CANADA

Department of Forestry

FOREST RESEARCH BRANCH

STRUCTURE AND GROWTH OF BLACK SPRUCE AND BLACK SPRUCE-BALSAM FIR STANDS IN FOREST SECTION B.1b., QUEBEC, 1950-1961

(Project Q-36)

by

R.J. Hatcher

Quebec District,
July 1962

Que. 62-8

TABLE OF CONTENTS

STRUCTURE AND GROWTH OF BLACK SPRUCE AND BLACK SPRUCE-BALSAM FIR[1/] STANDS IN FOREST SECTION B.1b., QUEBEC, 1950-1961

R.J. Hatcher[2/]

ABSTRACT

The origin, age structure, species composition, volume and basal area distribution, growth rate, mortality and reproduction of even- and uneven-aged stands of six site types in a five-square-mile forest, and changes which occurred from 1950 to 1961, are described. A comparison with yield table data is presented, some implications of the findings are discussed, and a need for additional investigation is indicated.

INTRODUCTION

The bulk of Quebec's pulpwood supply is harvested from Forest Sections B.1a (Rowe 1959), where black spruce[3/] and balsam fir predominate, and B.1b where extensive forests of pure or nearly-pure black spruce are found. The economic value of black spruce in Canada is indicated by a voluminous literature on the silvics, silviculture and management of this species. However, little study or experimentation in black spruce stands has been reported in Quebec apart from forest classifications by Linteau (1955) and Lafond (1960), and some investigations of regeneration (Bellefeuille 1935, LeBlanc 1954, Linteau 1941, 1957, MacArthur and Gagnon 1961).

For forest management to advance from the basic economic aim of efficient harvesting to the goals of successful regeneration after harvest

---

1/ Contribution NO.   from the Forest Research Branch, Dept. of Forestry.

2/ Research Officer Forestry, Forest Research Branch, Dept. of Forestry, Quebec.

3/ Nomenclature as in "Native Trees of Canada", Bulletin 61. Canada, Dept. of Forestry. 6th ed. 1961.

and production increases in second-growth stands, then a knowledge of yield potentials, growth rates, age structure, species composition, stand development and regeneration habits must be acquired.

In 1950 the Forestry Branch established sample plots over a five-square-mile area in Forest Section B.1b to study the growth, yield and regeneration of black spruce and black spruce-balsam fir stands. This report presents the results of the first remeasurement of plots in 1961 and of studies made to determine the age structure and origin of even- and uneven-aged stands.

THE FOREST

Forest Section B.1b as delineated by Rowe (1959) is an east-west band about 800 miles long by 100-170 miles wide between the spruce-fir forests of Section B.1a to the south and the subarctic woodland to the north. Eastward from Sept-Iles, Quebec, B.1b borders on the Gulf of St. Lawrence. The more rugged topography of the east, with southward drainage through moderately deep-cut valleys, gives way in the west to a rolling terrain with meandering rivers flowing westward.

Black spruce is the dominant tree on most sites, from the flat, low, peaty areas to the well-drained rocky uplands. Fir is scarce relative to Section B.1a but on one site it may form over 50 per cent of the stand by volume. Small groves of white birch are common, particularly in forests of recent fire history where it also forms mixedwood stands with black spruce. Aspen, balsam poplar and tamarack are sparsely represented. Stands of jack pine are restricted to the west part of the Section.

The Section has a long history of frequent and extensive forest fires and from the air it presents an interesting mosaic of fire stands of different ages. Regeneration after some of these fires has provided dense and high-volume black spruce stands comparable to any in the Province.

The three blocks of the study area border Lake St.Pierre ($50^{\circ}10'$N, 68° $25'$W) 70 miles north of Baie-Comeau and the St.Lawrence River. Elevation above sea level varies from about 1000 to 1300 feet. Meteorological data are scarce and the closest inland station is at Labrieville (elevation 500 feet), 80 miles to the southwest. Four-year records[4/] (1958-1961) indicate an average annual precipitation of 33.6 inches, 9.2 of which fell as snow. Mean July temperature was 63.5°F.

The forest contains uneven-aged black spruce and black spruce-balsam fir stands of unknown origin, and fire-origin stands of black spruce, and black spruce-white birch of approximately 64 and 120 years of age. The 64-year-old forest is part of a larger burned area along the west shore and back from the lake, up over a height of land and down to a chain of smaller lakes about one-half mile away. The 120-year fire origin stands occupy 200 acres at the north end of the lake.

About 600 acres on the north shore and 1500 acres on the east shore of the lake support uneven-aged stands containing trees as old as 280 years. Stands on the east border the lake for two miles and include a complete mountain side up to a height of land, a distance of about one mile.

At the 1961 remeasurement the sample plots were classified by site types recognized and defined by Linteau (1955). The types found at lac St-Pierre are described briefly below.

Hypnum Type (Hyp). This is a good, upland black spruce type with an average site index of 37 at 50 years. Uneven-aged stands are 75-80 per cent spruce (basal area) with a codominant fir element. Even-aged fire-origin stands contain about the same proportion of spruce but with the remainder

---

[4/] Quebec, Dept. of Industry and Commerce, Bureau of Statistics, Meteorological Bulletins.

divided equally between fir and birch. The forest floor is a continuous carpet of Calliergon schreberi and Hypnum crista-castrensis generally free of all herbs or ferns.

Calliergon-Vaccinium Type (Cal-Va). Described by Linteau as usually occupying dry, flat terrain, this type was found on the dry, steep upper slopes of the 1896 burn. Black spruce forms 70 per cent of the stand, white birch 25 per cent and fir 5 per cent. Calliergon schreberi is present in large patches and Vaccinium pensylvanicum is the main shrub but patchy in distribution.

Kalmia-Ledum Type (Ka-Le). This type is predominantly black spruce with a little fir and birch, and is found both on gentle lower slopes bordering lakes and gentle upper slopes where bedrock is overlain by a few inches of sand. A high water table results in defective drainage forming a peculiar vegetation pattern of alternating Sphagnum and Hypnaceae mosses. Kalmia angustifolia and Ledum groenlandicum of equal abundance grow in regularly distributed tufts.

Kalmia-Ledum, cladonia sub-type (Ka-Led, clad.). As a result of the 1961 vegetation study a sub-type of the Ka-Le type has been defined. Stands are dominantly black spruce but are more open, and spruce has a different height-diameter relationship, than in the typical Ka-Le. Found at both low and high elevations it always has a very thin sand layer overlying bedrock or boulders. Although the site looks dry the large patches of Cladonia lichens often provide a slippery or greasy footing. The sub-type is easily distinguished from the typical Ka-Le by the openness of the stand, the presence of Cladonia spp. in large patches and the lesser abundance of Sphagnum and Hypnaceae mosses.

Hypnum-Cornus Type (Hyp-Co). The black spruce component of this spruce-fir type at Lake St.Pierre dropped from 54 to 47 per cent of the total basal area from 1950 to 1961. About one-half the basal area is now fir and the small remainder white birch. The type is found on well-drained soils usually in somewhat sheltered areas particularly at the base of moderate to steep slopes and in gullies. The forest floor is covered by a mixture of Calliergon schreberi and Hypnum crista-castrensis with moderate sized patches of Cornus canadensis.

Hypnum-Hylocomium Type (H-H). At Lake St.Pierre black spruce presently provides 55 per cent, fir 41 per cent and birch 4 per cent of the total basal area. The occasional white spruce is seen. The site is characteristic of the gentle lower slopes with a generally slow drainage. Large patches of Hylocomium splendens alternate with smaller ones of Calliergon schreberi and Hypnum crista-castrensis. Several herbs are present but form no definite layer; the most frequent are Cornus canadensis, Coptis groenlandica, Clintonia borealis and Maianthemum canadense.

Hylocomium-Cornus Type (H-Co). Linteau considers this type to be an infrequent local variant of the H-H type. It is the only type at Lake St.Pierre in which fir dominates to the extent of 80 per cent by basal area. Black spruce plus a few white spruce provide 15 per cent of the basal area and birch the small remainder. The type is most often found in the narrow valleys and gullies of streams in protected places often with south or southwest aspects. More herbs were present than in any other type with Cornus canadensis and Maianthemum canadense the most abundant. The small patches of moss are mainly Hylocomium splendens.

Other site types identified but comprising very small isolated stands were Cornus-Maianthemum, Hylocomium-Oxalis, Sphagnum-Rubus and Kalmia-Vaccinium.

METHOD OF STUDY

Field

In 1950 ten-chain grids of permanent tenth-acre square sample plots were established in each of the three blocks. Classification of the 259 plots established was by cover type and general stand appearance and on each plot the following data were recorded: 1) d.b.h. in one-inch classes, by species, of all trees 0.6 inch and over, 2) d.b.h. of trees judged to have died between 1940 and 1950, 3) reproduction stocking on 10 milacre quadrats, by species, in two size classes, 4) three or four height-diameter measurements, 5) one or two age counts, and 6) a brief, general plot description comprising notes on lesser vegetation, topography, drainage and stand origin.

At the 1961 remeasurement the following information was recorded: 1) d.b.h. as in 1950, 2) d.b.h. of trees known from scribe marks to have died since 1950, 3) reproduction by species and origin, in two size classes on a single milacre quadrat, 4) three height-diameter-age determinations, 5) a detailed vegetation relevé, and 6) a brief soil profile description. In order to study the age structure of uneven-aged stands in more detail, 10 1/40-acre plots were located in representative stands. All trees 0.6 inch d.b.h. and over were cut at the root collar and discs were retained for accurate age counts. Height and d.b.h. also were measured on these trees.

Office

The 1961 vegetation relevé cards were checked against Linteau's classification as a first step in compilation. A vegetation table was made for the Ka-Le type to facilitate separation of the typical from the *Cladonia* sub-type. Site Index was used as an aid in classifying some doubtful plots. The remaining plots of doubtful site type, of types sparsely represented and of transition types were omitted from analysis. The classification of plots is shown in Table 1 and the per cent of each type of the total number of plots is included as an indication of its importance.

Height was plotted over diameter and the resultant curves were compared with those constructed for volume and yield table purposes by the Branch in Quebec. As the curves were almost identical for a given species and type, volumes were calculated using the existing tables. Stand and stock tables were prepared which provided the data for calculating mean and current increments.

Ages on root collar discs from the 10 1/40-acre plots were determined in the laboratory using a binocular microscope. The age structure of even- and uneven-aged stands was studied in detail.

RESULTS

Uneven-aged Forest

Spruce Stands

Based on a limited number of age counts, the conclusions after the 1950 establishment were that spruce stands tended to be even-aged and that spruce-fir stands were uneven-aged. Following the 1961 classification by site types, the numbers of trees were plotted over d.b.h. and immediately it was clear (Figure 1) that the spruce stands did not conform to the typical bell-shaped curve of even-aged stands. The curves for the Hypnum type suggested three possible age structures, 1) a young, and an old even-aged stand superimposed, 2) an uneven-aged, and an old even-aged stand superimposed, and 3) a mosaic pattern with patches of both even- and uneven-aged forest. The third possibility was eliminated by checking tree ages on individual plots. Usually a wide range in age occurred on a given plot, often up to 100 years or more.

Compilation of the age frequency distributions by diameter classes for spruce and fir on each site type revealed a definite uneven-aged distribution for fir and also an element of uneven-aged structure for spruce. This latter fact merited further study. The spruce data were combined for all types because of the similarity in age distributions. Indicative of the difficulty in locating saplings of seed origin are the small numbers of ages in the 1-3 inch diameter classes. Most stems of this size were layers and attempts to determine where on the stem the ages should be determined were unsuccessful.

Examination of the combined data for spruce eliminated the possibility of two superimposed even-aged stands. Thus it remained to investigate the other possibility , an uneven-aged stand and an even-aged stand on the same acre, and to separate the two components if possible. A separation was made by seeking the even-aged component. The largest black spruce age frequency occurred in the 141-150 year class, and using 25 per cent[5/] of an approximate 200 year natural spruce rotation age as the even-aged limits, this component was delineated by lines including ages from 121 to 170 years (Table 2). Thus the total spruce age sample was divided into three parts, a) an uneven-aged element, b) an even-aged main stand, and c) what was now considered as a veteran element from the previous stand.

To verify the hypothesis that the spruce component of the forest had such a composite age structure, it was decided to apply the proportions of a, b, and c as they occurred in the age samples for individual diameter classes to the spruce stand tables. Three curves were expected, a) the typical J-shape, b) the typical bell-shape, and c) a short, flat bell curve.

5/ Maximum per cent age range, even-aged stand, as defined in Forest Terminology, Society of American Foresters, 1950.

It was also reasoned that the bell curve (b) for the richer Hypnum type should have a peak lower than and to the right of the peak for the Kalmia-Ledum. The actual proportions in a, b, and c by diameter classes were plotted, curves drawn and values obtained (Table 2). These adjusted proportions were then applied to the black spruce stand table. Testing with the Hypnum and Kalmia-Ledum types would appear to support the hypothesis (Figure 2). The resultant curves are exactly as predicted.

Similarities and differences between the three black spruce types can be seen in the stand and stock table summaries (Appendix Table 1). Substantially lower volumes and basal areas are noted going from the richer Hypnum type to the poorer Kalmia-Ledum, clad. but somewhat surprisingly the types have approximately equal numbers of trees per acre.

Although number of trees increased substantially in all types between 1950 and 1961, volumes and basal areas show only slight increases. Larger volumes in 1961 are mainly due to increases in the 1-3 inch diameter classes (Figure 3). The changes in volume distribution by species in diameter groups show no signs of imminent stand breakup nor does the basal area distribution (Figure 4) show any marked changes in species proportions.

Volume of spruce and fir 4 inches d.b.h. and over hardly changed since 1950 (Appendix, Table I). However, mortality from 1950-1961 ranged from nearly five cords per acre in the Hypnum type to one and one-half cords in the Kalmia-Ledum, clad. (Appendix, Table V). This mortality almost balanced growth resulting in small positive or negative net annual increments (Table 3). Gross annual increments reflect the site type differences in productivity ranging from 50 cubic feet per acre in the Hypnum to 13 cubic feet in the poorer Kalmia-Ledum, clad.

Data on the growth of individual spruce trees from a one-acre permanent sample plot in the Kalmia-Ledum type (Table 4) indicates larger increments for the larger diameter trees.

The number of advance regeneration below 0.6 inch d.b.h. ranges from over 9,000 spruce and fir stems per acre in the Hypnum type to under 2,000 stems in the Kalmia-Ledum, clad. (Table 5). Most spruce regeneration originated from layers contrasted to fir which is mostly of seedling origin (Figure 5).

Spruce-Fir Stands

About one-third of the uneven-aged forest is occupied by three site types supporting spruce-fir stands. Black spruce frequency over diameter curves for the Hypnum-Cornus and Hypnum-Hylocomium types both suggest the same combination of even- and uneven-aged components that was described for spruce stands (Figure 6). The fir component is uneven-aged. The Hylocomium-Cornus type, 80 per cent fir, is completely uneven-aged. In these and in spruce stands, it is important to note that very few spruce over 12 inches d.b.h. are present.

A large increase in numbers of 1-3 inch spruce and fir trees occurred between 1950 and 1961 with the result that total numbers of trees about doubled during the 11-year period (Appendix, Table II). Standing total volumes increased by about 200 cubic feet per acre, due mostly to increases in fir.

The changes in the distribution of volume by diameter groups from 1950-1961 are similar for the three types (Figure 3). All show a marked increase in the 1-3 inch but little change in the 4-6 inch group, except for an increasing proportion of fir. Hypnum-Cornus and Hypnum-Hylocomium 7-9 inch volumes dropped with little change in species composition; conversely volume increased in the Hylocomium-Cornus type with an increase in fir proportion.

Study of the volume and basal area changes since 1950 (Figures 3 and 4) leave little doubt that fir has made the largest gains resulting in an increased proportion of this species in all types.

Merchantable volumes (4 inches d.b.h. plus) changed very little (Appendix, Table II). Mortality ($4\frac{1}{2}$ to $5\frac{1}{2}$ cords per acre) almost balanced growth and the negative or positive net increments were small (Table 6). Gross increments ranged from 41 to 47 cubic feet per acre.

Regeneration was more abundant than in the spruce types and a much larger proportion was fir (Table 7, Figure 7). Black spruce layers account for most regeneration of this species in the Hypnum-Cornus and Hypnum-Hylocomium types but are outnumbered 2-1 by seedlings in the Hylocomium-Cornus.

1896 Fire Origin Forest

Well-stocked black spruce and black spruce-white birch stands originated following a fire about 1896. The date of the fire was established by comparing the range in tree age with age ranges of three other forests of known fire origin. An interesting recent study of two burned forests in the Gaspé Peninsula (MacArthur and Gagnon, 1961) indicated a time lag in seedling establishment following fire, plus a rise to a peak establishment. These data, plus unpublished data from a 1960 study of a burn at Lake Métis, P.Q., were plotted (Figure 8). A short peak period of seedling establishment also was discovered at Lake St.Pierre, and the peak year was plotted under the peaks for Lake Métis and York River, nine years since fire. The Lake St.Pierre curve is remarkably similar to that of Lake Métis, and starts at one year since the origin year for the other burned areas. Thus nine years were added to tree age at the peak year, and four years added to adjust for the height of age borings above the ground (4-6 inches) to arrive at the reasonably accurate date of fire of 1896.

Seventy-five per cent of the forest is composed of four site types, all predominantly black spruce (Figure 4). In earlier years white birch undoubtedly formed a larger part of the stands but recent mortality has reduced its importance. The generally small fir component reached a maximum of 9 per cent of the stand in the Hypnum type.

An unexpected large increase in the number of spruce and fir saplings occurred since 1950 (Figure 9). It is noted (Table 8) that most of the 1-3 inch black spruce are of layer origin and the increase in spruce is thus attributed to layers entering the one-inch diameter class. On the other hand, most of the new fir are seedlings. The increases did not occur uniformly but in patches where the young stand was somewhat open, or where white birch died out. No ingrowth occurred where original conifer stocking was dense (Figure 10). The effect on the forest as a whole is that the even-aged structure has already begun to evolve towards the uneven-aged.

As expected, volumes increased greatly since 1950. The effect of the larger number of 1-3 inch trees is revealed in volume increases which occurred for this diameter group (Figure 11). Increases in the 4-6 and 7-9 inch groups are due almost entirely to spruce growth while birch volumes remained constant or decreased.

The current annual rate of volume increment ranges from 38 to 118 cubic feet per acre from the poorest Kalmia-Ledum, clad. type, to the best Hypnum type (Table 9). For volumes 4 inches d.b.h. and over the values are 29 to 94 cubic feet respectively. These rates are certainly comparable to those further south in Section B.1a. The results of high birch mortality are clearly evident in the low, or negative, net increments for this species. Mean annual increments for spruce and fir rose appreciably whereas birch has shown a drop (Table 10). The total M.A.I.'s to 1961 compare very favourably with those shown in yield tables for black spruce stands in other parts of Canada (Bedell 1955, Horton 1961, Kabzems 1953, Plonski 1960). Standing volume, M.A.I. and C.A.I. for the Hypnum type and, with one exception, for the Calliergon-Vaccinium type at Lake St.Pierre are higher than all the types shown in these yield tables (Figure 12).

1840 Fire Origin Stands

Some of the densest and highest volume black spruce stands originated after a fire estimated to have occurred in 1840. This estimate of fire date was made in the same manner as that of the 1896 fire, although with fewer age counts.

Evidently initial stocking was uniformly dense with the result that there are relatively few layers or seedlings on the ground (Figure 13). The tree frequency-over-diameter curves (Figure 14) are the usual bell shape curves of even-aged stands and the rightward and downward shift of the curves since 1950 is typical of normal stand development.

It is not known what proportion of white birch was present in earlier years but the amount remaining in 1961 is small and diminishing (Figure 4). Increases occurred in spruce and fir volumes and basal areas for both types since 1950. The number of trees decreased in the Hypnum type but increased slightly for the less dense Kalmia-Ledum, clad. (Appendix, Table IV).

The difference in site quality is evident in the changes in volume distribution since 1950 (Figure 11). In the richer Hypnum type the 4-6 inch diameter group increased in volume only slightly while the 7-9 and 10 inch and over groups registered large gains. In the Kalmia-Ledum, clad. type, the volume of 4-6 inch trees increased much more than either the 7-9 or 10 inch and over group.

Mortality of spruce and fir, 4 inches d.b.h. plus, since 1950 was 105 and 96 cubic feet per acre, roughly 10 and 9 cubic feet per year, for the Hypnum and Kalmia-Ledum, clad. types respectively. Current net volume increment in the Hypnum type (Table 11) was less than that of 1896 fire stands but oddly the C.A.I. of the Kalmia-Ledum, clad. type was greater.

TABLE 1. LINE PLOT CLASSIFICATION, 1961

Stand Origin	Number of Tenth-Acre Line Plots and Per Cent of Total								
	Spruce Forest				Spruce-Fir Forest			Others and Undetermined	TOTAL
	Hypnum	Calliergon-Vaccinium	Kalmia-Ledum	Kalmia-Ledum, clad.	Hypnum-Hylocomium	Hypnum-Cornus	Hylocomium-Cornus		
Unknown	26	1	61	30	26	14	11	22	191
(Uneven-aged Stands)	14%	< 1%	32%	16%	14%	7%	6%	11%	100%
Fire, 1896	13	10	8	6		1		12	50
	26%	20%	16%	12%		2%		24%	100%
Fire, 1840	8		2	8					18
	44%		12%	44%					100%
TOTAL	47	11	71	44	26	15	11	34	259

TABLE 2. BLACK SPRUCE AGE FREQUENCY BY DIAMETER AND AGE CLASSES, KA-LE; KA-LE, CLAD.; HYP, HYP-CO AND H-H TYPES COMBINED

Stand Element	Age Class Years	Frequency of Age Samples — Diameter Class-Inches: 1	2	3	4	5	6	7	8	9	10	11	TOTAL
(a) Uneven-aged	31-40	2											2
	41-50												
	51-60				2								2
	61-70		1	3	3	1							8
	71-80	1		1	2	2		1					7
	81-90	1			6	4	1		1				13
	91-100	2			6	2	4	1					15
	101-110	2		2	8	4	2	3	1	1			23
	111-120			3	5	9	5	3	1	1			27
(b) Even-aged Main Stand	121-130			1	16	9	7	7	2	4	2	2	50
	131-140		1	2	11	14	12	8	9	7	2		66
	141-150		1		9	16	13	13	17	7	2	1	79
	151-160			2	7	10	7	16	10	4	1	2	59
	161-170			1	6	9	10	8	7	7	2		50
(c) Veterans	171-180				3	4	5	7	3	2	4	1	29
	181-190				4	2	4	6	5	2	1	1	25
	191-200			1	3		3		1	2	1	1	12
	201 +				1	3	5	2	1	1	3		16
	Value	a, b and c as Per Cent of Total for Diameter Class											
a	Actual	-	-	57	35	25	15	11	5	5	0	-	
	Curve	100	98	77	36	24	16	11	5	2	0	0	
b	Actual	-	-	37	53	65	63	69	78	76	50	-	
	Curve	0	2	17	52	61	68	73	75	73	56	21	
c	Actual	-	-	6	12	10	22	20	17	19	50	-	
	Curve	0	0	6	12	15	16	16	20	25	44	79	

TABLE 3. CURRENT ANNUAL INCREMENT (C.A.I.) 1950-1961, FOUR INCHES D.B.H. PLUS, UNEVEN-AGED SPRUCE STANDS [6/]

Site Type	Annual Increment	C.A.I., Total Cubic Feet Per Acre			
		Spruce	Fir	White Birch	TOTAL
Hyp	Net	-7.4	17.0	-0.1	9.5
	Gross	26.9	23.0	0.5	50.4
Ka-Le	Net	2.0	2.7	0.1	4.8
	Gross	20.5	3.8	0.5	24.8
Ka-Le, clad.	Net	-0.8	-0.1	-0.1	-1.0
	Gross	12.4	0.2	0.2	12.8

6/ Small amounts of aspen and tamarack not shown in Tables 3, 6, 9, 10, and 11.

TABLE 4. AVERAGE INCREMENTS FOR BLACK SPRUCE TREES BY DIAMETER CLASSES, 1950-1961, KALMIA-LEDUM TYPE, UNEVEN-AGED STAND

D.B.H. Inches 1950	Number of Samples	Average Increment, 1950-1961		
		Diameter Inches	Basal Area Square Feet	Volume Cubic Feet
4	121	.19	.009	.24
5	183	.24	.013	.30
6	173	.27	.018	.45
7	95	.30	.023	.65
8	51	.30	.027	.85
9	23	.38	.040	1.15
10	2	.32	.034	1.20
11	1	.48	.057	2.00
12	1	.28	.035	1.20

TABLE 5. NUMBERS OF SPRUCE AND FIR STEMS BELOW 0.6 INCH D.B.H. PER ACRE, UNEVEN-AGED SPRUCE STANDS, 1961

Site Type	Spruce		Fir		Total	
	Seedlings	Layers	Seedlings	Layers	Seedlings	Layers
Hyp	190	3,690	4,840	500	5,030	4,190
Ka-Le	0	2,740	800	440	800	3,180
Ka-Le, clad.	230	1,460	100	0	330	1,460

TABLE 6. CURRENT ANNUAL INCREMENT (C.A.I.) 1950-1961, FOUR INCHES D.B.H. PLUS, UNEVEN-AGED SPRUCE-FIR STANDS

Site Type	Annual Increment	C.A.I., Total Cubic Feet Per Acre			
		Spruce	Fir	White Birch	TOTAL
Hyp-Co	Net	-5.8	12.1	-1.0	5.3
	Gross	23.9	22.7	0.6	47.2
H-H	Net	2.0	8.4	-0.3	10.1
	Gross	20.7	24.4	0.5	45.6
H-Co	Net	2.4	1.0	-7.6	-4.2
	Gross	7.9	32.1	1.4	41.4

TABLE 7. NUMBERS OF SPRUCE AND FIR STEMS BELOW 0.6 INCH D.B.H. PER ACRE, UNEVEN-AGED SPRUCE-FIR STANDS, 1961

Site Type	Spruce		Fir		Total	
	Seedlings	Layers	Seedlings	Layers	Seedlings	Layers
Hyp-Co	0	3,000	8,780	570	8,780	3,570
H-H	190	2,730	5,450	40	5,640	2,770
H-Co	1,730	820	10,640	450	12,370	1,270

TABLE 8. NUMBER OF SPRUCE AND FIR PER ACRE ON MILACRE QUADRATS BY ORIGIN AND SIZE CLASSES, 1896 FIRE ORIGIN STANDS, 1961

Site Type	Spruce		Fir	
	Seedlings	Layers	Seedlings	Layers
	Trees less than 0.6 in. D.B.H.			
Hyp	390	310	850	0
Cal-Va	0	3,000	0	0
Ka-Le	500	750	0	0
Ka-Le, clad.	0	670	0	670
	Trees 0.6-3.5 in. D.B.H.			
Hyp	80	620	690	80
Cal-Va	0	1,000	500	0
Ka-Le	380	880	500	0
Ka-Le, clad.	500	2,340	0	330

TABLE 9. CURRENT NET ANNUAL INCREMENT (C.A.I.) 1950-1961, 1896 FIRE ORIGIN STANDS

Site Type	C.A.I., Total Cubic Feet Per Acre			
	Spruce	Fir	White Birch	TOTAL
	One Inch D.B.H. and Over			
Hyp	105.8	9.2	2.9	118.4
Cal-Va	69.4	5.4	4.2	79.0
Ka-Le	61.6	4.0	-2.4	63.6
Ka-Le, clad.	42.9	1.3	-6.6	38.1
	Four Inches D.B.H. and Over			
Hyp	86.4	4.7	2.4	94.0
Cal-Va	59.8	2.2	3.3	65.4
Ka-Le	48.4	1.7	-1.7	48.7
Ka-Le, clad.	33.1	0.6	-5.4	28.7

TABLE 10. MEAN ANNUAL INCREMENT (M.A.I.) TO 1950 AND 1961, TREES ONE INCH D.B.H. AND OVER, 1896 FIRE ORIGIN STANDS

Site Type	Period, Year 1896 to	M.A.I., Total Cubic Feet Per Acre			
		Spruce	Fir	White Birch	TOTAL
Hyp	1950	25.7	2.8	8.2	36.8
	1961	39.3	3.9	7.3	50.6
Cal-Va	1950	17.0	0.7	15.3	33.0
	1961	25.9	1.5	13.4	40.8
Ka-Le	1950	14.2	0.7	3.2	18.1
	1961	22.2	1.2	2.3	25.8
Ka-Le, clad.	1950	8.4	0.1	2.3	10.8
	1961	14.2	0.3	0.8	15.4

TABLE 11. CURRENT ANNUAL INCREMENT (C.A.I.) 1950-1961, FOUR INCHES D.B.H. AND OVER, 1840 FIRE ORIGIN STANDS

Site Type	Annual Increment	C.A.I., Total Cubic Feet Per Acre			
		Spruce	Fir	White Birch	TOTAL
Hyp	Net	36.6	0.5	-2.3	34.8
	Gross	45.7	0.9	1.3	47.9
Ka-Le. clad.	Net	30.6	0.6	0.4	31.6
	Gross	39.4	0.6	1.3	41.3

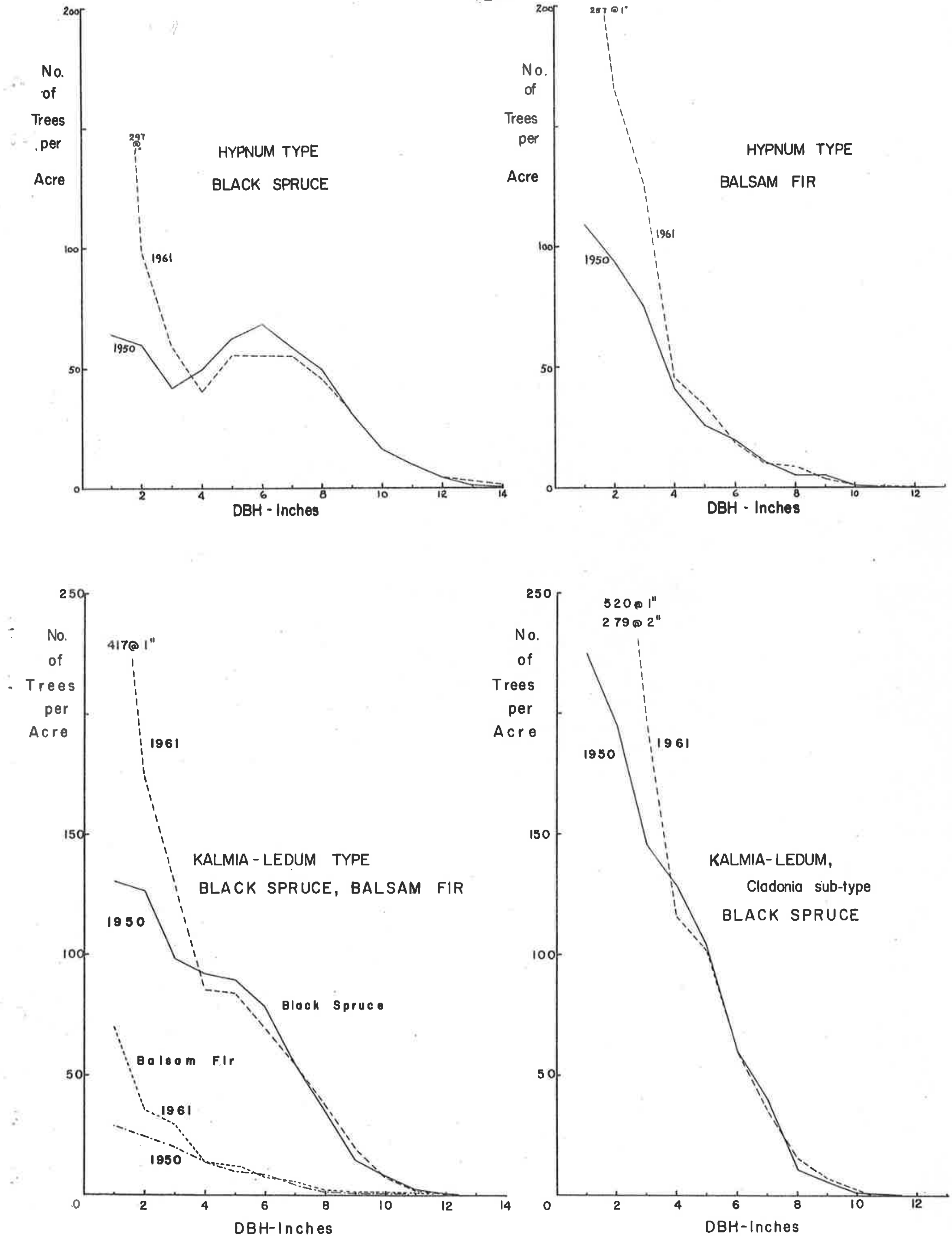


Figure 1. Number of trees per acre over DBH, uneven-aged spruce stands, 1950 and 1961

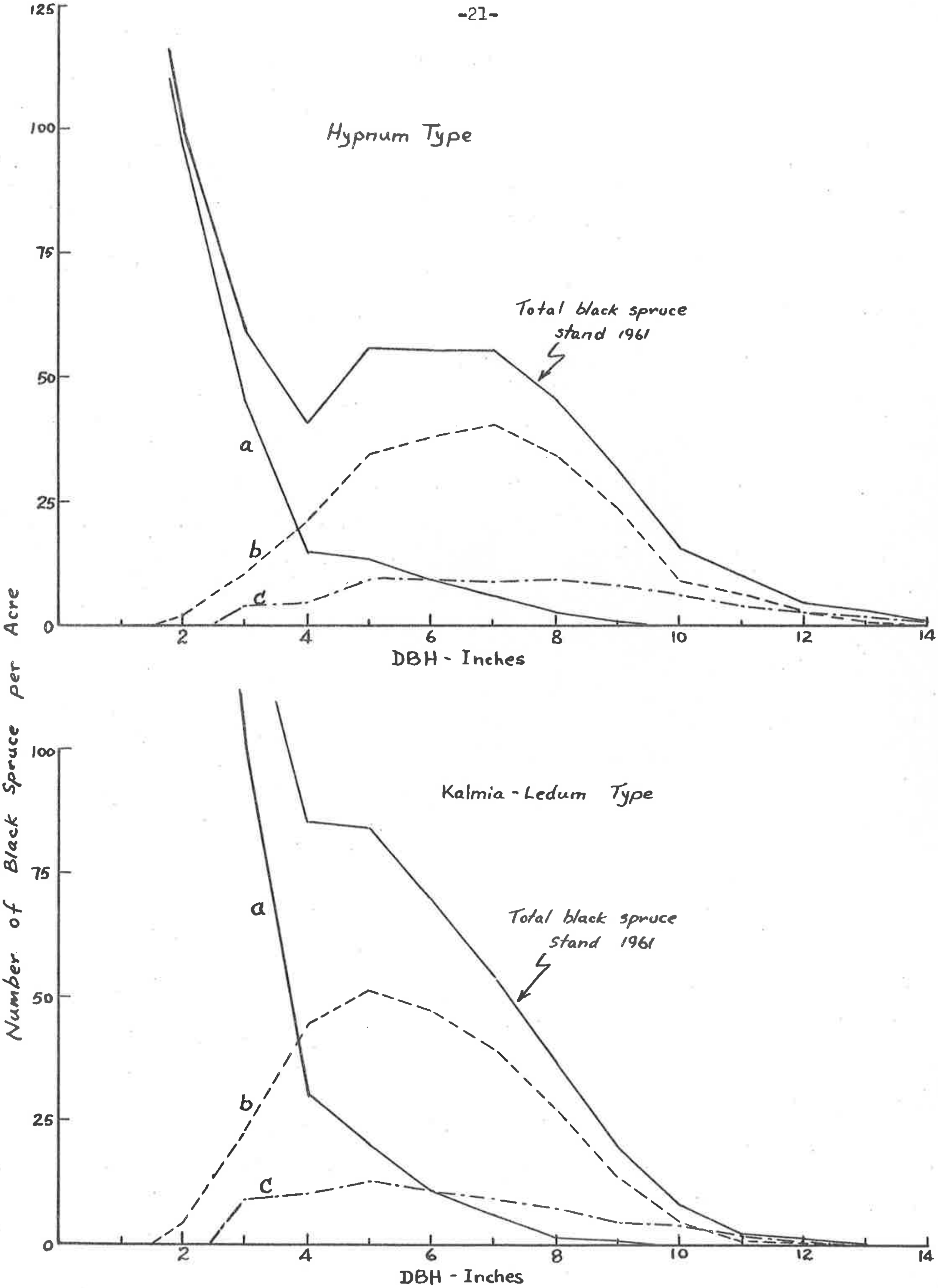


Figure 2. Number of black spruce per acre over DBH for the total stand and the estimated components a, b and c.

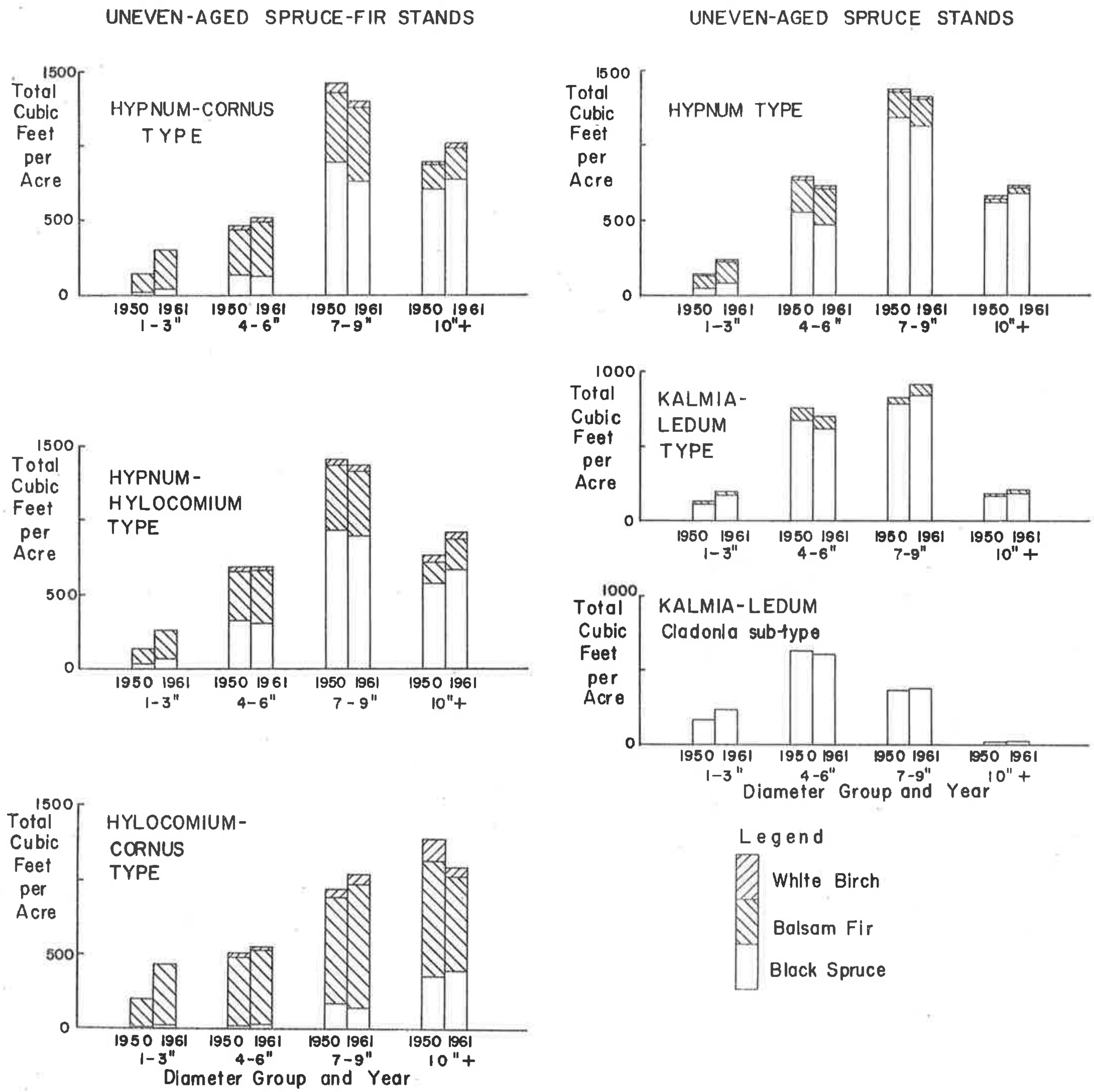


Figure 3. Volume per acre by diameter groups, 1950 and 1961

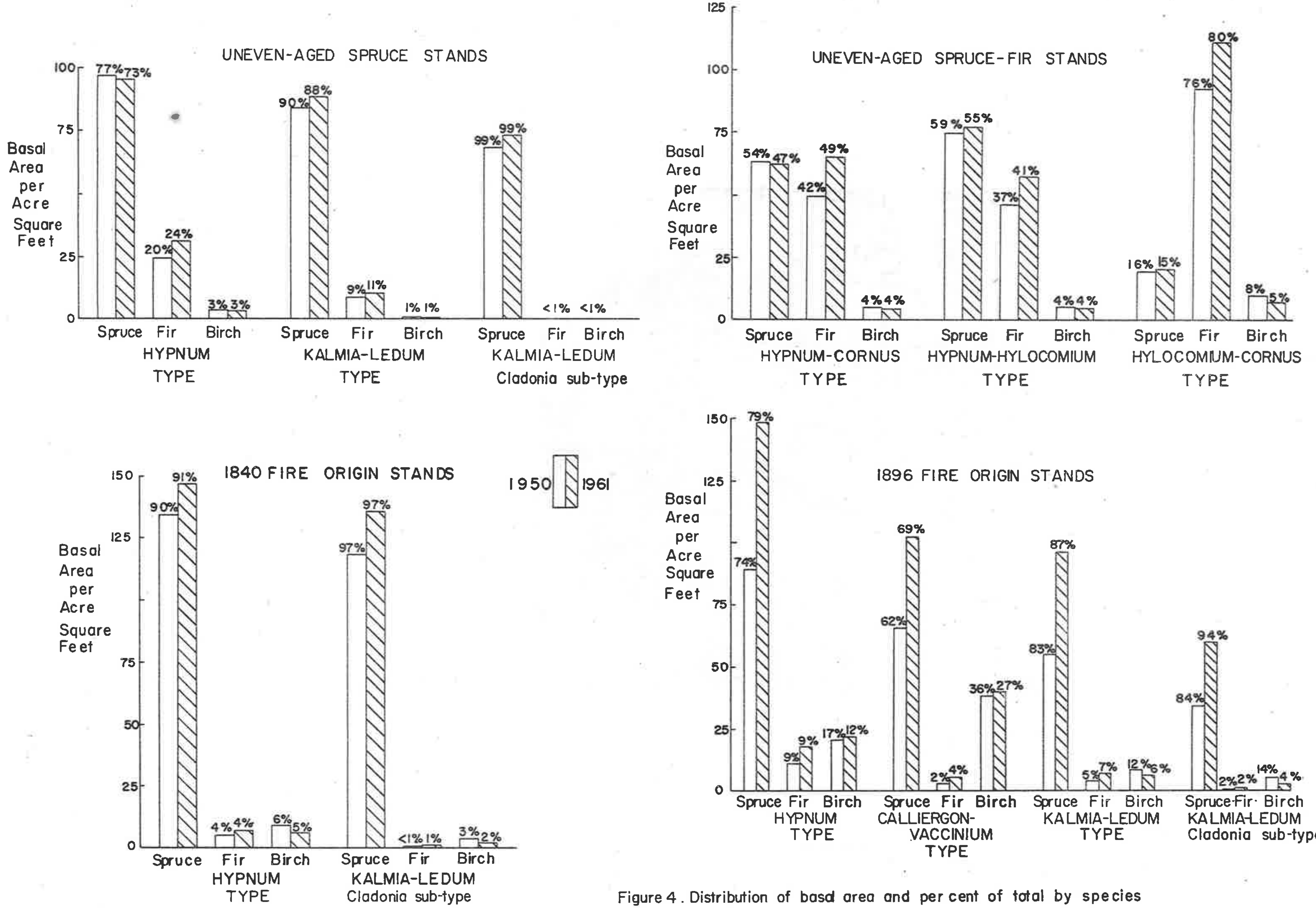
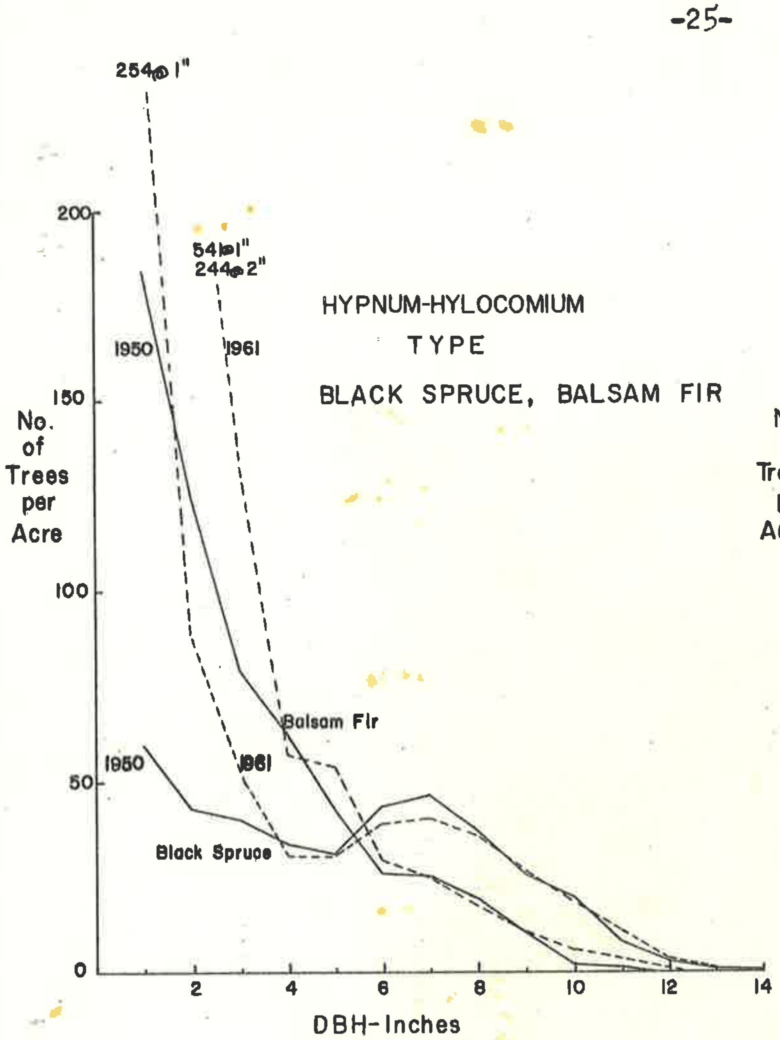
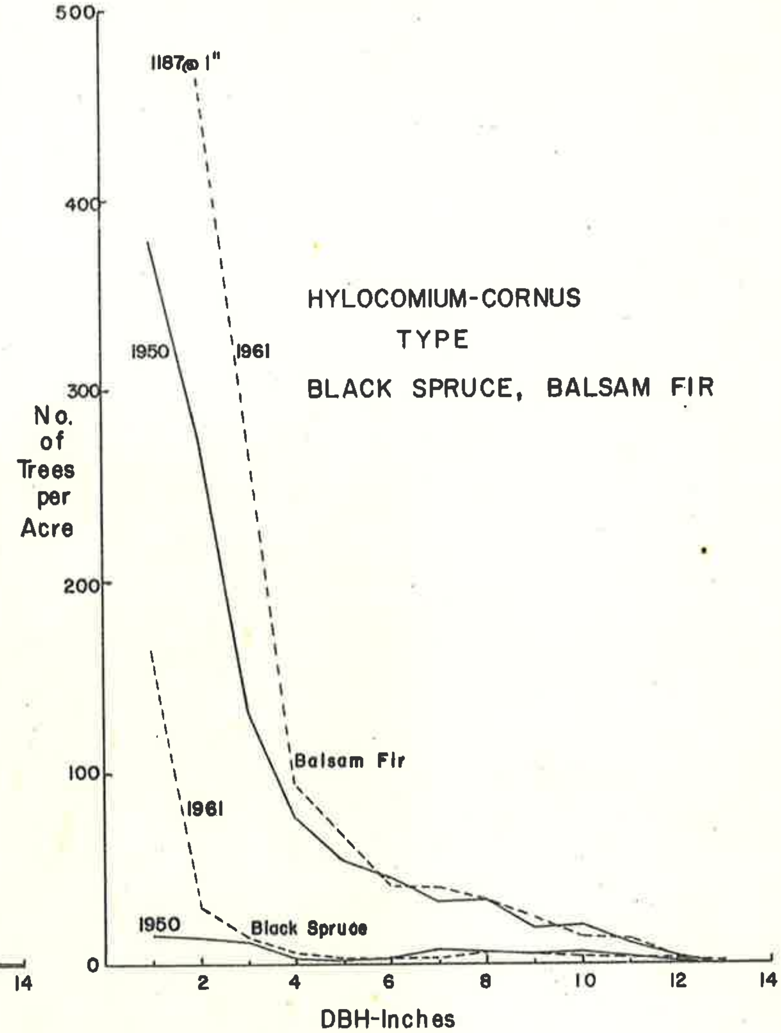


Figure 4. Distribution of basal area and per cent of total by species

Figure 5. Uneven-aged Kalmia-Ledum stand showing spruce layering (right) and fir seedlings (centre).





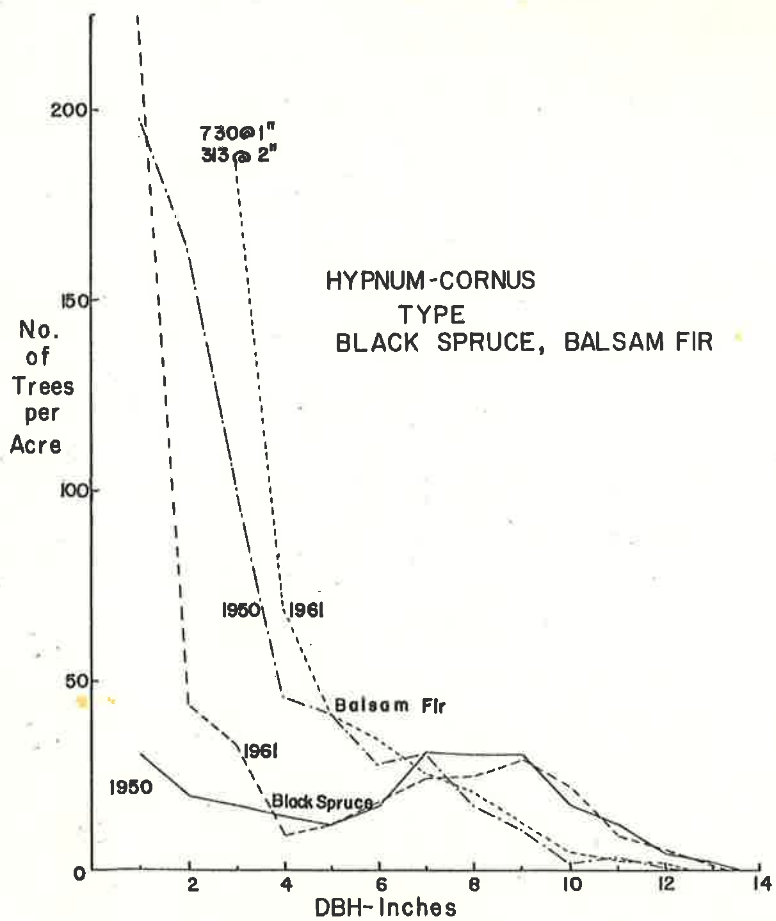


Figure 6. Number of trees per acre over DBH, uneven-aged spruce-fir stands, 1950 and 1961

Figure 7. Uneven-aged Hypnum-Hylocomium stand showing fir saplings in the understory.

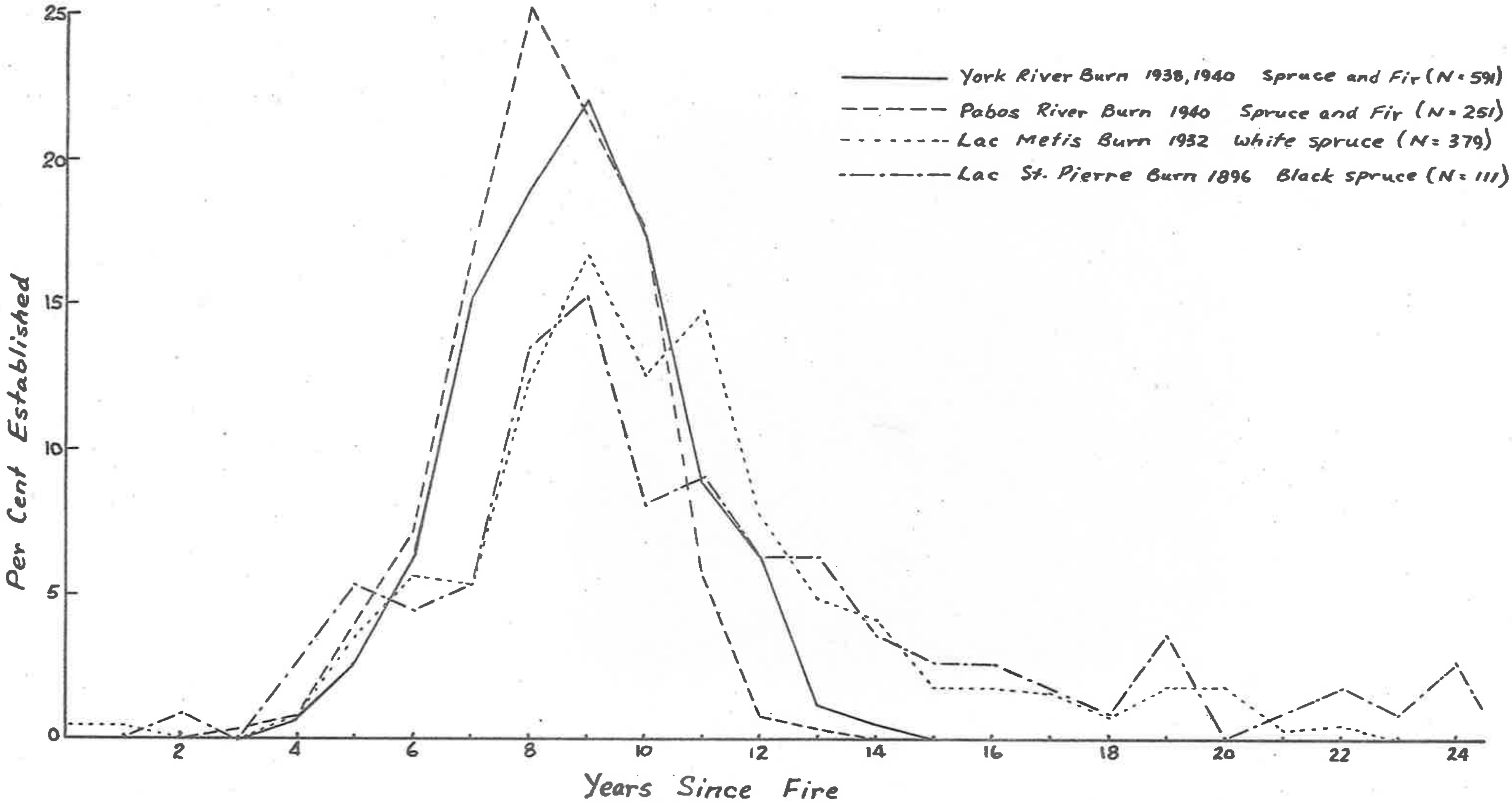
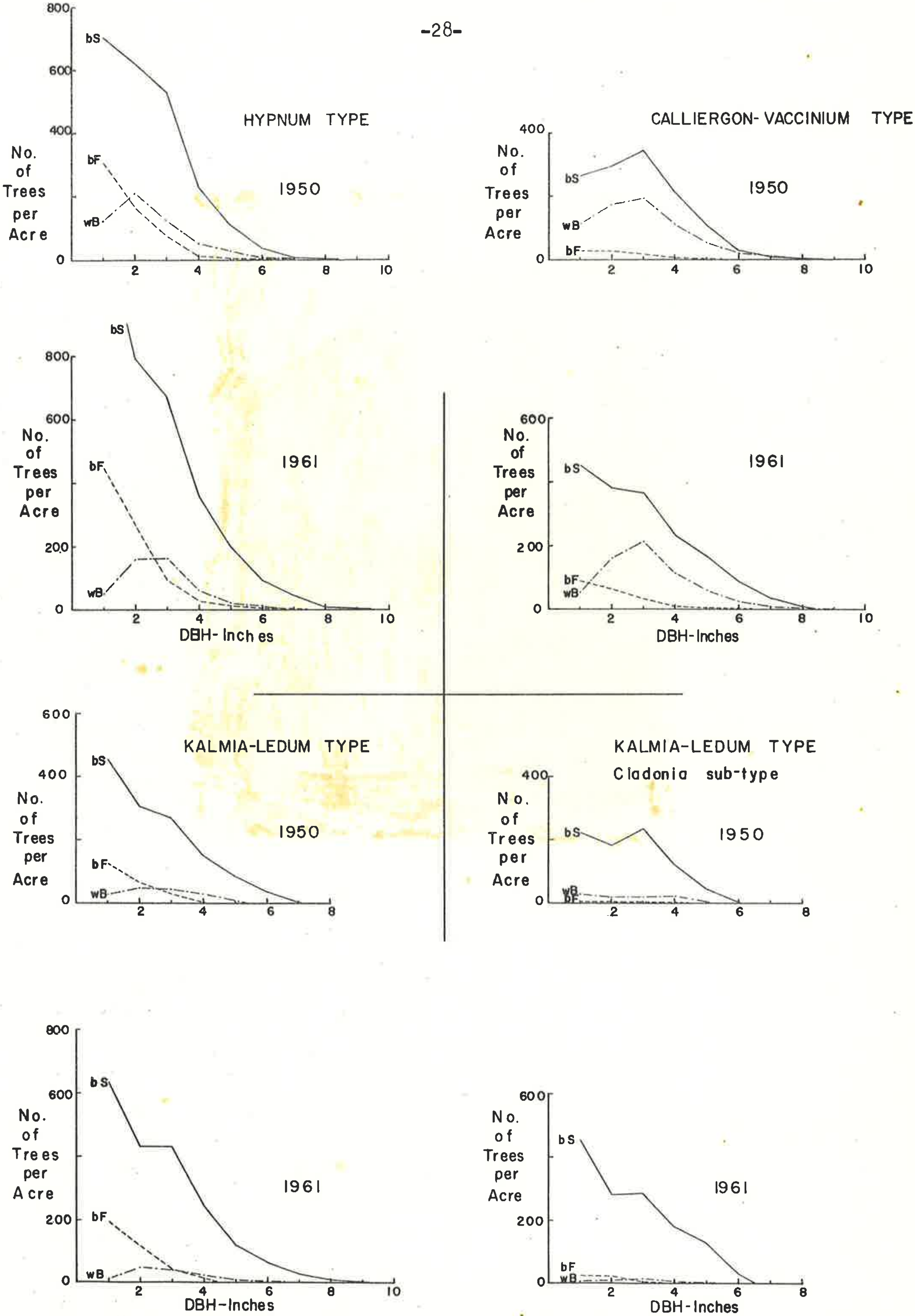


Figure 8. Rate of seedling establishment by years since fire

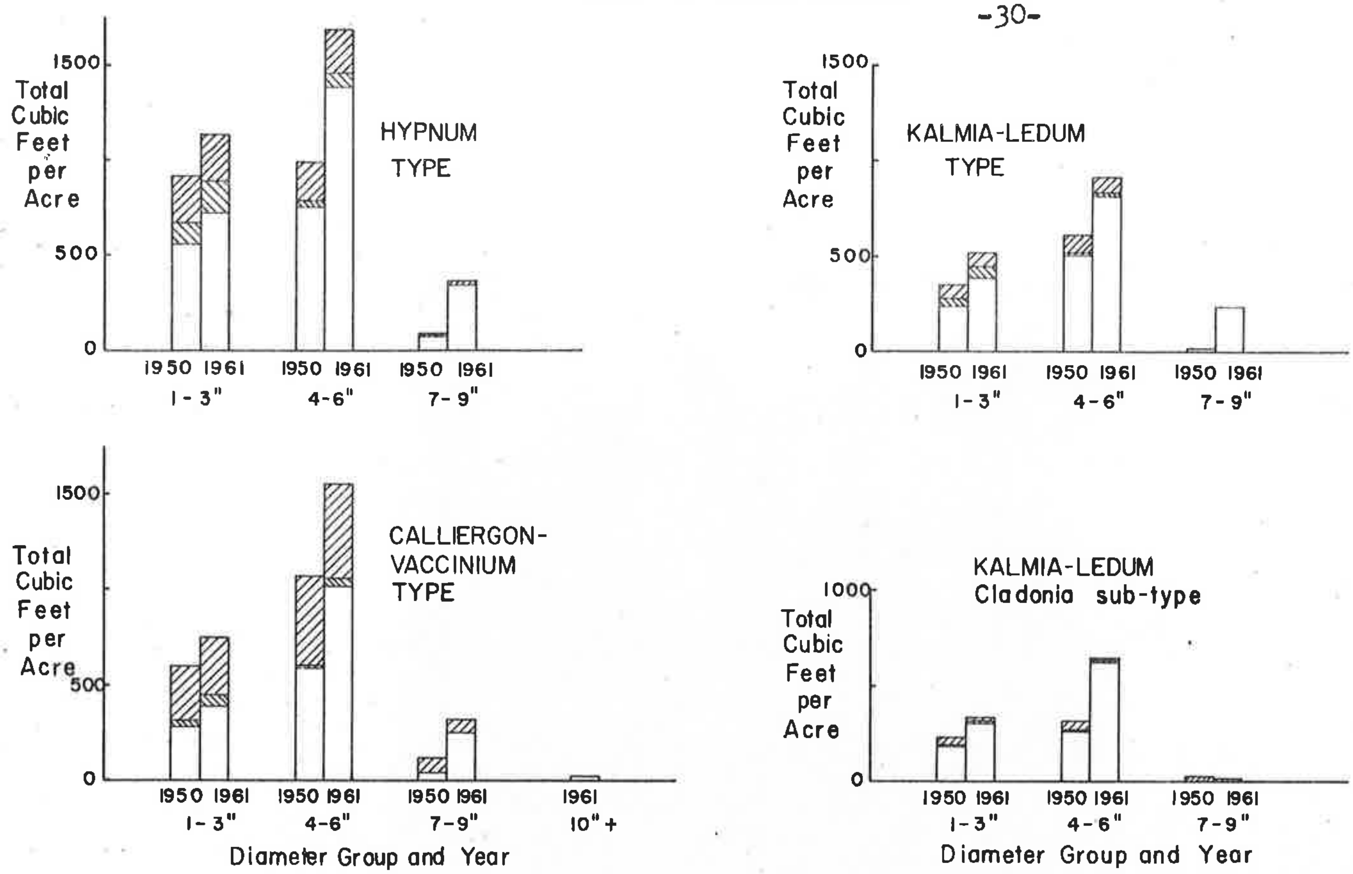


Legend Black Spruce : bS, Balsam Fir : bF, White Birch : wB

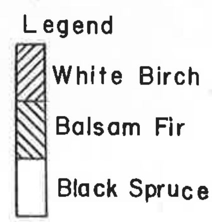
Figure 9. Number of Trees per Acre over DBH, 1896 Fire Origin Stands, 1950 and 1961

Figure 10. Dense even-aged black spruce stand of the Hypnum type of 1896 fire origin. Note complete lack of seedlings or layers.

1896 FIRE ORIGIN STANDS



1840 FIRE ORIGIN STANDS



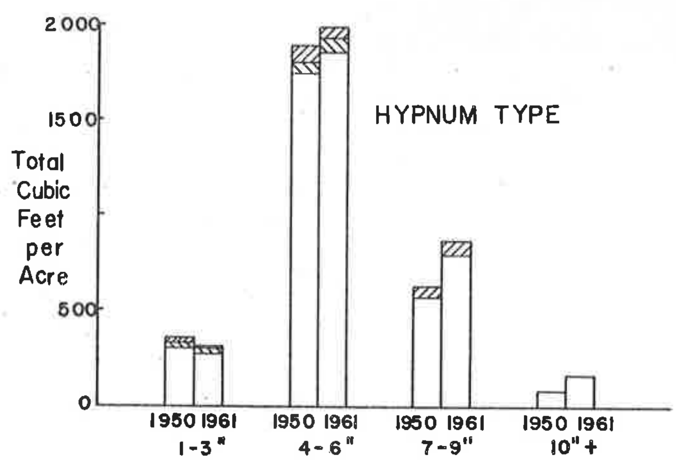
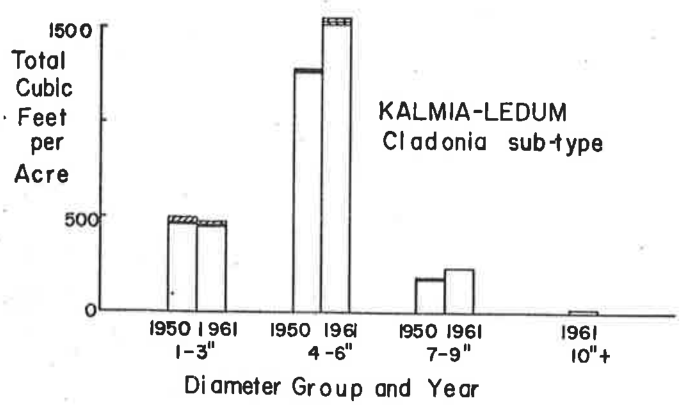


Figure 11. Volume per acre by diameter groups, 1950 and 1961



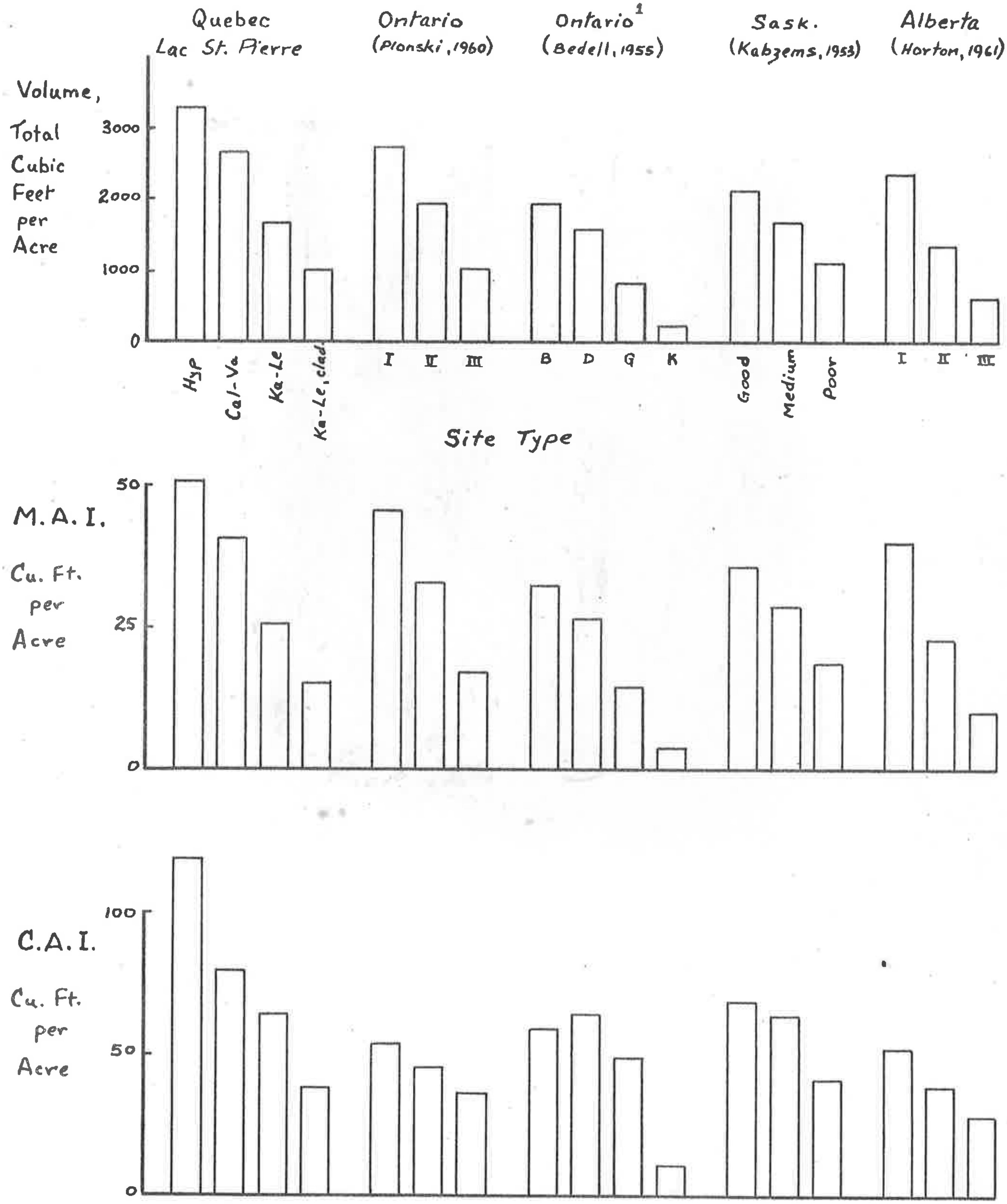


Figure 12. Comparison of 64-year-old stands at Lac St. Pierre with yield table data for 60 year stands

1 4"+ DBH

Figure 13. Stereo-pair showing a typical black spruce stand of 1840 fire origin. Note lack of seedlings and layers.

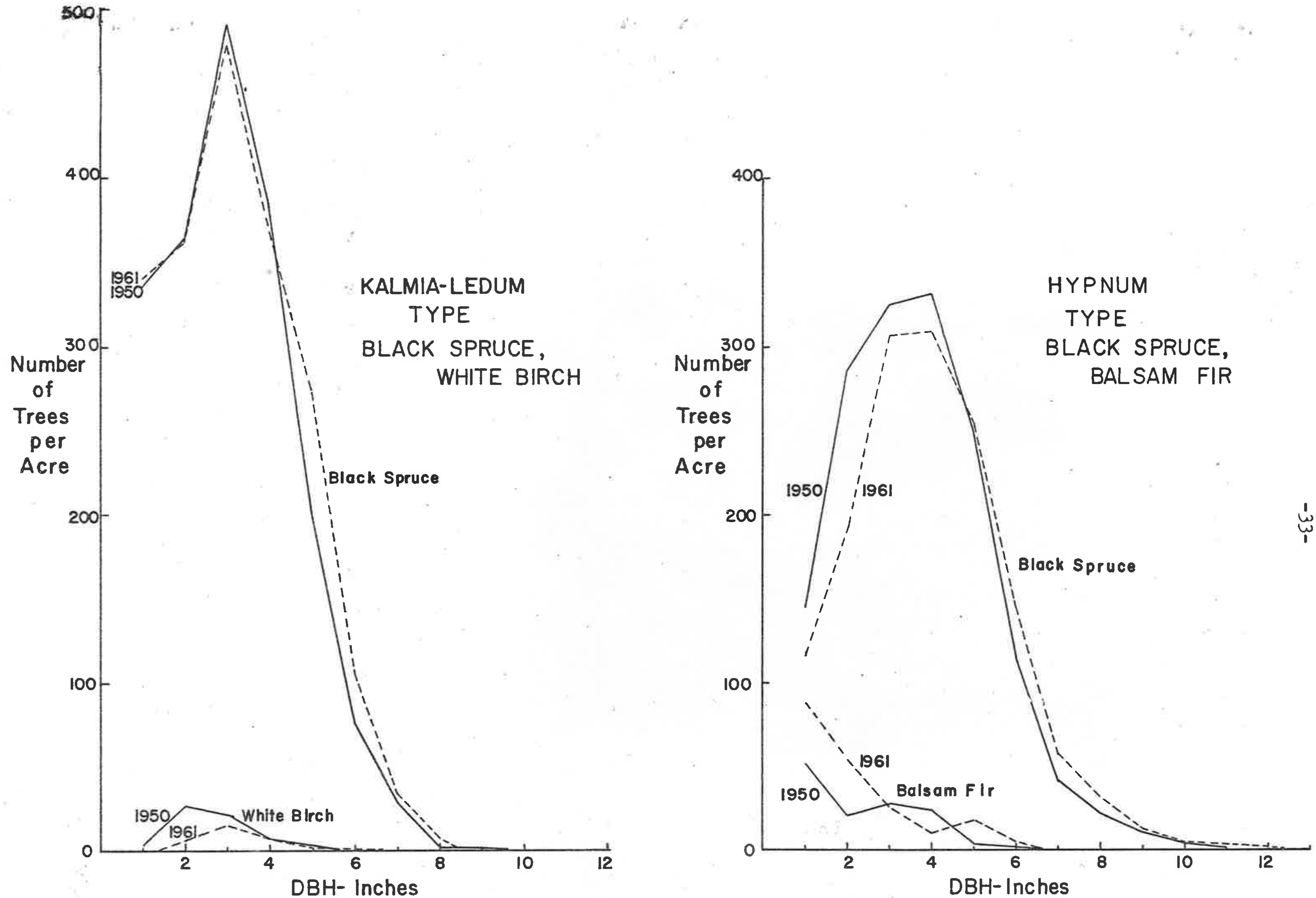


Figure 14. Number of trees per acre over DBH, 1840 fire origin stands, 1950 and 1961

DISCUSSION

Black spruce stands at Lake St.Pierre that appear to be even-aged are in fact uneven-aged stands of composite age structure with both even- and uneven-aged components. The method of separating the components as applied herein was not intended to delimit precisely these components but rather to illustrate a method of division which may be helpful in revealing age structure, in indicating the relative importance of even- and uneven-aged elements, and as an indicator of the mode of stand origin.

How the uneven-aged stand structure developed is not known. Traces of carbon were found on the surface of the mineral soil throughout the forest but lack of fire evidence on the oldest spruce trees and the high proportion of fir in the spruce-fir stands both suggest that the forest may not have burned for over 200 years. However, the largest part of the stands is the even-aged component approximately 150 years old. It is difficult to explain the origin of this component without at least a light fire 160 to 170 years ago. The literature abounds in statements to the effect that dense black spruce stands of seedling origin often follow fire but none has reported dense stands resulting from layering or rooting. Nevertheless the possibility that the even-aged element developed from layers or from seedlings which followed severe and extensive blowdown cannot be eliminated.

Regardless of the mode of origin of the uneven-aged stands it seems likely that volumes per acre were larger in the past than in 1961, even though 1961 volumes were slightly larger than in 1950. Larger volumes in some of the 1896 and 1840 fire-origin than in uneven-aged stands tend to support this belief as does the fact of near-constant or decreasing volumes of spruce. Perhaps fire in old-growth black spruce had a rejuvenating effect on the site. If present volumes are lower than in the past the stands may be said to have deteriorated. Indisputably such a reduction in volume represents a definite loss of wood but such deterioration can hardly be considered critical when much of the forest in 1961 contained over 3000 cubic feet of spruce and fir per acre. The slight increase in volume since 1950 suggests that fluctuations within a limited range may occur for some years. Since there appears to be a size limit on the lifespan of black spruce (i.e. very few trees over 12 inches d.b.h.), eventually the mortality rate will accelerate as the peak of the even-aged stand element approaches the critical size. Judging from present diameter growth rates this acceleration may not occur for 40-50 years.

Since 1950 the uneven-aged forest experienced a marked increase in the numbers of both spruce and fir saplings, many of which were of layer origin. The resultant volume increase in the sapling group (1-3 inches) balanced to a large extent the mortality losses which were as high as $5\frac{1}{2}$ cords per acre. At the next remeasurement, stems of layer origin should be tallied separately in order to follow their development and to provide a comparison with seed-origin stems. Development of layers and layer origin stands is a facet of spruce and fir silvics which has been neglected.

The proportion of fir is increasing on all but the poorest Kalmia-Ledum, clad. type. This phenomenon has been noted in black spruce stands elsewhere (Holt 1949, Lebarron 1948, Losee 1961, Millar 1936). The main explanation given is that in the absence of fire the moss and litter cover build up to a thickness which inhibits spruce seedling survival. The same reasoning no doubt applies at Lake St.Pierre. The conversion to stands with more fir than spruce is proceeding slowly and probably will continue rather slowly, barring a sudden catastrophe such as hurricane-force winds. The largest increase in fir from 1950 to 1961 was from 42 to 49 per cent of the total basal area in the Hypnum-Cornus type. The increase in fir proportion may be cause for concern for two reasons; 1) spruce is a more highly regarded pulpwood species than fir, and 2) as fir proportion increases so does susceptibility to severe spruce budworm attack.

Evidently a post-fire pattern of stand origin, characterized by an initial time lag followed by peak years of seedling establishment noted recently for three other conifers in three other burns, has been repeated at Lake St.Pierre. In as much as this pattern has now been found in four quite different burns in Quebec, it seems imperative that studies be initiated immediately after fire to determine precisely what happens. The chances of success in artificial seeding of burned areas might be greatly improved if the reasons for such a time lag could be definitely established. The tentative explanation of the origin pattern given for the York and Pabos burns (MacArthur and Gagnon 1961) was that seed moved into the burned area from a distant source. At Lake St.Pierre it seems improbable if not impossible that the 1896 burn could have seeded in this manner. Here it would appear that either a good many seed-bearing trees survived for several years after the fire or that spruce seed generally remains viable in cones of fire-killed trees for longer than has been reported. Only two references were found stating that viable spruce seed was present in cones as long as 10 years after fire (Chai and Hansen 1952, Nickerson 1958). The duration of black spruce seed viability in cones on fire-killed trees is a subject which needs more study.

In 1896 fire-origin stands the number of trees increased substantially between 1950 and 1961 because seedlings and layers were filling stand openings. Although this did not occur uniformly throughout the forest it nevertheless introduced an uneven-aged element into many stands. Future changes should be studied closely as this may explain the development of other uneven-aged stands in the area. The degree to which even-aged stands become uneven-aged in this way is probably a function of the original post-fire stocking. Dense 120-year-old fire origin stands had very little advance regeneration or ingrowth.

Growth rates for 64-year-old stands compare very favourably with black spruce yield table data for other regions of Canada. Current annual increments of up to 90 cubic feet of spruce and fir per acre 4 inches d.b.h. and over enhance the possibility of thinning or partial cutting to increase final yields. Experimentation in thinning and harvesting black spruce stands in this region, both to increase final yields and to encourage spruce regeneration would probably yield very worthwhile results.

SUMMARY

A study of stand development was begun in 1950 in black spruce and black spruce-balsam fir stands in Forest Section B.1b, Quebec. The five-square-mile study area 70 miles north of Baie Comeau contains uneven-aged stands of unknown origin and even-aged stands of fire origin. The tenth-acre line plots of the one per cent systematically located sample were remeasured in 1961 when additional age studies also were made to determine the origin and age structure of the forest.

Stands that appeared even-aged were discovered to be uneven-aged with both even- and uneven-aged components. A method of separating these components was applied which proved helpful in determining age structure, in revealing the importance of the stand components and in suggesting possible stand origin. Uneven-aged stand origin could not be precisely determined and the possibility that the even-aged element developed from layers or from seedlings after a severe blowdown could not be eliminated. Volumes per acre were probably lower in 1961 than in the past but increases in volume since 1950 suggest a possible pattern of fluctuation. Although the forest may be considered to have deteriorated to some degree, many stands still contain

over 3000 cubic feet per acre of spruce and fir. Volume of mortality was almost balanced by sapling ingrowth whose numbers increased greatly since 1950. However, more fir than spruce appeared in these small diameters resulting in an increase in the fir proportion. Most of the new spruce are of layer origin; most fir are from seedlings.

A pattern of spruce establishment following fire characterized by an initial time lag followed by peak years of establishment was found for the 1896 fire origin stands. This is the fourth burned area in Quebec to exhibit the same pattern. These stands have been growing remarkably fast and values for volume, M.A.I. and C.A.I. compare favourably with yield table data for other parts of Canada. An uneven-aged element recently entered this forest in the form of layers and seedlings filling openings that resulted from either low initial stocking or the death of birch.

The results suggest that studies should be undertaken to determine: 1) the development of layers and their value in forming stands, 2) the duration of black spruce seed viability in cones on fire-killed trees and 3) the pattern of seedling establishment following fire. Experimental thinning for higher yields and possibly better regeneration of spruce also would appear justified.

REFERENCES

Bedell, G.H.D. and D.W. MacLean and W.G.E. Brown, 1955. Preliminary empirical yield tables for black spruce. Forest Sections B.4 and B.9, Ontario and Quebec. Canada, Dept. of Northern Affairs and National Resources, For. Br., For. Res. Div. S. and M. 55-2.

Bellefeuille, R. 1935. La reproduction des peuplements d'épinette noire dans les forêts du Nord-Québec. For. Chron. 11 (4).

Chai, T.S. and H.L. Hanson. 1952. Characteristics of black spruce (Picea mariana) seed from cones of different ages. Minn. For. Note 2. (School of Forestry, University of Minnesota).

Holt, L. 1949. Restocking of spruce. Practical departures from our present cutting method when required. C.P.P.A., Woodlands Sect. No. 53 (F-2).

Horton, K.W. and J.C. Lees. 1961. Black spruce in the foothills of Alberta. Canada, Dept. of Forestry, For. Res. Br., Tech. Note No. 110.

Kabzems, A. 1953. The growth and yield of black spruce in Saskatchewan. Saskatchewan, Dept. of Natural Resources, For. Br., Tech. Bull. No. 1.

Lafond, André. 1960. Notes pour l'identification des types forestiers des concessions de la Quebec North Shore Paper Company (2ième édition). Quebec North Shore Paper Company, Baie-Comeau, P.Q.

Lebarron, R.K. 1948. Silvicultural management of black spruce in Minnesota. U.S. Dept. Agric., Circ. No. 791.

LeBlanc, J.H. 1954. A mode of vegetative reproduction in black spruce. C.P.P.A., Woodlands Sect. No. 1475 (F-2).

Linteau, A. 1941. Le feu régénérateur de la forêt. Forêt Québecoise 3(8): 40-49, (9): 35-50.

----------- 1955. Forest site classification of the northeastern coniferous section, Boreal forest region, Quebec. Canada, Dept. Northern Affairs and National Resources, For. Br., Bull. 118.

----------- 1957. Black spruce reproduction on disturbed soil conditions. Canada, Dept. Northern Affairs and National Resources, For. Br., For. Res. Div., Tech. Note No. 54.

Losee, S.T.B. 1961. Results of group cutting for black spruce regeneration at the Abitibi Woodlands Laboratory. C.P.P.A. Woodlands Sect. No. 2086 (F-2).

MacArthur, J.D. and J.D. Gagnon. 1961. Age ranges of post-fire black spruce and balsam fir in two poorly stocked Gaspé burns. Canada, Dept. of Forestry, For. Res. Br., Mimeo Series 61-10.

Millar, J.B. 1936. The silvicultural characteristics of black spruce in the clay belt of northern Ontario. Unpublished thesis, Univ. of Toronto.

Nickerson, D.E. 1958. Studies of regeneration on burnt forest land in Newfoundland. Newfoundland Research Committee, St. John's, Pub. No. 1, 1958.

Plonski, W.L. 1960. Normal yield tables. Ontario, Dept. of Lands and Forests, Silv. Series Bull. No. 2.

Rowe, J.S. 1959. Forest regions of Canada. Canada, Dept. Northern Affairs and National Resources, For. Br., Bull. 123.

APPENDIX

Summary Tables

(Small amounts of aspen and tamarack not shown)

TABLE I. NUMBER OF TREES, TOTAL VOLUME AND BASAL AREA PER ACRE, UNEVEN-AGED SPRUCE STANDS

Site Type	Spruce		Fir		White Birch		Total	
	1950	1961	1950	1961	1950	1961	1950	1961
	Number of Trees, One Inch D.B.H. Plus							
Hyp	516	773	385	670	24	20	925	1463
Ka-Le	732	1085	113	181	8	6	853	1276
Ka-Le, clad.	918	1335	7	10	1	<1	926	1345
	Basal Area, Square Feet, One Inch D.B.H. Plus							
Hyp	97	95	25	32	3	3	125	130
Ka-Le	84	88	8	11	1	1	93	100
Ka-Le, clad.	68	73	1	1	<1	<1	69	74
	Total Cubic Feet, One Inch D.B.H. Plus							
Hyp	2407	2357	487	738	66	64	2960	3159
Ka-Le	1729	1806	161	204	19	19	1909	2029
Ka-Le, clad.	1195	1258	13	12	1	<1	1209	1270
	Total Cubic Feet, Four Inches D.B.H. Plus							
Hyp	2360	2278	403	590	61	60	2824	2928
Ka-Le	1620	1642	139	169	18	19	1777	1830
Ka-Le, clad.	1027	1018	11	10	1	0	1039	1028

TABLE II. NUMBER OF TREES, TOTAL VOLUME AND BASAL AREA PER ACRE, UNEVEN-AGED SPRUCE-FIR STANDS

Site	Spruce		Fir		White Birch		Total	
Type	1950	1961	1950	1961	1950	1961	1950	1961
			Number of Trees, One Inch D.B.H. Plus					
Hyp-Co	239	456	645	1446	24	19	908	1921
H-H	391	632	580	1122	24	24	995	1778
H-Co	83	250	1092	2293	26	66	1201	2609
			Basal Area, Square Feet, One Inch D.B.H. Plus					
Hy-Co	63	62	49	65	5	4	117	131
H-H	75	77	47	57	5	5	127	139
H-Co	19	21	93	111	10	7	122	139
			Total Cubic Feet, One Inch D.B.H. Plus					
Hy-Co	1744	1707	1061	1321	107	96	2912	3124
H-H	1883	1933	995	1178	108	105	2986	3216
H-Co	555	594	2130	2356	231	156	2916	3106
			Total Cubic Feet, Four Inches D.B.H. Plus					
Hyp-Co	1723	1659	935	1068	104	93	2762	2820
H-H	1842	1864	897	989	106	103	2845	2956
H-Co	542	569	1942	1953	230	146	2714	2668

TABLE III. NUMBER OF TREES, TOTAL VOLUME AND BASAL AREA PER ACRE, 1896 FIRE ORIGIN STANDS

Site	Spruce		Fir		White Birch		Total	
Type	1950	1961	1950	1961	1950	1961	1950	1961
			Number of Trees, One Inch D.B.H. Plus					
Hyp	2246	3370	566	861	544	460	3358	4694
Cal-Va	1257	1740	83	204	676	694	2016	2578
Ka-Le	1308	1972	209	369	168	137	1685	2481
Ka-Le, clad.	815	1353	18	57	103	42	939	1452
			Basal Area, Square Feet, One Inch D.B.H. Plus					
Hyp	89	148	11	18	21	22	121	189
Cal-Va	66	102	2	5	38	40	106	148
Ka-Le	55	96	4	7	8	7	67	110
Ka-Le, clad.	34	60	1	1	6	2	41	64
			Total Cubic Feet, One Inch D.B.H. Plus					
Hyp	1388	2552	153	254	442	473	1988	3291
Cal-Va	918	1681	40	99	825	872	1783	2652
Ka-Le	767	1445	37	81	175	148	979	1679
Ka-Le, clad.	452	924	6	20	122	50	585	1004
			Total Cubic Feet, Four Inches D.B.H. Plus					
Hyp	828	1778	38	89	202	228	1072	2106
Cal-Va	635	1294	14	38	534	570	1183	1902
Ka-Le	525	1057	2	21	102	83	629	1165
Ka-Le, clad.	259	623	2	8	89	29	355	671

TABLE IV. NUMBER OF TREES, TOTAL VOLUME AND BASAL AREA PER ACRE, 1840 FIRE ORIGIN STANDS

Site Type	Spruce 1950	Spruce 1961	Fir 1950	Fir 1961	White Birch 1950	White Birch 1961	Total 1950	Total 1961
Number of Trees, One Inch D.B.H. Plus								
Hyp	1528	1431	130	200	79	50	1737	1681
Ka-Le, clad.	1885	1971	23	29	64	32	1972	2032
Basal Area, Square Feet, One Inch D.B.H. Plus								
Hyp	134	147	5	7	9	7	148	161
Ka-Le, clad.	118	136	1	1	3	2	122	139
Total Cubic Feet, One Inch D.B.H. Plus								
Hyp	2710	3076	85	119	169	131	2964	3326
Ka-Le, clad.	1899	2226	11	20	43	36	1953	2282
Total Cubic Feet, Four Inches D.B.H. Plus								
Hyp	2403	2806	57	83	149	124	2609	3013
Ka-Le, clad.	1437	1774	6	13	18	22	1461	1809

TABLE V. MORTALITY, FOUR INCHES D.B.H. PLUS, 1950-1961, UNEVEN-AGED STANDS

Site Type	Total Cubic Feet Per Acre			
	Spruce	Fir	White Birch	TOTAL
Hyp	378	66	7	451
Ka-Le	204	12	4	220
Ka-Le, clad.	146	3	2	151
H-Co	60	342	99	501
Hyp-Co	327	117	18	462
H-H	206	176	8	390