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Department of Forestry

FOREST RESEARCH BRANCH

A COMPARISON OF FOREST DEVELOPMENT AFTER CLEAR AND PARTIAL CUTTING IN FOREST SECTION L.7, QUEBEC, LAKE KENOGAMI 1923 TO 1958

(Project Q-8)

by

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TABLE OF CONTENTS

A COMPARISON OF FOREST DEVELOPMENT AFTER CLEAR AND PARTIAL CUTTING IN FOREST SECTION L.7, QUEBEC, 1923 TO 1958.

ABSTRACT

A 35-year comparison (1923-58) of the results of clear and partial cutting in a mixedwood forest in Forest Section L.7, Quebec, indicates that growth of pulpwood-size spruce and fir was greater on the clear-cut area. However, mortality from a spruce budworm outbreak, which began in 1947, had by 1958 resulted in a large reduction of commercial volumes through the whole forest and thus the greater growth on the clear-cut area was lost. The two cuts in the partial-cut forest yielded more pulpwood per acre than the initial clear cutting. This greater production represents an inherent advantage of cyclical partial cutting in forests susceptible to severe attack by the budworm.

INTRODUCTION

One of the oldest logging experiments in Quebec began in 1923 in a mixedwood forest of Forest Section L.7 (Rowe, 1959) at Lake Kenogami. The experiment was planned jointly by Price Bros. and Co., Ltd. and the Federal Government in consultation with the Quebec Dept. of Lands and Forests. The Company was responsible for conducting the woods operations, the Federal Gov't. was responsible for sampling, field measurements and reporting, and the Lands and Forests Dept. made an exception to their regulations to permit clear cutting.

The objective was to determine which of several combinations of cutting method and cultural treatment would result in the best development of coniferous regeneration. At that time it was felt that suppression of conifer seedlings and saplings by hardwoods after pulpwood cutting would be a serious problem. But soon after the experiment began it was realized that the abundance of conifer advance regeneration was such that adequate stocking would result regardless of hardwood development. Attention was then focused on pulpwood production.

Unfortunately, sampling was insufficient. This fact precludes comparisons of the combinations of cutting method and cultural treatment. Consequently the only possible valid comparison is of the two basically different cutting methods, clear cutting and partial cutting. The clear cutting in 1923 was in effect a diameter limit cutting down to and including trees 5 inches d.b.h., obviously quite different from clear cutting as currently practised.

This paper presents a comparison of growth, yield, production and mortality after clear and partial cutting from 1923 to 1958, including a second harvest from the partial-cut forest in 1954, and a spruce budworm outbreak which began about 1947.

THE FOREST

The Lake Kenogami Experimental Area of 381 acres is two miles south of Lake Kenogami (48° 15' N, 71° 15' W), just inside the boundary of Forest Section L.7. According to Rowe (1959), the forests of the Section are essentially boreal in appearance, with communities of jack pine[1] on sandy areas and with aspem, white birch white and black spruce and balsam fir common on other sites. Sugar maple and yellow birch occur in protected areas but stands of these species are not extensively developed. White pine and scattered red pine are present with cedar, basswood, white elm, black ash and balsam poplar in patches along river banks.

The Experimental Area lies on the foothills of the Laurentian Plateau and ranges in elevation from 1100 to 1400 feet above sea level. Gentle to moderate slopes with occasional rises to rocky ridges characterize the terrain. Small swampy areas are scattered throughout. The soil is a brown sandy loam varying in depth from a few inches to over two feet and is covered with a humus layer seldom exceeding three inches thickness. According to Villeneuve (1946) the frost-free period is 100-125 days, mean annual temperature 34-38°F, mean July temperature 62-66°F and mean temperature for the four warmest months 58-60°F.

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

The forest in general is mixedwood but individual stands may vary from pure hardwood to pure softwood. Typical stands are composed of balsam fir, white and black spruce, yellow and white birch. Sugar and red maples and black ash occur locally, the latter being confined to wet areas. Cedar grows near lake shores and a few veteran white pine still remain on higher ground. Ridges with thin soils support stands of black spruce and balsam fir while small swamps are occupied by open stands of black spruce. Both swamp and ridge stands were omitted from the study.

The approximate volume distribution in 1923 was 22 per cent spruce, 34 per cent fir and 44 per cent hardwoods. Formerly the pencentage of conifers was higher but sawlog cutting about 1890 and a spruce budworm outbreak about 1910 greatly reduced the spruce-fir volumes. In 1923 the volume of dead spruce and fir in the area equalled 45 per cent of the living volume which indicates a severe budworm attack. Consequently, stands were somewhat understocked at the outset of the experiment, containing less than 900 cubic feet per acre of spruce and fir and less than 700 cubic feet hardwoods.

The abundance of conifer regeneration noted by early observers probably followed the 1910 budworm attack. In 1923 there were almost 16,000 spruce and fir seedlings per acre less than five feet high, with fir outnumbering spruce by 17 to 1.

TREATMENT

The silvicultural treatments originally applied have been grouped under the two different cutting methods analysed (Table 1).

TABLE 1. DESCRIPTION AND DISTRIBUTION OF TREATMENTS

Cutting Method and Treatment	Area, Acres	Number of quarter-acre plots
Clear cutting		
Conifers cut to 5" d.b.h.		
Hardwoods cut, slash removed	27	3
Hardwoods girdled, slash left	27	3
Hardwoods uncut, slash left	27	2
Conifers cut to 5" d.b.h. on strips 250 feet wide		
Hardwoods uncut, slash burned	28	9
Hardwoods uncut, slash left	27	9
Total	136	26
Partial cutting		
Conifers cut by selection		
Hardwoods cut by selection	40	5
Hardwoods uncut	32	4
Conifers cut on half the area leaving seed trees in groups		
Hardwoods uncut	77	9
Total	149	18

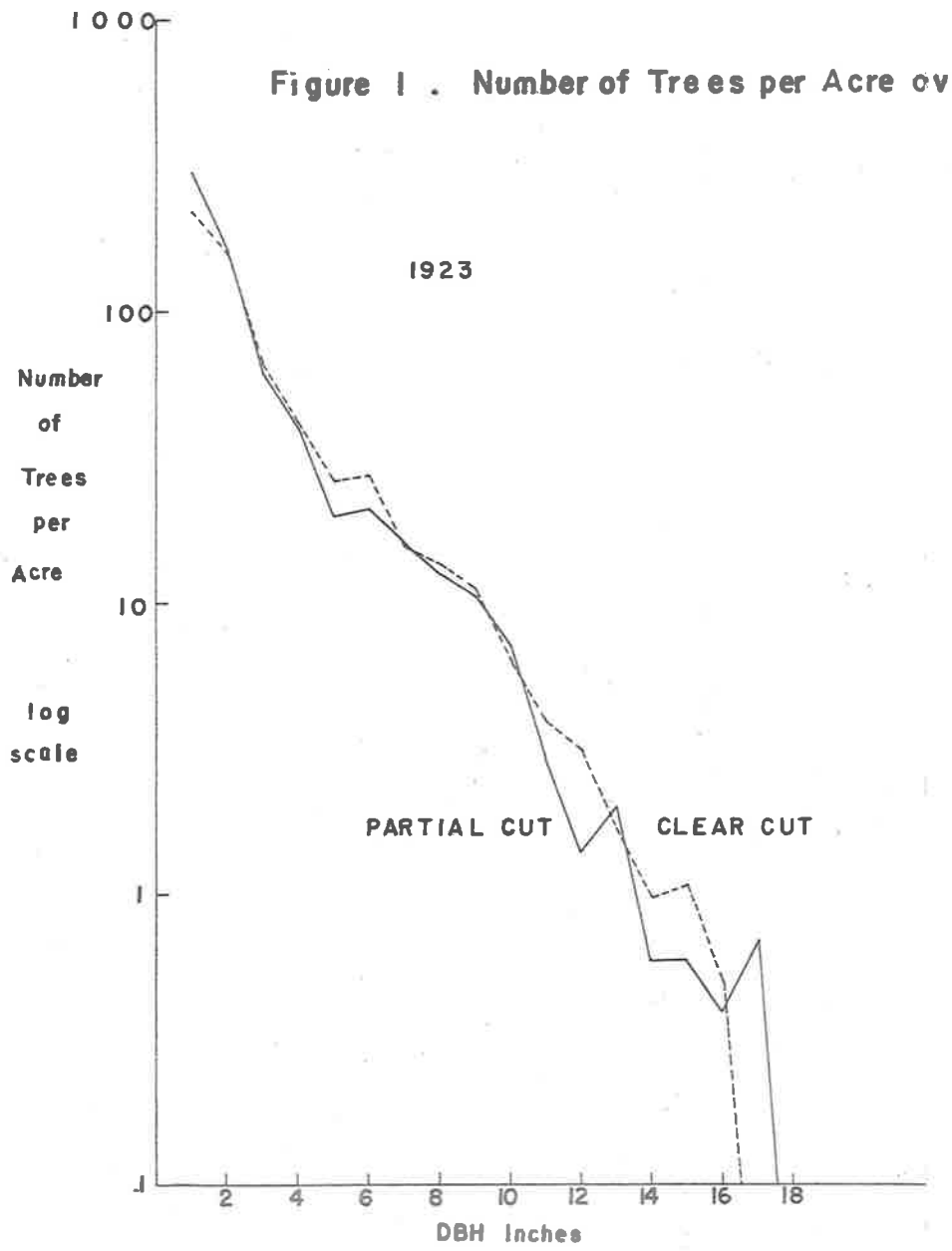
Clearly the experiment has severe limitations if gauged by present-day standards of experimental research. Stand treatments were not replicated nor were the same treatments applied within the different cutting methods. These limitations were recognized in the early 1930's (Mulloy, 1936) but the decision was made to carry on remeasurements in order to compare clear with partial cutting. A recent attempt to analyse the effects of hardwood treatment within the cutting methods gave inconsistent results.

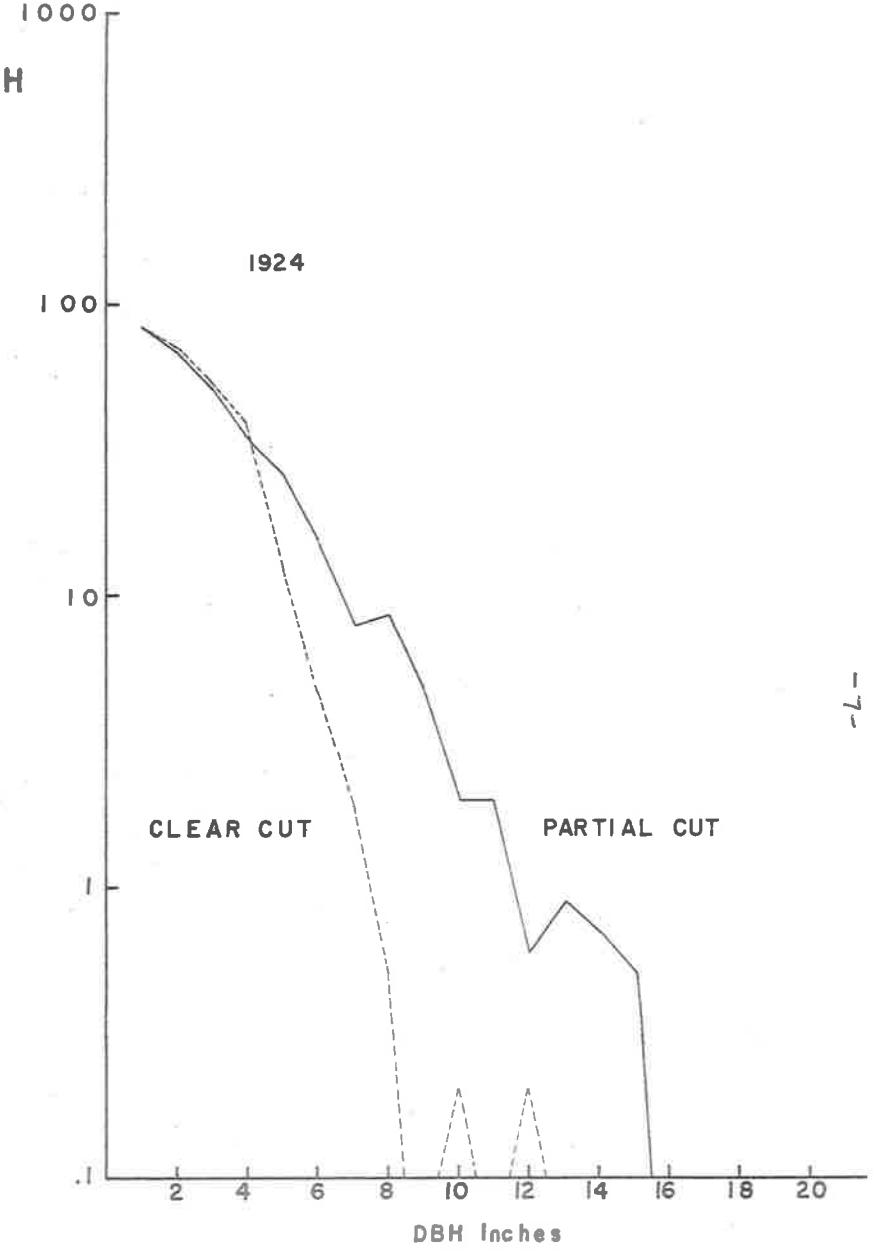
Differences in treatment within the cutting method no doubt had some influence on subsequent stand development. Nevertheless these differences likely had much smaller effects than those ascribable to the cutting methods themselves where 84 per cent of the spruce-fir volume and 76 per cent of the basal area were removed from the clear-cut forest compared to only 42 and 40 per cent from the partial-cut. The effects of the cutting methods on the distribution of trees and volume are shown in Figures 1 and 2.

Concerning the treatment of hardwoods, it is noted that they were cut or girdled on 23 per cent of the clear-cut plots and 28 per cent of the partial-cut (Table 1). Thus the two cutting methods were more or less equally affected by these treatments. Burning of slash, which was attempted only in the clear-cut forest, was reported to be only partially successful. This treatment is believed to have had very little effect on regeneration.

A small volume of wood was accidentally cut in 1942-1943 but not enough to upset the experiment. A second cut took place on the partial-cut area in 1954-1955.

Figure 1 . Number of Trees per Acre over DBH





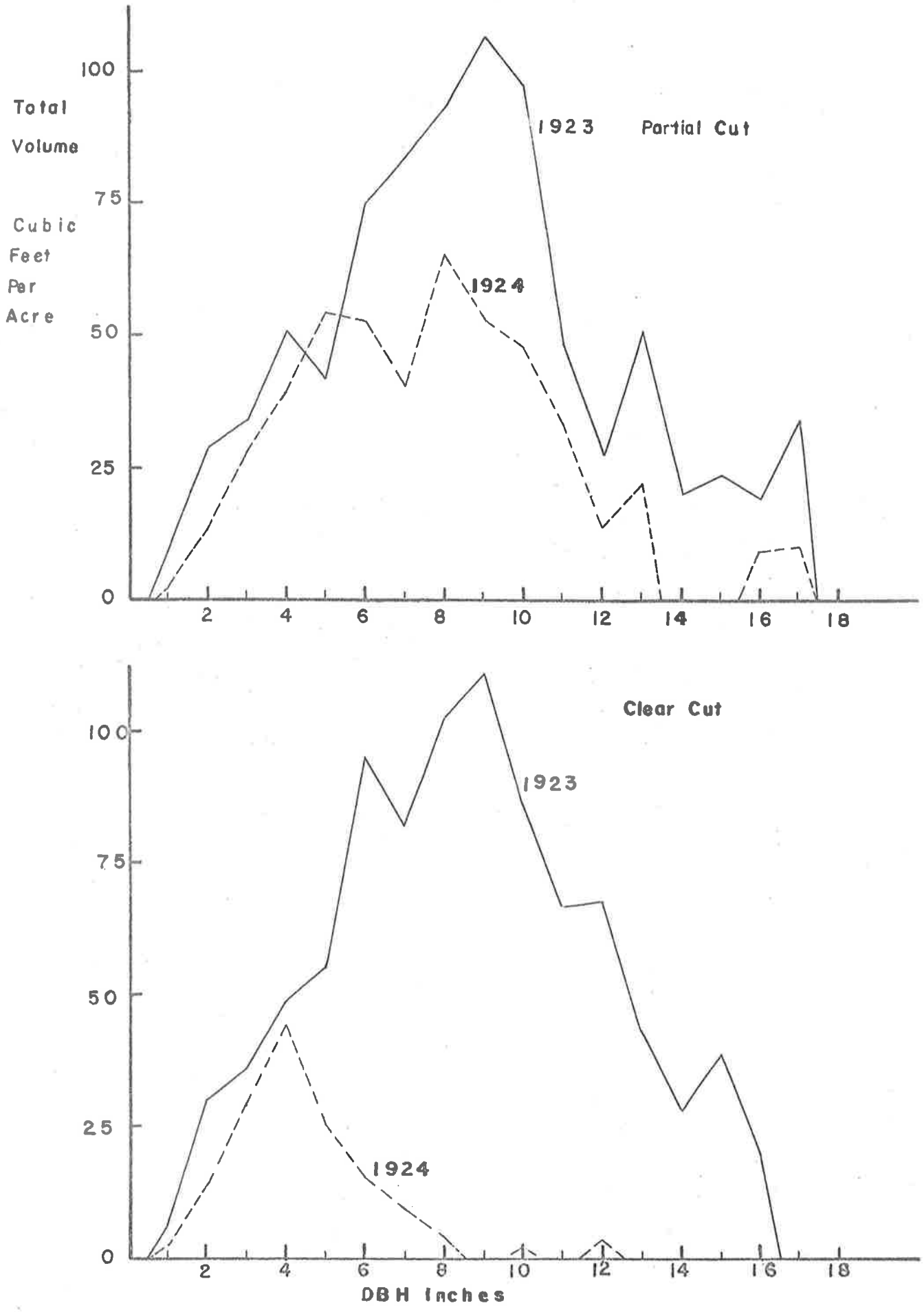


Figure 2. Stock Profiles, Spruce and Fir Combined, 1923 and 1924

METHOD OF STUDY

In 1923 the two blocks comprising the experimental area were laid out and sampled by 44 rectangular quarter-acre plots located at 500-foot intervals on parallel lines across the blocks. On each plot a diameter tally was made of all trees 5 inches d.b.h. and larger. Smaller trees and seedlings were tallied on small sub-plots. Treatment areas were delineated after the plots had been established.

In 1924 the plots were remeasured after treatment. All trees down to one inch d.b.h. were tallied. Subsequent remeasurements were made in 1929, 1947, 1953, 1955 in the partial-cut forest, and 1958. Results from the 1929 and 1947 remeasurements are not included in the study because of discrepancies in plot tallies.

RESULTS

Production of pulpwood-size spruce and fir was greater on the clear-cut than on the partial-cut area, both over the initial 30-year period to 1953 and the 35-year period to 1958 which included the second harvest from the partial-cut forest (Table 2). This higher production to 1953 resulted from the larger initial cut in the clear-cut forest and not from a much greater net increment. It is true that the partial-cut forest in 1953 had the larger volume per acre as a result of its greater residual volume in 1924. But under a partial-cut system a certain volume remains after each cut; this volume is never available for cutting, and thus does not enter into the production calculation.

TABLE 2. COMPARISON OF SPRUCE-FIR PRODUCTION, 1923-1953, 1923-1958, TOTAL CUBIC FEET PER ACRE, 4 INCHES D.B.H. AND OVER

	Partial Cut	Clear Cut
Cut 1923-1924	331	743
Cut 1942-1943	6	1
Net Increment 1924-1953	739	786
Production 1923-1953	1076	1530
Cut 1954-1955	528	0
Net Increment 1924-1958	20	475
Production 1923-1958	885	1219

The superiority of the clear-cut forest was reduced somewhat after the second cut in the partial-cut forest but was still 334 cubic feet per acre. The lower production values for the period ending in 1958 compared to th se ending in 1953 was caused by mortality attributed to the spruce budworm. The partial-cut forest suffered a smaller loss than the clear-cut from this insect because some dead fir was cut in the 1954 operation (Table 3).

TABLE 3. COMPARISON OF SPRUCE-FIR LOSSES ATTRIBUTED TO SPRUCE BUDWORM 1953-1958, TOTAL CUBIC FEET PER ACRE, 4 INCHES D.B.H. PLUS

	Partial Cut	Clear Cut
Volume 1953	1194	890
Volume 1958	465	580
Reduction	729	310
Cut 1954-1955	528	0
Net loss	201	310

Stand development to 1953 indicates that early fears of conifer regeneration being suppressed by hardwoods were groundless. Increases in number of conifer saplings in both the partial- and clear-cut forest testify to the successful development of seedlings and advance growth (Figure 3).

Spruce-fir volume increased in both forests at almost equal annual rates to 1958 (Table 4). By 1953, volumes were greater than before the original cuttings, with the bulk of the larger volume in the partial-cut forest found in the 6 to 14-inch diameter classes compared to the concentration of the clear-cut volume between 3 and 10 inches (Figures 4 and 5).

TABLE 4. NET AND GROSS ANNUAL INCREMENT PER ACRE, 1923-1958, ONE INCH D.B.H. AND OVER

Annual Increment	Partial-Cut			Clear-Cut		
	Softwood	Hardwoods	Total	Softwoods	Hardwoods	Total
Net	16	4	20	15	4	19
Gross[2]	27	15	42	28	11	39

Between 1953 and 1958 spruce-fir volume in the clear-cut forest dropped below that of 1923 because of budworm mortality. Combined budworm mortality and cutting in the partial-cut forest resulted in a volume reduction to the 1924 level. Budworm losses occurred proportionately through the diameter classes (Figure 6). In 1958 more than 80 per cent of the volume of fir was classified as badly defoliated.

2 1929 and 1947 mortality not included in calculation.

Hardwood species apparently did not benefit much from the initial cuttings. Only a small volume increase occurred up to 1953. Any gains in smaller diameter classes were balanced by white birch losses from dieback.

However, since 1953 they have evidently taken advantage of the decreased stand density caused by the death of fir. Volume increases for the short 1953-1958 period were almost equal to the increases over the first 30 years. Yellow birch would appear to have gained more than other hardwoods, particularly in the partial-cut forest (Table 5).

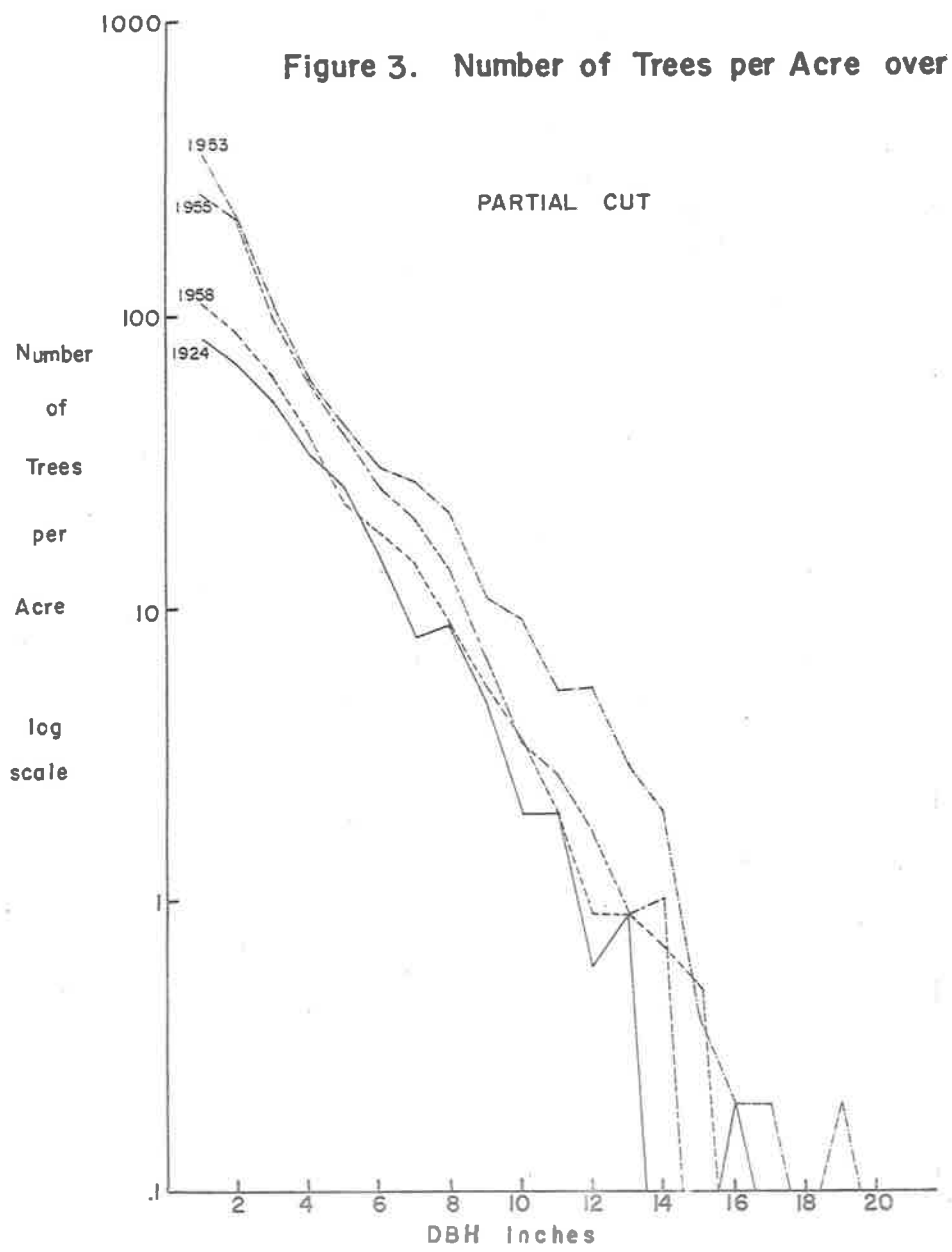
TABLE 5. VOLUME OF HARDWOODS, PER ACRE ONE INCH D.B.H. AND OVER, 1924, 1953, 1958

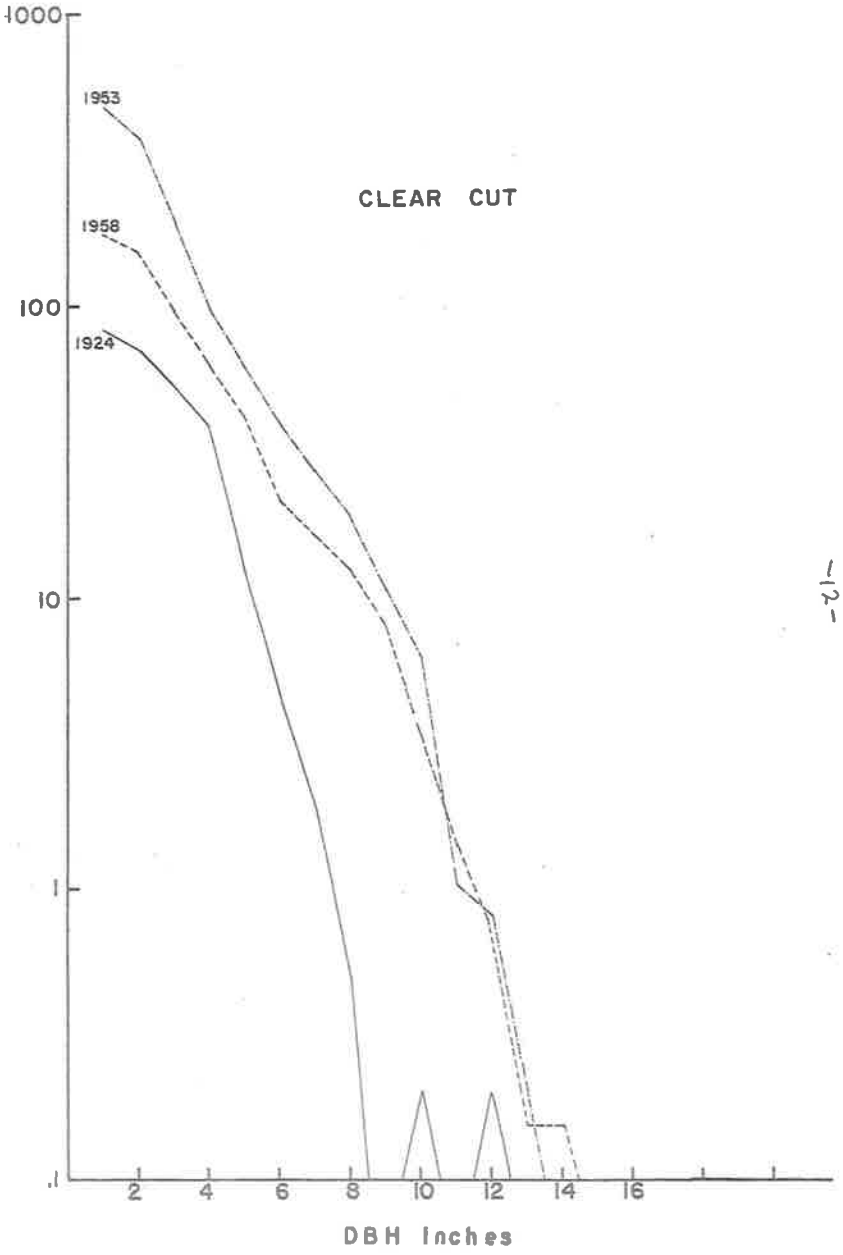
Year	Partial-Cut			Clear-Cut		
	Yellow Birch	Other	Total	Yellow Birch	Other	Total
1924	446	317	763	352	171	523
1953	630	183	813	384	222	606
1958	709	178	886	441	236	677

DISCUSSION

A valid comparison to determine superiority of conifer volume production between partial and clear cutting can be made only after a period of years equal to the conifer rotation age has elapsed. However, any trends after 35 years in this forest, where the spruce-fir rotation would be about 60 years, would be significant.

Figure 3. Number of Trees per Acre over DBH





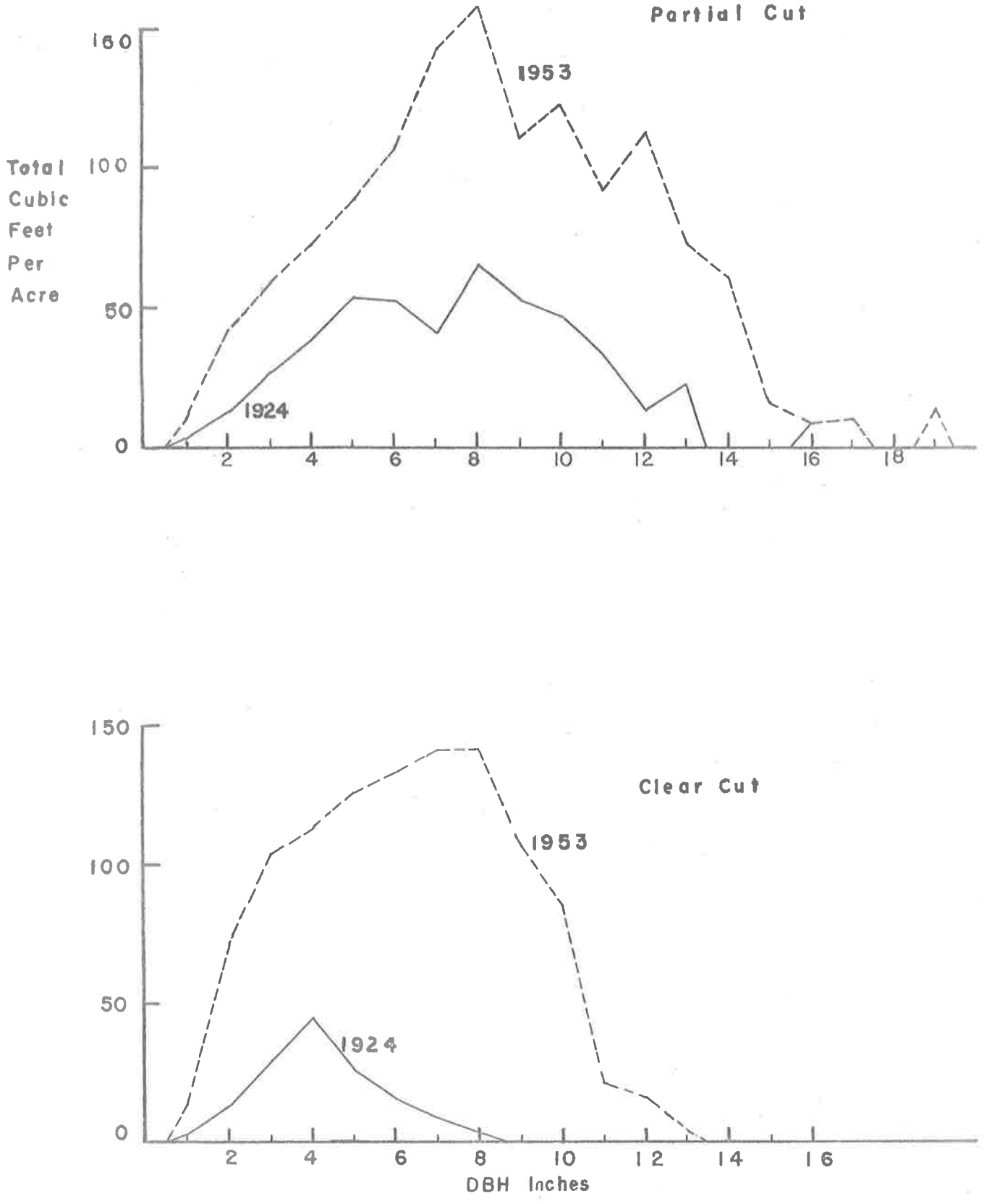


Figure 4. Stock Profiles, Spruce and Fir Combined, 1924, 1953

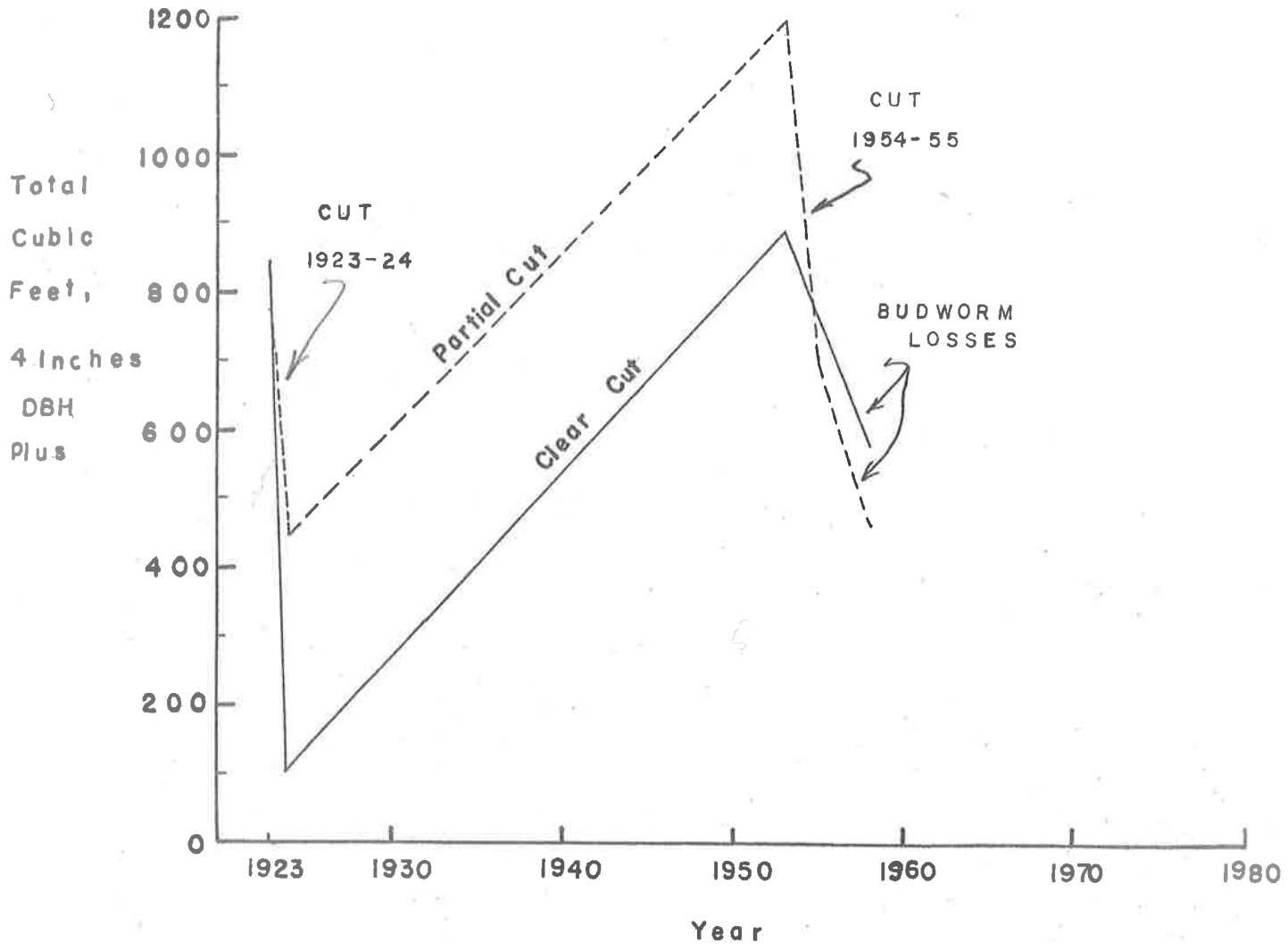


Figure 5 . Fluctuations in Spruce - Fir Volume, 1923 to 1958

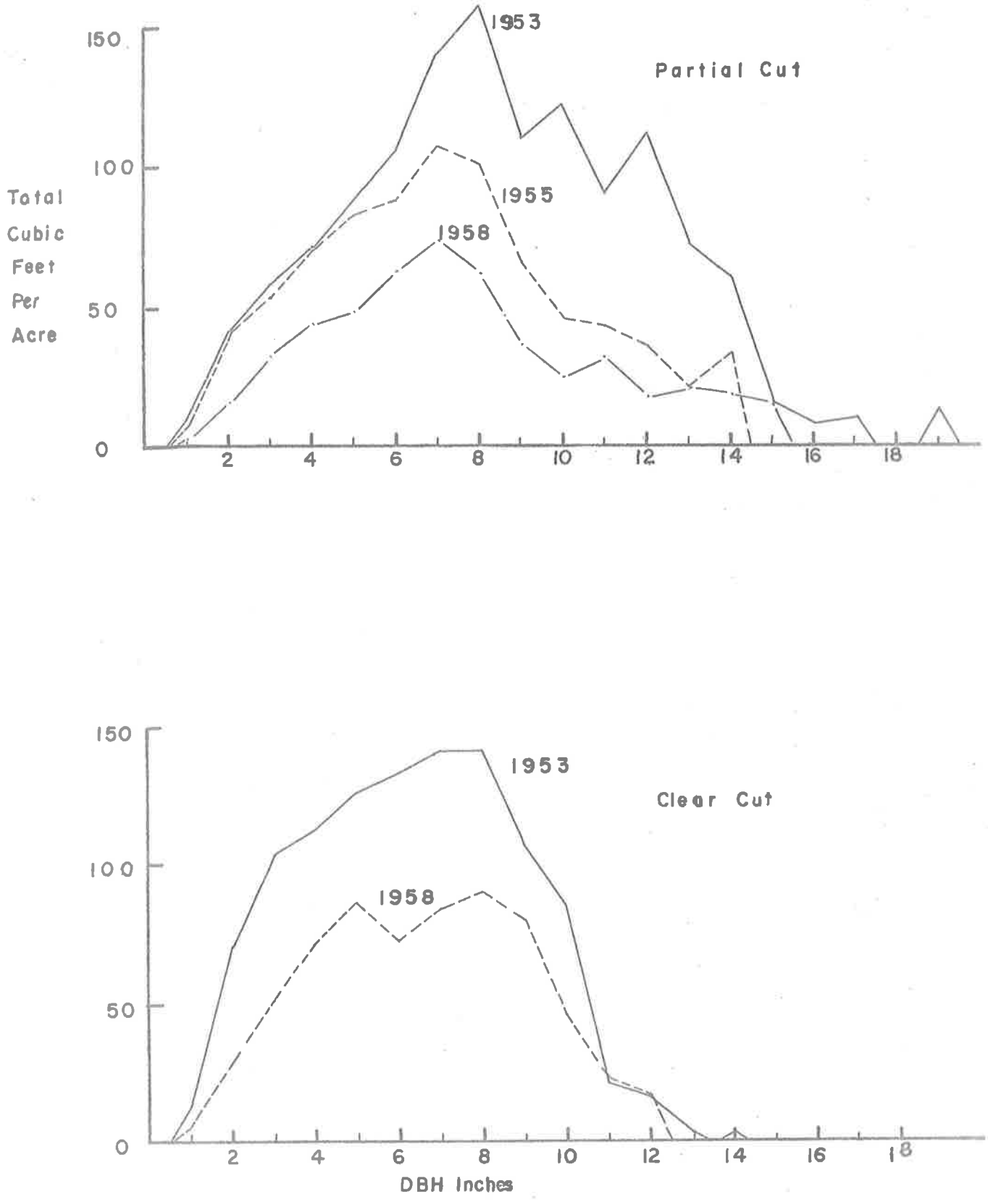


Figure 6. Stock Profiles, Spruce and Fir Combined, 1953, 1955 and 1958

Proponents of clear cutting would suggest that the production advantage of this system after 35 years could hardly be offset by faster growth in the partial-cut forest over the remaining 25 - 30 yea rs of the rotation. The author would agree with such an appraisal of this experiment, but two facts must be remembered: First, many more 4- and 5-inch trees were left after the clear cutting of 1923 than would generally be found after present-day clear cutting. Second, the 30-year cutting cycle in the experiment would today be reduced to one of 15-25 years. The first of these facts favoured better than average production in the clear-cut area; the long 30-year cutting cycle reduced the effectiveness of the partial-cut system in harvesting the volume that is otherwise lost through natural mortality.

Advocates of partial cutting would claim that the original spruce-fir volume in the partial-cut forest was 71 cubic feet per acre less than that of the clear-cut, and would adjust the production values by reducing the clear-cut advantage from 334 to 263 cubic feet. They would also note that volume loss due to budworm was less in the partial-cut forest because seme dead trees were utilized. Their best argument would be the fact that if commercial volumes over the whole area are reduced to nil by the budworm, which seems probable, then it is significant that up to 1955, 885 cubic feet of pulpwood per acre was removed from the partial-cut forest compared to 743 cubic feet from the clear-cut.

Probably neither cutting system, as applied at Lake Kenogami, would have proved much more productive than the other at the end of the rotation. Had the clear cutting been to a 3-inch rather than

to a 5-inch diameter limit, and had the partial cutting been on a 15-year rather than on a 30-year cutting cycle, then the results might have been very different.

It is feared that the spruce budworm has effectively ended the experiment as far as production comparisons are concerned. It remains for other studies to provide the answers as to the superiority of cutting systems.

STAND TABLES

Number of Trees per Acre

Diameter Class-Inches	CLEAR-CUT								PARTIAL-CUT									
	Spruce and Fir				Hardwoods				Spruce and Fir					Hardwoods				
	1923	1924	1953	1958	1923	1924	1953	1958	1923	1924	1953	1955	1958	1923	1924	1953	1955	1958
1	221.6	83.0	478.0	178.7	135.6	135.6	86.1	32.3	303.0	83.9	363.0	269.0	112.0	19.3	19.3	25.7	28.9	20.8
2	160.1	71.7	376.0	159.2	19.2	19.2	73.8	57.7	151.8	68.6	222.0	219.8	87.9	30.2	30.2	30.9	28.8	32.8
3	67.8	54.0	193.0	95.7	9.7	9.7	36.9	44.8	63.1	51.7	110.0	101.2	61.3	9.1	9.1	13.3	16.9	20.4
4	43.1	39.3	99.7	63.0	9.9	9.9	15.9	23.2	45.3	34.8	63.5	62.4	39.5	8.7	8.7	8.2	10.4	16.8
5	27.0	12.3	60.9	42.1	5.8	6.9	7.8	14.8	20.2	26.2	42.9	39.7	23.5	6.9	10.3	6.2	7.1	7.2
6	28.3	4.6	39.2	22.0	5.9	4.9	3.8	7.9	22.2	15.5	31.3	25.8	18.6	6.9	6.4	4.7	3.5	4.6
7	16.0	1.9	27.4	16.5	4.0	4.4	3.4	3.1	16.2	8.0	27.5	20.8	14.5	4.4	5.1	4.6	4.6	4.8
8	14.0	.5	19.1	12.3	4.0	3.5	4.4	3.2	12.7	8.9	21.3	13.8	8.7	7.3	6.5	4.9	4.0	4.4
9	11.2		10.6	8.0	4.0	1.2	2.7	2.9	10.7	5.4	10.9	6.7	3.8	3.3	3.3	5.1	3.6	4.4
10	6.5	.2	6.3	3.4	1.4	3.4	3.9	2.2	7.4	3.6	9.2	3.5	2.0	4.2	2.5	3.6	4.0	4.9
11	4.0		1.3	1.4	2.7	2.5	1.3	2.6	2.9	2.0	5.3	2.7	2.0	3.5	3.5	2.5	2.6	3.8
12	3.2	.2	.8	.8	4.6	1.7	1.5	1.7	1.4	.6	5.4	1.7	.9	5.5	4.7	2.8	2.7	1.8
13	1.7		.2	.1	1.9	2.7	2.2	1.7	2.0	.9	2.9	.9	.9	2.7	1.8	2.2	2.0	2.2
14	1.0			.1	1.3	1.4	1.1	1.5	.6		2.0	1.1	.7	3.6	2.9	2.2	2.0	2.5
15	1.1				1.2	1.2	1.2	.8	.6		.4		.4	1.3	.9	2.0	2.2	2.0
16	.5				1.4	.8	1.0	1.2	.4	.2	.2			1.1	1.1	1.6	1.1	1.3
17					.7	.5	1.4	1.2	.7	.2	.2			1.1	1.7	.2	.4	1.1
18					.8	.6	.3	.9						1.1	1.7	.4	.9	.9
19					.5	.4	.5	.1			.2			.7	.4	.2		
20						.6	.3	.4							.2	.4	.2	.2
21							.2	.1							.2	.9	.9	.9
22							.2							.2				.4
23					.3			.1							.2	.7	.7	
24					.2			.1								.2	.2	.7
25							.2							.2				.2
26																.2	.2	.2
27							.2	.1						.2		.2		.2
28								.1										
29																	.2	
30					.2											.2		
Total	607.1	267.7	1312.5	603.3	215.3	211.1	250.3	204.7	661.2	310.5	918.2	769.1	376.7	121.5	120.7	124.1	128.1	139.5

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