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PRELIMINARY RESULTS OF A THINNING EXPERIMENT IN BALSAM FIR IN QUEBEC

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by

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PRELIMINARY RESULTS OF A THINNING EXPERIMENT IN BALSAM FIR IN QUEBEC

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INTRODUCTION

Balsam fir (Abies balsamea (L.) Mill.) is one of the most economically important pulpwood and lumber species in Eastern Canada. Yet little in the way of ideas even seems to be published about thinning in this species.

The development of balsam fir stands under natural conditions and following clear or partial cutting is known from studies conducted especially in Quebec and New Brunswick. These studies are valuable for the methods they describe, and for the insights they give on fir response, particularly to crown release. Studies by Baskerville (1961a, 1961b), Hatcher (1960, 1961), Vincent (1962), and others, leave little doubt that thinning immature or young mature balsam fir will increase the rate of diameter growth of residual trees. The problem is to learn how and when to manipulate the overstorey to increase growth, improve tree quality, and secure a vigorous and sound development of the fir.

Soil fertility and drainage conditions are nearly never limiting factors in commercial balsam fir stands. Length of the growing season and density of the stands appear to be the most significant factors affecting tree growth. Most of the young even-aged fir stands in Quebec which have established after windthrow, fire, insect attack or clear-cutting, are well-stocked and more often over-stocked. Crowding of trees causes a serious reduction in diameter growth. Even when crown classes are well differentiated, too many trees persist owing to their shade-tolerance. Properly timed artificial thinnings appear to be the most economical way of producing larger and better quality trees quickly.

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Few precise recommendations, however, are available for guidance in thinning balsam fir stands. Numerical thinning schedules were produced by Wile (1961) for New Brunswick and, more recently, by Vézina (1963, Figure 2) for Quebec in attempts to define thinning standards. These schedules provide a guide to the orderly reduction in number of trees and/or basal area per acre as stand diameter increases. Research is needed, however, to substantiate the validity of these standards.

During the past four years the writer has initiated three studies aimed at determining the optimum levels of reserve stocking for balsam fir of both precommercial and commercial sizes. In one of these studies, sixteen plots were established on the Montmorency Experimental Forest in Quebec. The preliminary results of remeasurement of these plots in 1963, after three growing seasons, are summarized in this paper.

THE STUDY AREA

The study area is typical of conditions under which second-growth balsam fir grows north of Quebec City. Rounded hills and moderate slopes at elevations of 1,000 to 2,000 feet and over are characteristic of the terrain. Soils are well drained, moderately deep, sandy loam, glacial till overlying a granitic substratum. Average annual precipitation is high, about 58 inches, and well distributed throughout the year. The frost-free period is only 60 days at the higher elevations.

The stand selected for study was 43 years old at the time of treatment. It was on a 35-percent middle slope facing southwest and belonged to the Dryopteris-Oxalis site-type, as described by Linteau (1955). It originated very likely from a diameter-limit cutting. About two-thirds of the trees were balsam fir; the remaining were white spruce (Picea glauca (Moench) Voss) and white birch (Betula papyrifera Marsh.). Dominant balsam fir averaged 43 feet high, and average stand diameter was 5.2 inches (Table 1). The stand was over-stocked and trees were below normal size and development.

METHOD OF INVESTIGATION

Four blocks, with a total of 16 treatment plots, 3/5 acre each, were established to test different degrees of thinning. Each treatment plot was composed of a 1/5-acre study plot with a surround half a chain wide. Each block contained four plots and one plot in each block was left unthinned as a control. Treatments were distributed at random among plots in any given block.

Thinning treatments. Treatments were uniform thinnings that left the best trees available at the desired spacing. The poorest dominant and co-dominant and most of the intermediate and suppressed trees were cut. Three thinning grades, hereafter called light, moderate, and heavy, removed 12, 23, and 35 per cent of the original basal area, respectively. The stand composition was not significantly modified as a result of thinning. (Vézina 1961).

Measurements. Measurements before and after thinning in 1960 and again in 1963 were made to the same standards. The diameter of every live tree was measured to the nearest 0.1 inch at breast height. Total heights were taken on 25 dominant and codominant trees per plot. Basal areas were computed by 1-inch d.b.h. classes for the entire stand of each plot. Increases in basal area are expressed as net mean annual increment per acre. No deductions were made for defects. Diameter growth is expressed as average annual increment per tree.

RESULTS

Mortality. Thinning, which reduced the original number of stems 62 to 79 percent, effectively reduced subsequent mortality. Seven to 15 per cent of the trees died on the unthinned plots, whereas only 2 to 9 per cent died on the thinned plots. Losses in all plots were due essentially to suppression of smaller trees. Mortality between 1960 and 1963 increased with an increase in number of stems left after thinning. The number of living stems after thinning in 1960 varied from 840 to 1370, and it averaged 810 to 1230 after three years, depending on treatment (Table 2).

Diameter growth per tree. Average annual diameter growth was increased by all thinning grades tested. It was 7 to 26 per cent greater in thinned than in unthinned plots. The rate of diameter growth decreased curvilinearly with increasing numbers of trees. Thus, for numbers of trees varying from 840 to 1370 after thinning in 1960 the average annual diameter growth was 0.117 to 0.093 inches per tree (Table 2).

Basal area growth per acre. Net basal area growth after thinning was the greatest on the lightly thinned plots with a mean annual increase of 3.96 square feet per acre. The mean annual increase in basal area was 3.81 square feet per acre on the unthinned plots, and it was only 3.23 square feet on the heavily thinned plots (Table 2). However, when expressed as a percentage of the basal area immediately after thinning, the mean annual increase was the greatest on the heavily thinned plots, and decreased with increasing basal area per acre left after thinning (Figure 3).

DISCUSSION AND CONCLUSIONS

Thinnings in balsam fir are made to (1) concentrate growth on the best stems available for the final crop, (2) shorten the rotation, and (3) increase total yield. The preliminary results of this study show that thinnings are needed in dense second-growth stands of balsam fir in Quebec. The results indicate, however, that thinning to an intensity that will produce the greatest growth per tree opens up the stand too much and might lead to damage from windthrow. Hatcher (1961), in a study of partial cutting in immature 50-year balsam fir stands in the same general area has shown, indeed, that when cutting exceeds 40 per cent of the total basal area, the chances of mortality being very high are much greater than when cutting is less than 40 per cent.

Figure 2 shows the normal density line and a thinning schedule recommended by the writer for balsam fir in Quebec (Vézina 1963). At the time of thinning, however, no schedule was available for balsam fir, and the treatments had been applied according to the silviculturist's best judgment. Moreover, the stand treated was overstocked, as evidenced by (1) a comparison of the residual densities with the "normal" numbers of trees per acre for balsam fir stands of given average diameters (Figure 2), (2) the observed poor development of tree crowns and the quasi-absence of differentiation into canopy classes, and (3) the slow radial growth during the 10-year period just prior to thinning in 1960 as shown by increment borings. As a result, all the plots in 1960 were subjectively thinned more lightly than is recommended in the schedule for "normal" stands in order to avoid too large a reduction in the growing stock and excessive mortality.

Thinning series in other tree species in various countries suggest that there exists a short-term recovery pattern after thinning, which consists of an initial drop of increment followed by a period of increased increment. During the first season much of the growth potential is expended in developing the spread of crowns and roots and the extent of this phase normally is in proportion to the degree of release. With increased crown and root spread, the remaining trees will be able to exploit the mineral resources of the site to a greater extent and, as further spread of roots and crowns become restricted by competition, more of the total dry matter increment will be put in the form of stemwood (Bradley 1963). Results of the 1963 remeasurement suggest that the stand is still in the period in which the increment is below normal immediately following a thinning. It is expected that the current annual increment, expressed as a percentage of that in the unthinned condition, that dropped immediately as a result of thinning, will continue to increase during the coming few years, and that both the duration and the magnitude of the period of increased increment will be affected by thinning grades (Figure 4). The fact that the lightly thinned plot has the highest current mean annual increment and that the increment decreases with heavier thinning grades tend to confirm this supposition. It also seems that in this stand the delay between thinning and response was very short and that wider rings did form at breast height the first or the second year after thinning.

These preliminary results show that balsam fir growth response is closely related to changes in stand density. The results also demonstrate that thinning in overly dense young-mature stands of balsam fir is necessary to increase growth and reduce mortality, and these findings are in close agreement with other findings arrived at by the writer (Vézina 1962, 1963).

Another remeasurement of the plots should be made in the fall of 1966. The data should then permit to define the optimum levels of stocking for dense balsam fir stands in need of thinning. Also the design is such that a breakdown of the data into tree and size classes coupled with standard multiple regression and variance analyses should provide answers to the problems of the choice of the thinning method and of the designation as crop trees of those individuals which have had the best response to release.

SUMMARY

A study was initiated in 1960 in the Montmorency Experimental Forest, Quebec, to determine optimum levels of stocking for thinning young-mature balsam fir. Sixteen plots were established in an over-stocked 43-year-old stand. All plots except one in each of four blocks were thinned to different grades. The remaining plot was left unthinned as a control. Plots were remeasured in 1963.

Diameter growth was stimulated by the grades of thinning tested. It was greater on the most heavily thinned plots. Basal area increment per acre after thinning was greater on the lightly thinned plots and the smallest basal area growth followed heavy thinning. Mortality was reduced effectively by thinning: it was only 4 per cent on the heavily thinned plots, of which stocking corresponds to about 90 per cent of normality, as compared with 11 per cent on unthinned plots.

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TABLE 1. DESCRIPTION OF PLOTS BEFORE THINNING IN 1960.

Treatment	Entire Stand Before Thinning in 1960			
	Trees	Average diameter	Average height	Basal area
	Number	Inches	Feet	Sq. ft.
Unthinned	1,368	5.30	43.5	214.26
Light	1,539	5.10	44.2	217.66
Moderate	1,548	5.55	44.5	198.52
Heavy	1,158	4.65	41.5	189.17

TABLE 2. PLOTS AFTER THINNING AND IN 1963

Treatment	Trees per acre			Average diameter			Basal area per acre		
	After thinning	1963	Mortality	After thinning	1963	Mean Annual increase	After thinning	1963	Mean annual increase
Unthinned	1,368	1,228	11.4	5.47	5.75	0.093	214.26	225.68	3.81
Light	1,209	1,144	5.4	5.45	5.75	0.100	193.89	205.78	3.96
Moderate	955	897	6.1	5.97	6.30	0.111	161.80	172.36	3.52
Heavy	842	807	4.2	5.12	5.47	0.117	133.37	143.06	3.23

Figure 1. Moderately thinned 43-year-old plot of balsam fir on the Montmorency Experimental Forest, owned by the Seminary of Quebec, in 1960. There were 1,000 trees per acre with an average diameter of 5.3 inches.

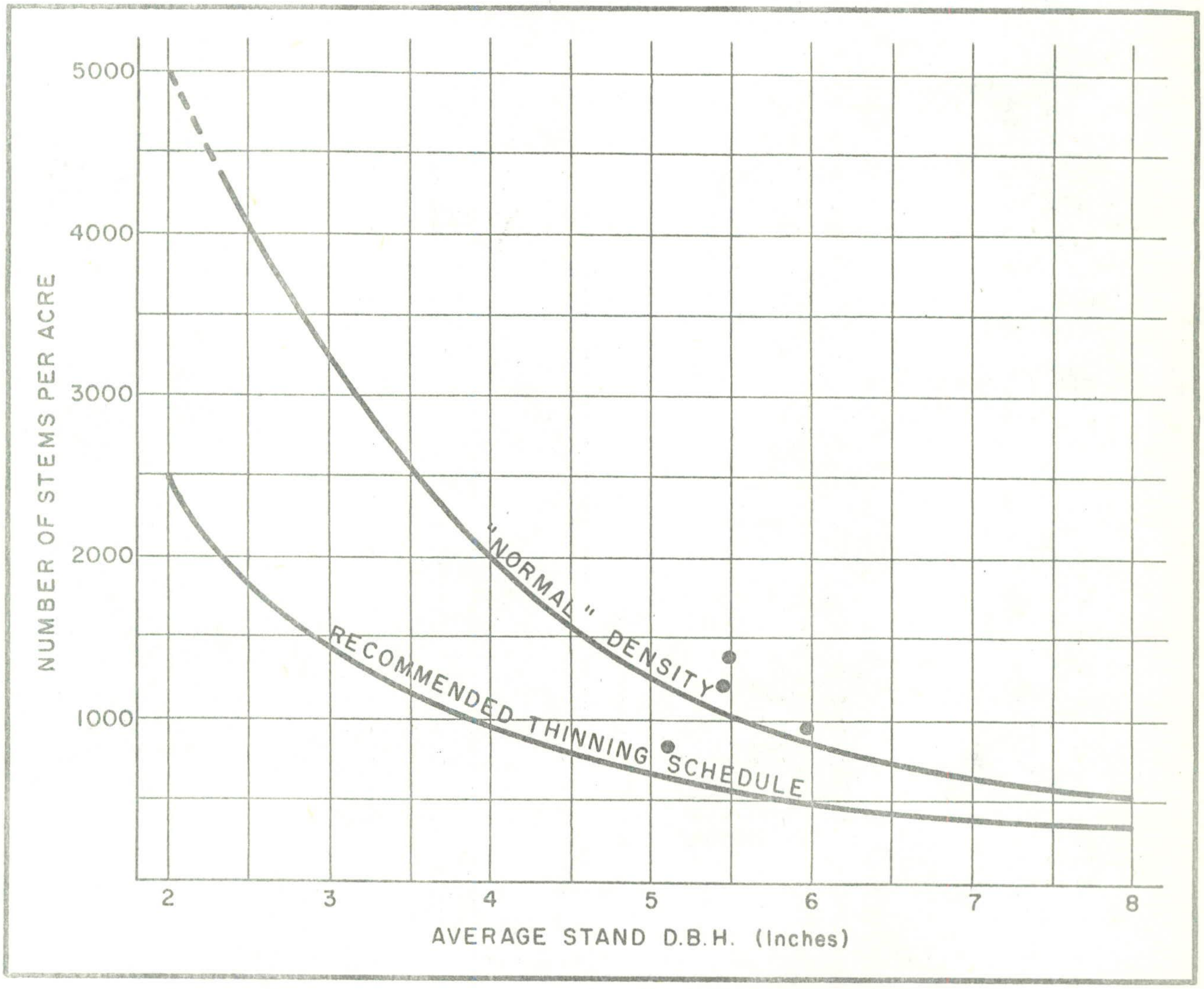

Figure 2. Comparison of the thinning grades tested with both the "normal" density for balsam fir stands in Quebec and a thinning schedule recommended by the writer.

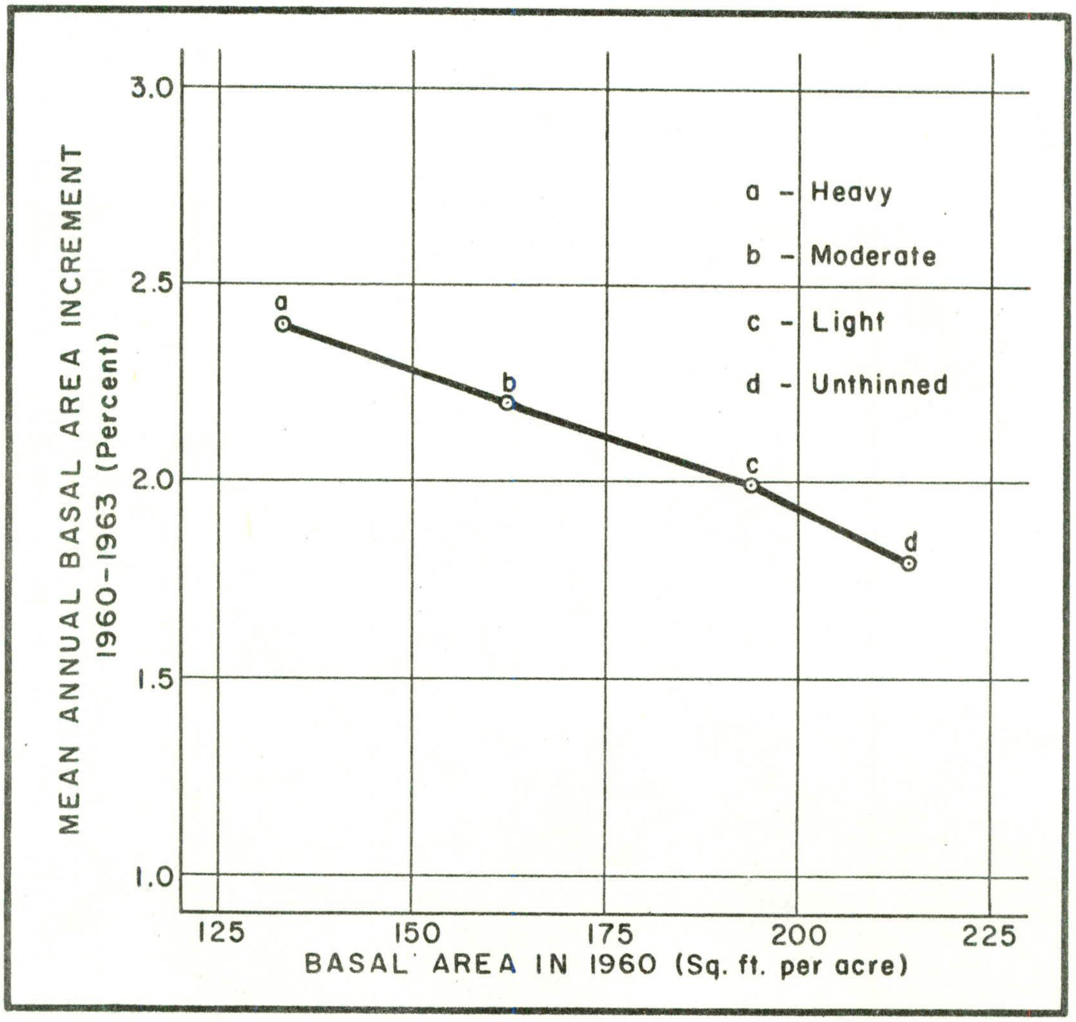

Figure 3. Relationship between current mean annual increment and basal area, for 4 treatments, 43-year-old balsam fir, 1963.

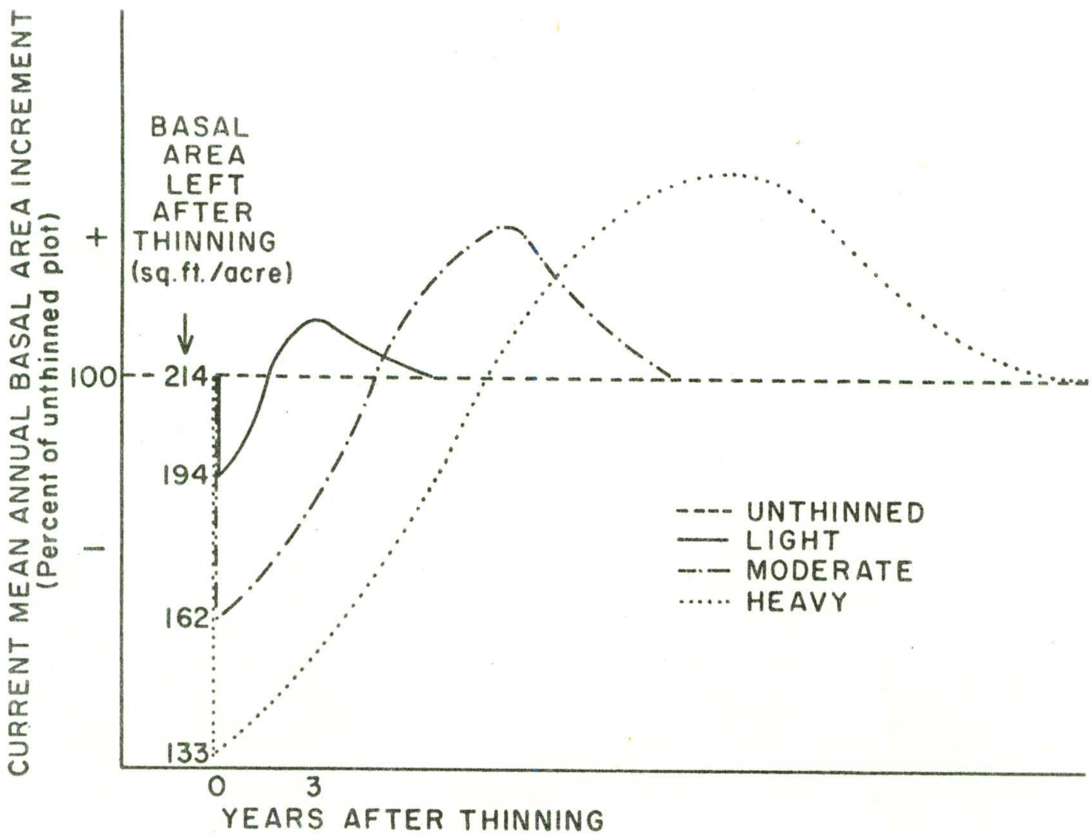

Figure 4. The relationship between the basal area left after thinning and the probable pattern of recovery of current mean annual basal area increment per acre.