 feet for expansion
3. heavy—crown allowed 8 to 10 feet for expansion
4. control—crown not released.

It appears that, commensurate with the amount of effort required, the moderate release is the most favourable treatment tested. An analysis of five years growth on an individual tree basis shows that the heavy and moderate releases produced significantly better basal area increments than either the

TABLE 6.—AVERAGE CROWN DIAMETER INCREMENT ON CROP TREES

Treatment	Number trees	Crown diameter		Crown diameter increment	
		1951	1957	5 years	Annual
		(feet)		(feet)	
Control	49	6.90	7.25	.35	.07
Light release	50	6.15	7.92	1.77	.35
Moderate release	50	6.07	8.87	2.80	.56
Heavy release	50	5.63	8.66	3.03	.61

TABLE 7.—AVERAGE LENGTH OF LIVE CROWN AND CLEAR BOLE ON CROP TREES

Treatment	Year	Length live crown	Length clear bole	Live crown ratio
		(feet)	(feet)	
Control	1951	13	10	56
	1957	17	10	69
Light release	1951	13	10	56
	1957	16	10	68
Moderate release	1951	13	9	59
	1957	17	9	65
Heavy release	1951	13	10	56
	1957	17	10	63

light release or the control. There was not, however, any significant improvement in increment between either the moderate and heavy releases or between the control and light releases.

The contribution of several tree factors to basal area increment is appraised. It would appear that size (diameter at breast height) contributed most to the trees' growth after treatment. Crown diameter, per cent live crown, and inter-crown distance were other significant factors.

Dominant trees, which are often assumed to be growing at their maximum rate, responded well to release. In fact, the greatest response in terms of basal area increment occurred on the largest trees. It would appear that the trees should have been released even earlier than they were.

There is no indication that the treatments would promote the development of wolf trees. Increases in crown width seem to be normal. Gaps in the canopies about the lightly released trees were mostly closed in 1957. Canopies about the moderate and heavy releases were expected to close in 1959 and 1960 respectively.

Release had no determinable effect upon height growth, natural pruning or epicormic branching.

The assessment is preliminary and further time is necessary to confirm some of the results.

RÉSUMÉ

Le présent mémoire est un compte rendu préliminaire d'une expérience de dégagement des cimes dans un jeune peuplement d'érables à sucre près de Nuttby, dans le comté de Colchester, en Nouvelle-Écosse. A partir de 1951, on a entrepris des dégagements de cimes entières, selon quatre intensités différentes, dans dix petites superficies, à raison de 20 arbres de récolte par superficie. Les traitements de dégagement ont été:

1. faibles—allouant aux cimes de trois à quatre pieds d'expansion;
2. modérés—allouant aux cimes de cinq à six pieds d'expansion;
3. forts—allouant de huit à dix pieds d'expansion aux cimes;
4. nuls (superficies témoins)—les cimes n'ont pas été dégagées.

Le dégagement modéré semble être le traitement le plus favorable en proportion du travail requis. L'étude de l'accroissement en cinq ans d'arbres pris individuellement indique que les dégagements forts et modérés ont produit de plus forts accroissements de la surface terrière que les dégagements faibles ou que l'absence de dégagement dans les superficies témoins. On n'a pas constaté de différence appréciable, cependant, entre l'amélioration de l'accroissement par les dégagements modérés et par les dégagements forts, d'une part, et entre l'accroissement dans les superficies témoins et dans les superficies faiblement dégagées, d'autre part.

L'influence de plusieurs facteurs forestiers sur l'accroissement de la surface terrière est également étudiée. Il semble qu'à la suite du traitement l'accroissement en volume se soit produit surtout sous forme d'accroissement en diamètre (à hauteur de poitrine). Le diamètre de la cime, la proportion encore verte de la cime, et la distance entre les cimes ont été d'autres facteurs importants.

Les arbres dominants, qu'on considère habituellement comme croissant à leur taux maximum, ont bien réagi au traitement. De fait, les meilleurs résultats, pour ce qui est de l'accroissement de la surface terrière, ont été obtenus chez les plus gros arbres. Il semble que les arbres auraient dû être dégagés encore plus tôt qu'ils ne l'ont été.

TABLE 8.—CHANGES IN INTER-CROWN DISTANCES FOR RELEASED SUGAR MAPLE BETWEEN 1951 AND 1957

Per cent change in inter-crown distance 1951–57	Light crown release			Moderate crown release			Heavy crown release		
	Number trees	Avg. inter-crown distance (feet)		Number trees	Avg. inter-crown distance (feet)		Number trees	Avg. inter-crown distance (feet)	
		1951	1957		1951	1957		1951	1957
−100	9	3.2	0	5	4.9	0	2	7.9	0
−80 to −99	9	3.4	0.5	14	4.7	0.8	4	7.8	1.0
−60 to −79	15	3.6	1.1	15	5.0	1.6	27	7.9	2.5
−40 to −59	7	3.0	1.5	10	4.7	2.4	10	7.2	4.6
0 to −39	5	2.9	2.0	5	5.2	4.5	7	7.3	5.1
+ 1 to + 30	5	3.6	4.2	1	4.4	4.7			
All trees	50	3.3	1.3	50	4.9	1.7	50	7.7	2.9
Reduction inter-crown distance 5 years (feet)		2.0			3.2			4.8	
Reduction inter-crown distance per year (feet)		0.40			0.64			0.96	

TABLE 9.—NUMBER OF SUGAR MAPLE TREES WITH EPICORMIC BRANCHES FIVE YEARS AFTER RELEASE

Number of branches per stem	Length of epicormic branches			
	Up to 6 inches	7 to 12 inches	Over 12 inches	Total trees
Control (Basis 49 trees)				
1–5	4	4		8
6–9	3	3		6
10+	2	1		3
Total	9	8		17
Light Release (Basis 50 trees)				
1–5	4	14	1	19
6–9		3		3
10+		3		3
Total	4	20	1	25
Moderate Release (Basis 50 trees)				
1–5	1	14	2	17
6–9		2	1	3
10+				
Total	1	16	3	20
Heavy Release (Basis 50 trees)				
1–5		10		10
6–9	1	11	1	13
10+		5		5
Total	1	26	1	28

Rien n'indique que les traitements pourraient provoquer l'apparition d'arbres loups. L'augmentation du diamètre des cimes semble normale. Les trouées de la voûte foliacée dans le voisinage des arbres légèrement dégagés étaient presque toutes comblées en 1957. Les trouées de la voûte foliacée dans le voisinage des arbres modérément et fortement dégagés devraient être comblées en 1959 et en 1960, respectivement.

Le dégagement n'a pas d'effet calculable sur la croissance en hauteur, l'émondage naturel ou l'apparition de branches gourmandes.

L'étude dont il est ici question n'en est qu'à ses débuts, de sorte qu'il faudra laisser écouler un certain temps avant de pouvoir confirmer ces résultats.

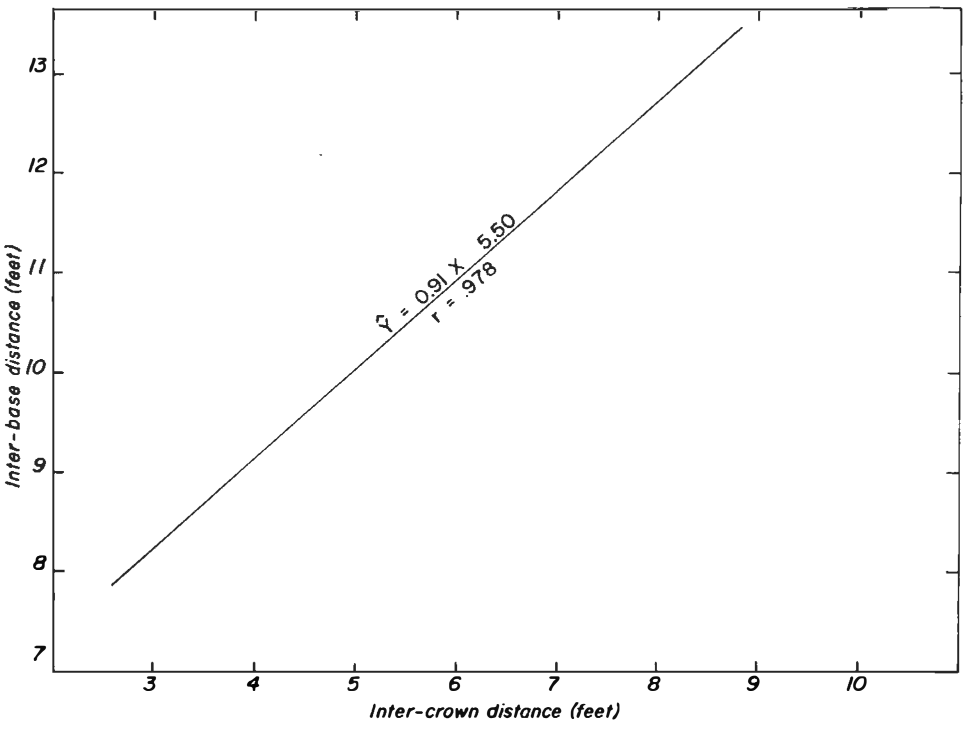

Figure 3. Regression of inter-base distance on inter-crown distance for released sugar maple saplings.

REFERENCES

ANON. 1940. Do young, second growth northern hardwoods need care? Lake States Forest Experiment Station. Tech. Note 167.

CHURCH, T. W. 1955. Weeding—an effective treatment for stimulating growth of northern hardwoods. J. For. 53:717-719.

DOWNS, A. A. 1942. Early response to weedings in some eastern mountain hardwoods. J. For. 40:865-872.

DOWNS, A. A. 1946. Response to release of sugar maple, white oak, yellow poplar. J. For. 44:22-27.

MACLEAN, D. W. 1950. Improvement cutting in tolerant hardwoods. Canada Dept. Resources and Development, Forestry Branch, For. Res. Div. Silvicultural Res. Note No. 95.

STOECKELER, J. H. and C. F. ARBOGAST. 1947. Thinning and pruning in young second-growth hardwoods in northern Wisconsin. Proc. Society American Foresters, 1947, pp. 328-346.

APPENDIX

Common and Botanical Names of Trees

Beech	*Fagus grandifolia* Ehrh.
Birch, white	*Betula papyrifera* Marsh.
Birch, yellow	*Betula lutea* Michx. f.
Fir, balsam	*Abies balsamea* (L.) Mill.
Maple, mountain	*Acer spicatum* Lam.
Maple, sugar	*Acer saccharum* Marsh.
Oak, red	*Quercus rubra* L.