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DEVELOPMENT OF BALSAM FIR FOLLOWING A CLEARCUT IN QUEBEC

by
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(Project Q-13)

INTRODUCTION

The large areas of coniferous forest in Quebec which have been commercially clear cut for pulpwood since 1920 will shortly present a challenge to forest managers. For these even-aged second-growth forests suitable management practices, perhaps including changes in silvicultural treatment, will have to be developed from a detailed knowledge of post-cut forest evolution. To obtain information on the development of forests after commercial cutting operations in Quebec, the Forestry Branch has established 15 study areas since 1947. Each area comprises approximately 5 square miles and is covered with a grid of tenth-acre line plots to be remeasured at 10-year intervals.

The following report describes the development of a balsam fir forest during the first 15 years after a commercial clearcut operation in Forest Section B.1 of the Boreal Forest Region. The cutting took place between 1941 and 1944. Data presented are from measurements on line plots established in 1948 and remeasured in 1958. Findings are also presented from a 1958 study of the origin and early development of balsam fir, *Abies balsamea* (L.) Mill., the most important post-cut species.

REVIEW OF LITERATURE PERTAINING TO THE ORIGIN AND EARLY DEVELOPMENT OF BALSAM FIR STANDS

Origin of Stands

Pure, even-aged, balsam fir stands originate after fire, blowdown, and cutting. Little difference is apparent in stocking between young stands originating from cutting and blowdown; often both form densely stocked thickets known colloquially in Quebec as Saint-Michel. After fire, stocking is more likely to vary widely depending on the severity of the fire and the quantity of seed present (Heikkenen 1957).

Fir is a prolific seed producer, providing a good crop every two or three years. Seed is generally the only important source of reproduction although locally layering may be abundant (Roe 1950). Bonner (1941) estimates that one per cent of the fir reproduction in the Clay Belt of Northern Ontario results from layering and on Ile Royale, Michigan, Cooper (1911) found that it was responsible for a large proportion of fir regeneration.

Roe (1948), Morris (1948) and Webb (1957) observe that fir stands begin to produce seed at between 20 and 30 years of age. Zon (1914) states that in the northeastern United States fir produces seed regularly after 30 to 35 years of age.

Germination on forest litter generally occurs in late May and June (Roe 1950). Seedlings which germinated after the middle of July seldom survived the winter (Place 1955). Webb (1958) reports evidence of seed remaining viable 3 or 4 years under slash piles, and MacGillivray (1955) advances the hypothesis that some seed may remain viable after 2 or 3 years in cold sphagnum bogs.

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It is frequently noted that most fir in new stands develop from seedlings present when the old stand breaks up or is cut or blown down (Dana 1930, Westveld 1931, Smithers 1948, Roe 1953, Vincent 1956, Ghent 1958, Webb 1958, Ellis 1958). However, there is a lack of data showing the proportions and the relative importance of advance reproduction and new seedlings forming young stands.

Fir stands in Michigan typically have a reserve of established seedlings at all times after seed production begins, even where the crown cover is very dense (Roe 1953). Webb (1957) states that in the Gaspé Peninsula of Quebec, fir seeds germinate under dense 20- to 45-year-old stands but do not live more than one or two years.

Seedling Development

Fir seedlings are reported to be inherently slow-growing for the first five or six years even under full light (Zon 1914). Roe (1950) states that early growth of seedlings in the open is slow, amounting to one foot or less in seven years. In the northeastern United States fir seedlings reach heights of one foot and 4.5 feet in about the same number of years as two common associates, white and red spruce, *Picea glauca* (Moench) Voss, and *P. rubens* Sarg. (Meyer 1929).

Seedlings of fir can survive long periods of suppression, up to 50 years or more (McGraw 1948, Morris 1948, Roe 1950, Webb 1957, Ghent 1958). When released these seedlings rapidly attain a growth rate comparable to that of non-suppressed seedlings. Heikkenen (1957) suggests that the rate of recovery may be related to the duration of the suppression period. Ellis (1958) states that the time taken for fir advance growth to exhibit increased height growth following logging is dependent upon both its age and height at the time of logging. This relationship also exists for red spruce (Westveld 1931).

Little research has been initiated in spruce-fir stands of a given age or density to determine the quantity, quality, or height distribution of advance growth necessary to assure full stocking. Johnson (1953) advocates shelterwood cutting to secure a minimum stocking of 500 well-spaced seedlings per acre. He states that these seedlings at the time of the final cut should be at least one foot tall on rich sites and four feet on poor sites. Webb (1957) observes that when mature fir stands in Gaspé begin to deteriorate, fir seedlings that previously had lived for only a few years grow into saplings and gradually replace the old stand. At 60 years there are sufficient seedlings to provide fully stocked stands.

Westveld (1928) found that dense conifer slash prevented the establishment of seedlings for a period of 15 to 20 years. In New Brunswick, only conditions at the *centre* of slash piles were not favourable for regeneration for 15 years (Vincent 1956). In Gaspé, slash from cutting operations in the Causapscal River basin generally had deteriorated after only 8 years (Morais 1956). This rapid deterioration is ascribed to a more humid climate.

Vincent (1956) discovered that smothering by slash was a negligible factor in the mortality of seedlings but that there was stem breakage from its weight. He also found that in softwood stands raspberry spread rapidly after cutting, suppressed small advance growth and retarded regeneration, but affected only those seedlings which it over-topped.

Stocking in Young Stands

Young fir stands which develop after a logging operation are often densely stocked. Five years after a commercial clear cutting in Minnesota there were 28,850 seedlings per acre of which 7,650 were at least one foot tall (Roe 1957). Webb (1958) reports that four years after clear cutting in Gaspé there were 9,500 fir seedlings per acre up to 0.6 inch d.b.h. In New Brunswick, 3,600 to 6,800 seedlings per acre were found immediately after clear cutting and up to

32,000 per acre after shelterwood cutting (Vincent 1956). Two years after clear cutting in the rich spruce-fir-white birch type in Quebec there were 8,000 seedlings per acre (Smithers 1948). Results from a reproduction survey in eastern Canada (Candy 1951) also show that generally there is more than adequate fir regeneration after cutting. Although *per cent* mortality of advance growth may be high because of the adverse effects of logging and the resultant dense slash and shrub competition, fir survives in sufficient numbers to provide well-stocked stands.

Stagnation in sapling stands is not a problem although it is generally accepted that mortality is high in dense 40- to 60-year-old pole stands.

FOREST DESCRIPTION

The study area of about five square miles is in the Boreal Region (Section B.1) about 40 miles north of Quebec City at latitude 47° 20′N. Except for about 150 acres, it lies west of the Montmorency River and includes most of the drainage basins of two small tributaries.

Considerable variation in topography is encountered, from flat, low, swampy areas to high cliffs. However, most of the area comprises moderate slopes which rise from the Montmorency and its tributaries to the watersheds which form the boundary (Figure 1). The elevation above sea level varies from about 2,400 to 3,100 feet.

FIGURE 1. Gently sloping topography typical of the Montmorency River valley.

The soil over the pre-Cambrian granite on middle and lower slopes is generally a fairly deep, well drained, loamy till. It contains numerous stones and boulders although the surface is usually free of rock. On steep cliffs and ridges the bedrock is only thinly covered with humus and mineral soil.

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The climate is severe. According to Villeneuve (1946), the Laurentide Park, in which the area is located, has one of the shortest growth periods (60 to 90 days) of the inhabited areas of Quebec. On the neighbouring Epaule River basin the growing season averages 80 days (Tremblay 1954). Annual precipitation is heavy, between 32 and 56 inches, and the Park is noted as an area of pronounced summer evaporation due to high winds. The mean temperature of the four warmest months ranges from 54° to 58°F. and the mean monthly summer precipitation is 4.0 to 7.0 inches.

The site types mentioned hereafter were described by Linteau (1955). Only four of nine site types identified in the area were represented sufficiently by the line-plot sampling to permit analysis. These four are Dryopteris-Oxalis, Site Class I; Hylocomium-Oxalis and Hypnum-Cornus, Site Class II; and Sphagnum-Cornus, Site Class III. The Sphagnum-Cornus type is believed to contain areas of other site types where the ground vegetation has completely changed owing to a rise in the water table following cutting.

Only four tree species are commercially important. They are white spruce, black spruce, *Picea mariana* (Mill.) BSP., balsam fir, and white birch, *Betula papyrifera* Marsh. Other species present in small quantities are trembling aspen, *Populus tremuloides* Michx., tamarack, *Larix laricina* (Du Roi) K. Koch, and pin cherry, *Prunus pensylvanica* L.f.

Seventy per cent of the forest at the time of cutting was classified as virgin and uneven-aged. The uneven-aged structure was probably brought about by the patchy and gradual break-up of the former forest. The age of the firs in the main stand varied from 50 to 100 years, most trees being between 60 and 90 years. The spruce were older, ranging from 50 to 200 years and averaging over 100 years. About 25 per cent of the original forest was classified as being of fire origin and about 80 years old. This area in 1958 contained a relatively large amount of white birch indicating some past stand disturbance. However, a careful soil examination failed to show any trace of carbon particles. Thus, on the basis of evidence of disturbance, this area could not be separated from the uneven-aged virgin forest. Both areas, plus the remaining 5 per cent which originated following blowdown, had very similar postcut development. All were clear cut and large residual white birch are rapidly dying out.

The commercial clear cutting which took place between 1941 and 1944 was typical of this system of harvesting as practised in Quebec. Very little wood of commercial value was left standing (Figures 2 and 3). From 87 to 94 per cent of the total volume of spruce and fir 4 inches d.b.h. and up was removed from stands which originally contained 1,900 to 3,000 cubic feet per acre. The proportion of spruce ranged from 27 to 63 per cent of the total depending on the site type. The volume of white birch ranged from 20 to 600 cubic feet per acre, of which small quantities were cut for fuelwood in areas adjacent to camps.

METHOD OF STUDY

In 1948 a 10-chain grid of 286 permanent tenth-acre (66-foot-square) line-plots was established. The following data was recorded: 1) all trees 0.6 inch d.b.h. and larger were tallied by species and one-inch diameter classes; a separate tally was made of trees with visible defects; 2) stumps were measured and tallied by species and one-inch diameter classes; 3) trees that had died since the cut were tallied by species and diameter classes; 4) at each plot, a stocked quadrat tally was made on 20 milacre quadrats; species were tallied separately and in 6 size classes; 5) height-diameter measurements were made in order to construct local volume tables; 6) a general plot description was recorded, comprising notes on ground and shrub vegetation, topography, drainage, and plot origin and disturbances since origin.

FIGURE 2. A lower slope four years after clear cutting, covered with shrubs, mainly raspberry.

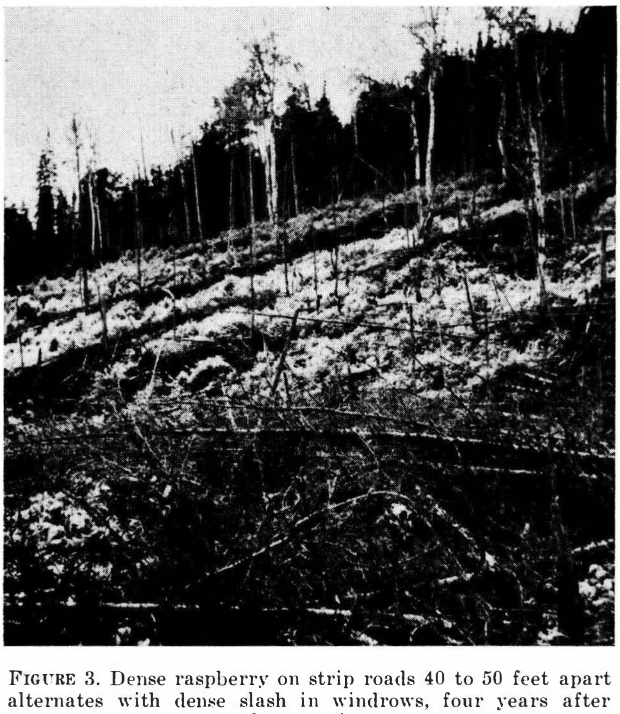

FIGURE 3. Dense raspberry on strip roads 40 to 50 feet apart alternates with dense slash in windrows, four years after clear cutting.

In 1958 the plots were remeasured and a supplementary study was made of the origin and height growth of balsam fir seedlings and saplings. A count of all spruce, fir and white birch below 0.6 inch d.b.h. was made on a single milacre quadrat on each plot.

One hundred and eighty-nine plots were site typed according to Linteau's classification, 156 of which comprised the four site types that had sufficient numbers of plots to permit analysis.

Stand tables for the types before and after cutting (1941) were prepared from the 1948 tallies of living, dead, and cut trees (stumps). The stand in 1948 plus the dead trees was considered as the stand after cutting. The stand before cutting was estimated by adding the stump tally. The fact that no allowance was made for growth or ingrowth for the period 1941-48 is a source of error in the 1941 tables. However, tree growth during this period was not rapid. The small seedlings were in heavy competition with a dense growth of raspberry and the larger residual saplings were recovering from previous suppression. Thus the 1941 tables are believed to present only slightly larger values than those which actually existed before and after cutting.

For the study of origin and growth, trees were selected outside but in the immediate vicinity of the plot. Selection was made to comprise representative samples of the trees growing in the plot. Each tree was placed in one of three competition classes: (1) no crown competition; open growing, (2) moderate competition; crown competition on one, two or three sides, and (3) high competition; crown competition on all four sides, or four sides plus top cover. It should be understood that the classifications "no competition" and "high competition" are not necessarily synonymous with "dominant" and "suppressed". A small sapling with ample growing space and receiving full light was classed as open growing, although it certainly did not occupy a dominant position in the stand. For each of the 373 fir in this study, the following information was recorded: d.b.h., total height 1958, and height for each year back as far as could be accurately determined. Discs about one inch thick were cut from each sample at the root collar, and additional discs were taken at one foot and three feet from 112 and 145 fir respectively. At each plot one or two additional root collar sections were collected for age counts. All sections were brought to the office for examination under a binocular microscope where total age was counted plus the number of years since release.

RESULTS

The results are discussed under three sub-headings: (1) stand development, (2) origin of the present balsam fir forest, and (3) height growth of balsam fir.

Under the first, the initial development of the forest in terms of numbers of trees per acre is described. Summarized data from the stand tables are stratified into four site types and the three species present are shown separately.

The data under the second and third sub-headings are concerned with the origin and initial growth of the dominant species, balsam fir.

Stand Development

From the time of cutting to 1948 the forest recovered slowly from the shock of cutting. In 1948 there were no striking signs of the dense future stocking (Table 1), although the reproduction survey revealed that about 90 per cent of the quadrats were stocked with fir (Table 2). A thick growth of raspberry, *Rubus idaeus* L., covered almost the entire cutover area (Figure 2) and hid most of this reproduction. Slash piles were still much in evidence (Figure 3). The small number of residual trees in the larger diameter classes was greatly reduced as the wind took its toll. Windfirm residuals usually had poor form, broken tops, rot, cracks, or some other visible defect.

Table 1. Stand Table Summary—Number of Trees per Acre

Site Type	Species	1941 Before Cutting				1941 After Cutting				1948				1958			
		DIAMETER GROUP (INCHES)															
		1-3	4-6	7-9	10+	1-3	4-6	7-9	10+	1-3	4-6	7-9	10+	1-3	4-6	7-9	10+
Dryopteris Oxalis (69 plots)	Balsam fir................	315	195	53	17	304	68	3	1	261	55	2	*	2,044	101	12	1
	Spruce....................	9	9	11	14	9	3	1	*	8	2	*	*	53	6	1	*
	White birch..............	55	78	15	13	51	66	12	11	30	55	11	6	574	34	9	3
Hylocomium-Oxalis (46 plots)	Balsam fir................	737	212	54	15	727	113	5	*	669	103	4	*	1,934	199	11	1
	Spruce....................	38	21	14	20	37	10	1	1	34	10	1	1	112	14	2	*
	White birch..............	42	44	8	15	40	42	7	14	32	37	5	6	318	27	5	2
Hypnum-Cornus (24 plots)	Balsam fir................	276	187	65	13	258	52	1	0	182	30	*	0	2,225	54	8	0
	Spruce....................	45	80	46	25	39	10	1	0	24	6	0	0	140	3	*	0
	White birch..............	63	53	7	4	59	48	5	3	38	41	2	2	125	16	2	0
Sphagnum-Cornus (17 plots)	Balsam fir................	370	143	46	6	354	54	3	0	299	44	2	0	1,802	72	6	0
	Spruce....................	104	88	48	15	97	14	1	0	71	11	1	0	328	25	0	0
	White birch..............	20	11	2	2	20	11	2	2	16	6	0	1	112	1	0	0

* less than 0.5

Table 2. Per Cent Stocked Quadrats in 1948 Compared to Numbers of Stems per Acre in 1958, One Year Old to 3.5 Inches d.b.h.

Species	SITE TYPE			
	Dryopteris-Oxalis	Hylocomium-Oxalis	Hypnum-Cornus	Sphagnum-Cornus
BALSAM FIR				
No. of stems per acre 1958				
Below 0.6 inch d.b.h.*	5,840	7,670	13,400	8,440
0.6–3.5 inches d.b.h.**	2,040	1,930	2,220	1,800
Total	7,880	9,600	15,620	10,240
Per cent stocked quadrats 1948	87	89	92	93
SPRUCE				
No. of stems per acre 1958				
Below 0.6 inch d.b.h	205	326	541	562
0.6–3.5 inches d.b.h	53	112	140	328
Total	258	438	681	890
Per cent stocked quadrats 1948	10	20	28	39
WHITE BIRCH				
No. of stems per acre 1958				
Below 0.6 inch d.b.h	1,630	2,060	2,620	1,560
0.6–3.5 inches d.b.h	574	318	125	112
Total	2,204	2,378	2,745	1,672
Per cent stocked quadrats 1948	24	13	18	17

* Data from milacre quadrat counts.
**Data from line-plot tally.

By 1958 the forest presented quite a different appearance (Figures 4 and 5). Fir had gained ascendency over raspberry which had almost completely disappeared. Only traces of slash remained. Stocking was dense except for small unstocked patches on poor sites. The average height of spruce and fir saplings ranged from 8 to 12 feet depending on the site. On rich sites white birch was closely associated with fir, in some places of almost equal density. White birch development, however, was greatly retarded by very heavy browsing by moose, *Alces alces* (Clinton), a protected animal in this area.

Initial post-cut mortality of residual fir and spruce was high but dropped appreciably after 1948 when very few survivors remained. White birch mortality continued high after 1948 and is ascribed to die-back. The few residual trees over 4 inches d.b.h. still living are considered to be of negligible value for potential crop or seed trees. Very little mortality has occurred in the new forest, even in the smaller suppressed height classes.

Butt rot is an important factor in the silviculture of balsam fir. Very little was observed in the seedling or sapling stage dealt with in this study.

The summarized data of Table 1 show forest development in terms of numbers of stems one inch d.b.h. and over per acre, but the 1958 data do not give a complete picture of stand density. Table 2 shows the number of seedlings (below 0.6 inch d.b.h.), and saplings (0.6 to 3.5 inches d.b.h.) in 1958, and the percentage of stocked quadrats in 1948. There is a direct relationship between per cent stocking in 1948 and numbers of stems in 1958 for spruce but not for fir or white birch.

Origin of the Present Balsam Fir Forest

It is generally accepted that a large proportion of balsam fir originates from advance growth. Figure 6 presents the results of 678 age counts on fir trees ranging in size from one foot in height to 3.5 inches d.b.h. The percentages

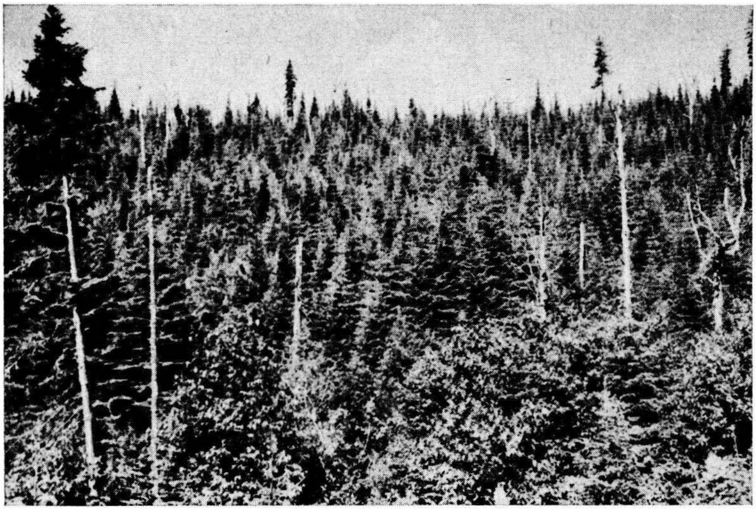

FIGURE 4. Fourteen years after clear cutting, balsam fir has overcome the suppressing effects of shrubs. Note occasional large residual white spruce.

FIGURE 5. The Hylocomium-Oxalis site type 15 years after the cut, exhibiting all sizes of balsam fir advance growth from two feet to 15 feet and taller.

of fir established at 15 and 10 years prior to cutting and at the time of cutting were approximately 20 to 30, 30 to 40, and 75 to 85 per cent respectively. Variations between site types were inconsistent and of little size. In studies at Green River, New Brunswick, Vincent (1956) found that up to 92 per cent of the fir originated from advance growth in 16-year-old cutover. Walton (1949) reported that 96 per cent of the spruce and fir originated before the cut on areas cutover between 1924 and 1949 in the Saguenay region of Quebec. Smithers (1948) found that about 80 per cent of fir regeneration was advance growth in cutover areas near Forestville, Quebec. These studies were conducted in stands where pre-cut age and stand structure were similar to the stands at Montmorency River.

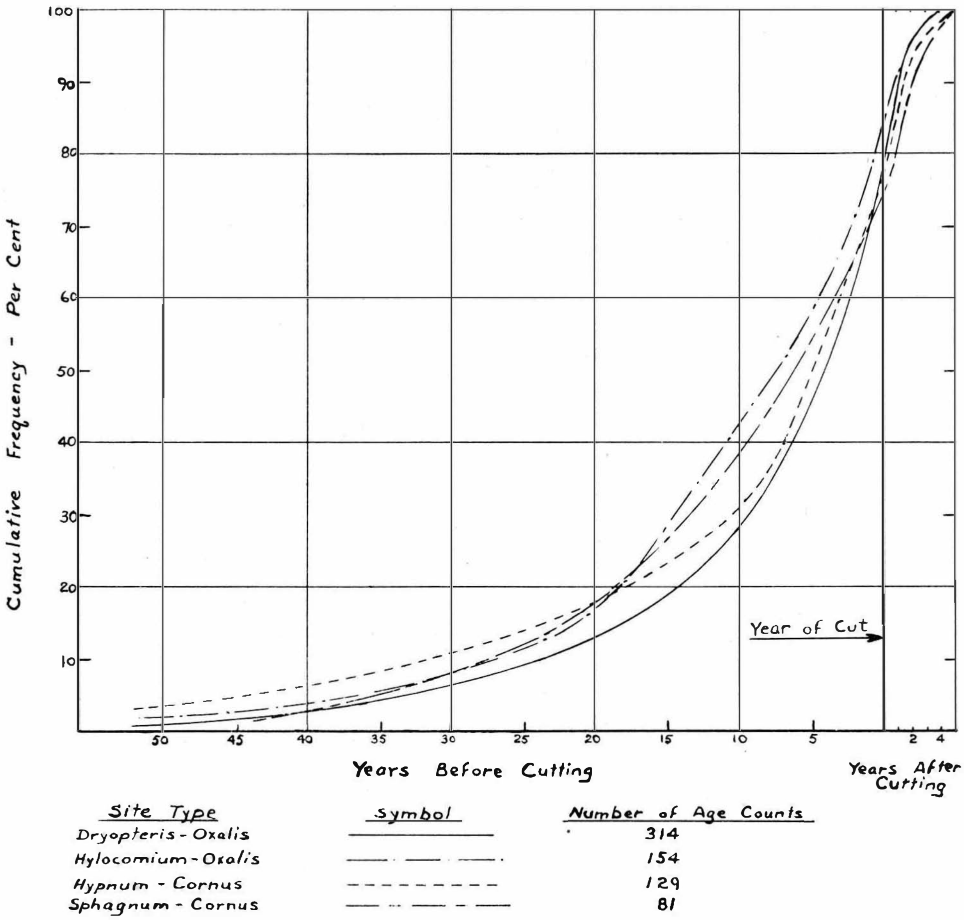

FIGURE 6. Accumulated per cent of the present balsam fir stand established at the indicated number of years before and after cutting.

Although most of the advance growth became established during the 20 years before logging, part of the present fir forest was formed from an accumulation of seedlings dating back 50 years. Older trees are possibly those which originated soon after seed production began and occupied the "seedling niches" referred to by Ghent (1958). None of the trees sampled were established later than 5 years after the cut. Layering by fir was not encountered during the study.

Occasional small thickets of 30- to 40-year-old fir growing amongst the tangled remains of the parent stand testify that the forest had begun to deteriorate before the cut. On the remainder of the area, stand break-up was less severe but sufficient to open the crown canopy and permit the survival of established seedlings. Forty per cent of the root collar sections examined for release showed increased diameter growth before the cut, another indication that the old forest had started to break up.

Most advance growth was very small when the cut took place, 78 to 90 per cent of it being less than 2 feet tall (Table 3). An immediate increase in diameter increment followed cutting; within 2 years, about 95 per cent had begun to produce wider annual rings at ground level.

Table 3. Present Percentage of Balsam Fir Saplings (0.6 to 3.5 inches d.b.h.) that existed at time of cutting

Height Class at Time of Cutting	Dryopteris-Oxalis	Hylocomium-Oxalis	Hypnum-Cornus	Sphagnum-Cornus
Under 0.5 ft.	56	46	37	47
0.6 to 1.0 ft.	18	19	29	27
1.1 to 2.0 ft.	13	13	24	13
Total	87	78	90	87

These percentages are slightly low because heights on several samples could not be accurately measured back farther than 1946 or 1947. A tree that was 1.5 feet tall in 1946 was compiled as being less than 2.0 feet at the time of cut whereas it was probably less than one foot. Therefore it would be a reasonable estimate that about one-half the present stand was less than 6 inches tall when released.

Height Growth of Balsam Fir

The number of years required for advance growth to attain heights of one foot and three feet respectively was double that required by the seedlings that were established after the cut (Table 4).

Table 4. Average Number of Years for Balsam Fir Seedlings to Reach Heights of One Foot and Three Feet

		Number of Years	
Seedling Establishment	Height above ground	Site Class I* Dryopteris-Oxalis	Site Class II Hylocomium-Oxalis Hypnum-Cornus
After cutting	1 foot	4.8 (12)**	4.6 (12)
	3 feet	7.4 (34)	7.6 (14)
Before cutting	1 foot	9.8 (35)	12.4 (42)
	3 feet	14.2 (50)	17.8 (33)

*Site Class III, Sphagnum-Cornus type omitted because of insufficient data.
**Number of samples.

Zon (1914) reported fir seedlings under full light reaching one foot in height in 5 years and 3 feet in 9 years and considered such growth as slow. He stated that slow initial growth is an inherent characteristic of the species. Roe (1950) also considers that initially fir grows slowly and stated that in Michigan seedlings of 7 years reach a height of only 6 inches to one foot when growing in the open. It is understood that "slow growing" is relative to other conifers, particularly those associated with fir in mixed stands. However, Meyer (1929) discloses that the average number of years required for red spruce, white spruce and balsam fir to attain a height of one foot under full light in the northeastern United States are almost the same, 6.9, 6.2 and 6.9 years respectively. Apparently, under full light, fir grows at a rate comparable to the spruces with which it is associated.

Table 5. Average Annual Height Growth in Feet of Balsam Fir, 1950-57, by Tree Classes and 1957 Height Classes

Site Type	Individual Tree Classification	Height 1957 (feet)				
		0.6–6.5′	6.6–12.5′	12.6–18.5′	18.6–24.5′	0.6–24.5′
Dryopteris–Oxalis	Open growing	0.4 (5)*	0.9 (18)	1.3 (34)	1.4 (10)	1.1 (67)
	Moderately competitive	0.4 (7)	0.9 (62)	1.1 (15)	1.1 (1)	0.9 (85)
	Highly competitive	0.4 (18)	0.8 (16)	1.2 (3)		0.6 (37)
Hylocomium–Oxalis	Open growing	0.4 (4)	0.9 (8)	1.0 (4)	1.1 (2)	0.8 (18)
	Moderately competitive	0.5 (10)	0.7 (24)	1.2 (2)		0.7 (36)
	Highly competitive	0.4 (6)	0.6 (5)	0.6 (1)	0.7 (1)	0.5 (13)
Hypnum–Cornus	Open growing	0.6 (2)	0.8 (18)	1.0 (8)		0.9 (28)
	Moderately competitive	0.5 (8)	0.8 (25)	1.4 (1)		0.7 (34)
	Highly competitive	0.3 (9)	0.6 (1)			0.4 (10)
Sphagnum–Cornus	Open growing	0.5 (7)	0.7 (6)	1.2 (9)		0.8 (22)
	Moderately competitive	0.5 (2)	0.7 (14)	1.1 (4)		0.8 (20)
	Highly competitive	0.4 (3)				0.4 (3)

*Number of trees in parenthesis.

As might be expected, the competitive position of individual trees influenced their height growth (Table 5), with those subject to the greatest competition making the poorest growth. It is evident also that seedlings maintained or increased their initial height advantage (Table 6).

Table 6. Average Height of Balsam Fir in 1957 Relative to Height in 1946

Site Type*	Number of Samples	1946 Height Class (in feet)	1957 Average Height (in feet)
Dryopteris-Oxalis	15	0.1–0.5	8.0
	43	0.6–1.5	10.2
	23	1.6–2.5	13.3
Hylocomium-Oxalis	10	0.1–0.5	6.2
	11	0.6–1.5	7.9
	10	1.6–2.5	9.6
Hypnum-Cornus	9	0.1–0.5	6.9
	15	0.6–1.5	10.0
	13	1.6–2.5	11.1

*Sphagnum-Cornus omitted because of insufficient data.

Table 7. Average Annual Height Growth in Feet of Balsam Fir, 1950-1957

Height Group 1957	Years of Suppression	Dryopteris-Oxalis	Hylocomium-Oxalis	Hypnum-Cornus	Sphagnum-Cornus
2.6–10.5 feet	nil	.9 (22)*	.7 (10)	.7 (13)	.7 (6)
	1–5 years	.8 (32)	.7 (12)	.8 (9)	.6 (5)
	6–10 years	.7 (8)	.7 (7)	.7 (7)	.6 (5)
	11–20 years	.8 (4)	.6 (7)	.7 (6)	.5 (5)
	over 20 years	**	**	.7 (4)	**
10.6 feet and taller	nil	1.1 (6)	**	**	**
	1–5 years	1.2 (14)	**	1.1 (5)	1.1 (4)
	6–10 years	1.2 (17)	**	1.0 (4)	1.1 (3)
	11–20 years	1.2 (17)	1.1 (6)	1.1 (4)	1.2 (5)
	over 20 years***	1.2 (28)	.9 (8)	.9 (8)	1.0 (6)

*Number of trees; multiply by 8 for number of height growth measurements.
**Insufficient data.
***Average age of 50 samples, all types: 50 years.

The difference in height between the shortest and tallest trees increased between 1946 and 1958. For the Dryopteris-Oxalis type an initial height difference of 1.5 to 2.0 feet has increased after 11 years to over 5 feet.

When suppressed seedlings are released they soon attain a growth rate comparable to that of new seedlings. This is evident from Table 7 which reveals growth rates to be only slightly different for seedlings suppressed for different periods. The results are inconclusive in showing whether or not the growth rate after release is a function of the length of the suppression period.

Figure 7 shows the height-diameter relationship for fir up to 3 inches d.b.h. Differences between site types are evident for trees over 1 inch d.b.h.

In his "Forest Site Classification of the Northeastern Coniferous Section, Boreal Forest Region, Quebec", Linteau (1955) has shown the site indices for these and other types in stands of more than 25 years of age. The tendency of height growth differentiation with site types already appears at the sapling stage, and the position of the curves would be as expected.

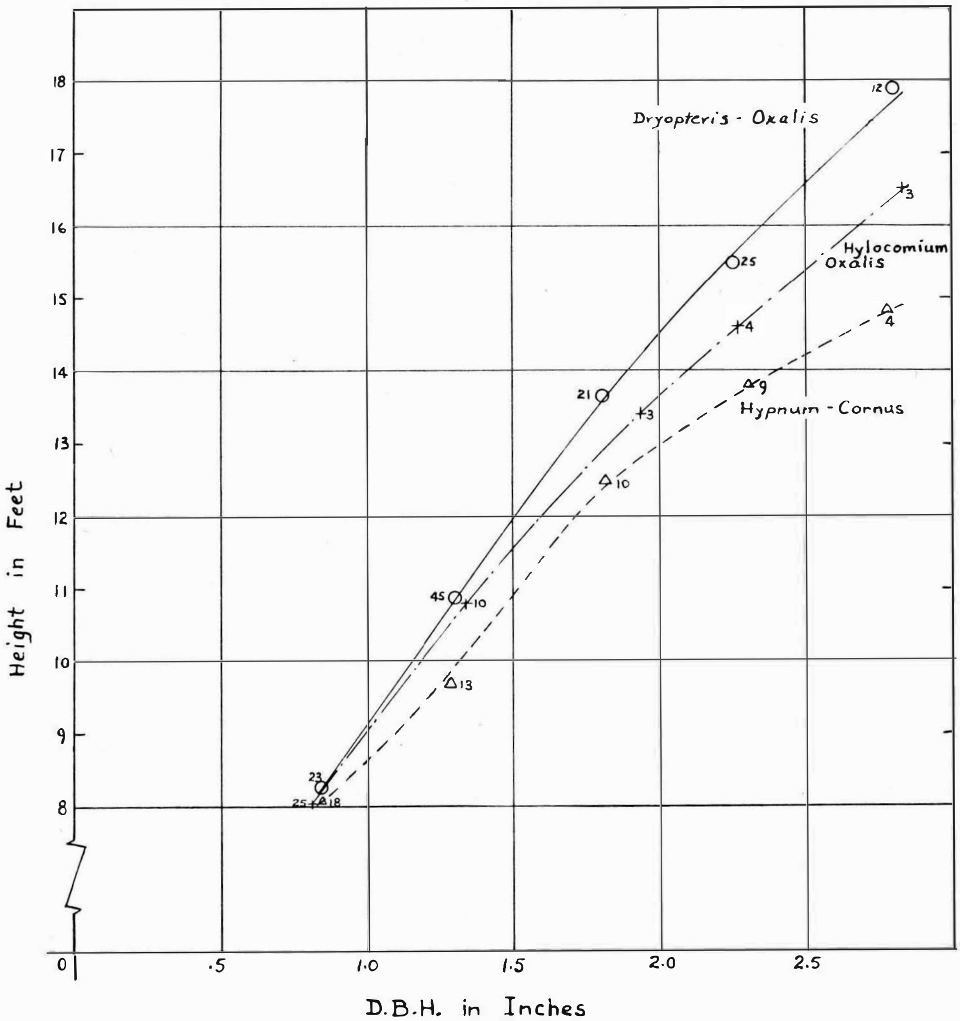

FIGURE 7. Height-diameter curves for balsam fir.

CONCLUSIONS

The rapid and satisfactory restocking of the forest with commercially valuable species, principally balsam fir, reveals that the clearcutting system is an acceptable method of harvesting for this type of forest. However, the high proportion of fir in the new stand presents a serious disadvantage; it will render these stands highly susceptible to attack by the spruce budworm, *Choristoneura fumiferana* (Clem.).

There is no reason to believe that a higher proportion of spruce than fir will survive up to 60 or 80 years. Thus spruce will not likely form as high a proportion of the stand at harvest as it did in 1941-44 if the forest is managed on a rotation of 90 years or less. White birch, unaffected by dieback at its present stage of development, almost certainly will form mixedwood stands on the richer sites in association with spruce and fir.

Fir is a species that reproduces by gradually accumulating regeneration for many years. After seed production begins seeds germinate each year and some survive as suppressed trees for long periods. The crown canopy retards the growth of seedlings until the parent stand begins to break up or is destroyed.

For adequate regeneration, it is immaterial how large the seedlings are at the time of cutting. Small seedlings were able to overcome the adverse effects of shrub competition and slash. In a forest where a large number of such small seedlings survive, the fact that shrubs and slash may prevent the establishment of new seedlings is not too important. However, new seedlings perform an important function in filling stand openings which lack advance growth.

Growth is related to growing space and light. The larger advance growth emerges from overtopping raspberry and slash sooner than the smaller seedlings and assumes a dominant position in the developing stand. However, the proportion of the advance growth that assumes this dominance is small.

Under present economic conditions it is not likely that many of the thousands of acres of second-growth fir forest in Quebec will be thinned or otherwise treated before the next harvest. These forests at 50 to 60 years will be (1) highly susceptible to spruce budworm attack, and (2) suffering high mortality owing to overcrowding. If they were clear-cut at this age rather than at 70-80 years, the period of high budworm susceptibility would be reduced by 20-30 years and considerable loss through mortality and increased butt rot would be averted.

Clear cutting 50- to 60-year-old fir stands introduces the problem of whether or not *at this age* there is sufficient advance growth to provide fully stocked stands. Applying the percentages from Figure 6 to the sapling stand in 1958 (Table 2), it is calculated that 15 years before cutting, when most of the fir were between 45 and 75 years, there were *at least* 1,400 fir seedlings per acre in the Dryopteris-Oxalis type and over 2,000 in the other three types. These seedlings represent survivors to the present time only, and no doubt a much larger number was present 15 years before logging. This indicates the possibility that regeneration might be successful after clear cutting fir stands as young as 50 years. There is also some evidence that volumes per acre may be only slightly larger at 70 years than at 50 years (Boynton 1956). An investigation of the quantity and distribution of advance growth and its development after clear cutting in 50- to 60-year-old stands would yield valuable results. If such stands can be adequately regenerated, management of fir on a clearcut basis would certainly be attractive in view of high susceptibility to spruce budworm attack and high mortality after 50 years.

SUMMARY

A study of stand development was begun in 1948 on a 5-square-mile area which was commercially clear cut for fir and spruce pulpwood between 1941 and 1944, in Section B.1 of the Boreal Forest Region in Quebec. Seventy per cent of the forest at the time of cut was classified as virgin and uneven-aged, 25 per cent was of fire origin, 80 years old, and 5 per cent was of blowdown origin. Most of the firs were between 60 and 90 years of age but the spruce were older with an average age of about 100 years and ranging from 50 to 200 years. The forest contained between 1,900 and 3,000 cubic feet per acre of spruce and fir, and between 20 and 600 cubic feet of white birch.

The 10-chain grid of semi-permanent tenth-acre line plots was remeasured in 1958 when a study was also made of the origin and height growth of balsam fir.

The forest recovered well from cutting and now comprises fully-stocked sapling stands, predominantly fir with much smaller quantities of white birch

and white and black spruce. It is unlikely that spruce will again form a proportion of the stand equal to that before the cut. Fir reproduced by accumulating regeneration for many years under a crown canopy that prevented normal growth until the parent stand was clear cut.

Between 78 and 90 per cent of the present fir was less than 2 feet tall at the time of cut. These small seedlings grew well after overcoming heavy competition from raspberry, the growth of individuals being related to their growing space and available light.

The study of the origin of the forest indicates the possibility that regeneration might be adequate after clear cutting 50- to 60-year-old stands. Valuable information would be forthcoming from studies made to determine the state of advance growth in 40- to 60-year-old stands and its development after clear cutting.

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