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CONVERSION TO PERIODIC SELECTION MANAGEMENT IN A FIR, SPRUCE AND BIRCH FOREST

by
G. L. Baskerville

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CONTENTS

82934–1—2

Conversion to Periodic Selection Management in a Fir, Spruce and Birch Forest

by

G. L. Baskerville[1]

INTRODUCTION

In 1947, a study was undertaken to determine the suitability of the periodic selection system in managing a fir-spruce-birch forest.[2] The work is being carried out on the Green River Project by the Forestry Branch in co-operation with Fraser Companies Limited. This paper summarizes the results obtained during the first ten years.

The experimental area is located near the northern end of the Green River watershed in northwestern New Brunswick (latitude 47° 50′ N., longitude 68° 19′ W.). This is a strongly rolling upland with elevations from 1,000 to 2,100 feet above sea level.

The dominating climatic influences are abundant precipitation, long cold winters and short cool summers. Weather records indicate a frost-free period of 110 days, a mean annual temperature of 36 degrees Fahrenheit and an annual precipitation of 42 inches, of which 18 inches falls between June and September.

The forest consists of balsam fir in association with white spruce, black spruce, white birch, and scattered yellow birch. Before 1940, the birches formed a major component of most stands. Dieback has since reduced them to minor proportions. Shrubs and young softwoods have developed in the openings left by the dead birch.

The spruce budworm outbreak of 1913 to 1919 killed many mature fir on the area and released an advance growth which has formed 40-year-old pole stands of up to 6,000 stems per acre. These young stands occur either as an understorey beneath a moderate stand of overmature fir and spruce which survived the budworm attack or as the main forest where the overwood was destroyed.

Balsam fir is well suited to the climate and soils of the area. Individual stems have attained heights of 50 feet and diameters of nine inches at breast height in 33 years. Fir reproduces abundantly on all sites, is remarkably shade-tolerant, and grows well, even after 40 years of suppression. It commonly lives 90 years from time of release without excessive rot and some individuals are still sound after 130 years.

Mature fir stands often have a dense advance growth. This combined with the regeneration that follows clear felling can within ten years result in 20,000 stems per acre. Stagnation is rare, but the growth of individual trees is greatly retarded until the stocking is reduced by competition. If the advance growth is small at the time of cutting, mountain maple quickly overtops and suppresses the softwoods.

[1] Forestry Officer, Forestry Branch, Maritimes District Office, Fredericton, N.B.
[2] The study was established by Messrs. D. E. Nickerson and A. B. Vincent of the Forestry Branch.

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THE EXPERIMENTAL FOREST

The experimental forest of 83 acres lies on a conical hill sloping gently in all directions. Local elevation ranges from 1,480 feet to 1,560 feet above sea level. The bedrock is strongly folded slate with a free vertical cleavage. It is overlain by a till which, though not deep, is nowhere shallow enough to limit tree growth. The soil is a silt loam, somewhat moist on the lower slopes, well-drained over the mid-slopes and somewhat dry on the hilltop.

Stand developments are followed on 48 tenth-acre plots. On each plot all stems 0.5 inch in diameter at breast height and larger are tallied by species and one-inch diameter classes. Also on each plot reproduction tallies (stems below 0.5 inch in diameter) are made on ten milacre quadrats. Sufficient height-diameter measurements are obtained at each remeasurement to construct local volume tables.

The whole area may be classed as softwood although a small part at the hilltop tends towards mixedwood, being 22 per cent birch by numbers of trees in 1947. On the basis of numbers of trees per acre the forest is 90 per cent fir, 5 per cent spruce, and 5 per cent birch.

The age and structure of the forest is irregular. However, four broad age groups can be recognized:

(1) 1 to 20 years; advance growth that was on the ground before the first felling and the predominantly fir regeneration that has come in since,

(2) 40 to 50 years; dense fir released following the 1913-1919 budworm infestation,

(3) 70 to 95 years; mostly decadent fir, remnants of the mature stands present before the first felling, and

(4) 110 to 140 years; veteran white and black spruce and the occasional fir.

The forest has three basic structural types. In the first type, because of blowdown, birch dieback and heavy felling, there is only the youngest age class (3 per cent of the area). This portion is fully stocked with softwood stems in the 1- to 20-year-old group. In the second type, stands of 70- to 95-year-old fir, and 110- to 140-year-old spruce, with low to moderate density, occur over a dense understorey of 40- to 50-year-old fir (67 per cent of the area). In many instances there is advance growth under the younger stand. The third type consists of stands of 70- to 95-year-old fir and 110- to 140-year-old spruce usually of moderate density, with abundant and well distributed reproduction in the 1- to 20-year-old group (30 per cent of the area).

THE PROBLEM OF CONVERSION

The objective of the study is to establish a stand structure which can be maintained by the periodic selection system of management operating under a ten-year cutting cycle. Ultimately this will result in a forest in which growth, drain, and growing stock are so balanced that the periodic harvest equals the periodic growth, and the basic structure and volume of the growing stock is maintained indefinitely.

True all-aged forests do not occur naturally in this area. However, because of the several-aged, all-sized nature of the stands the diameter class frequencies approximate the form of the reverse "J" curve typical of an all-aged structure (Figure 1). This curve becomes a straight line if plotted on semi-logarithmic paper. Thus, the first step towards attainment of the objective is to convert a

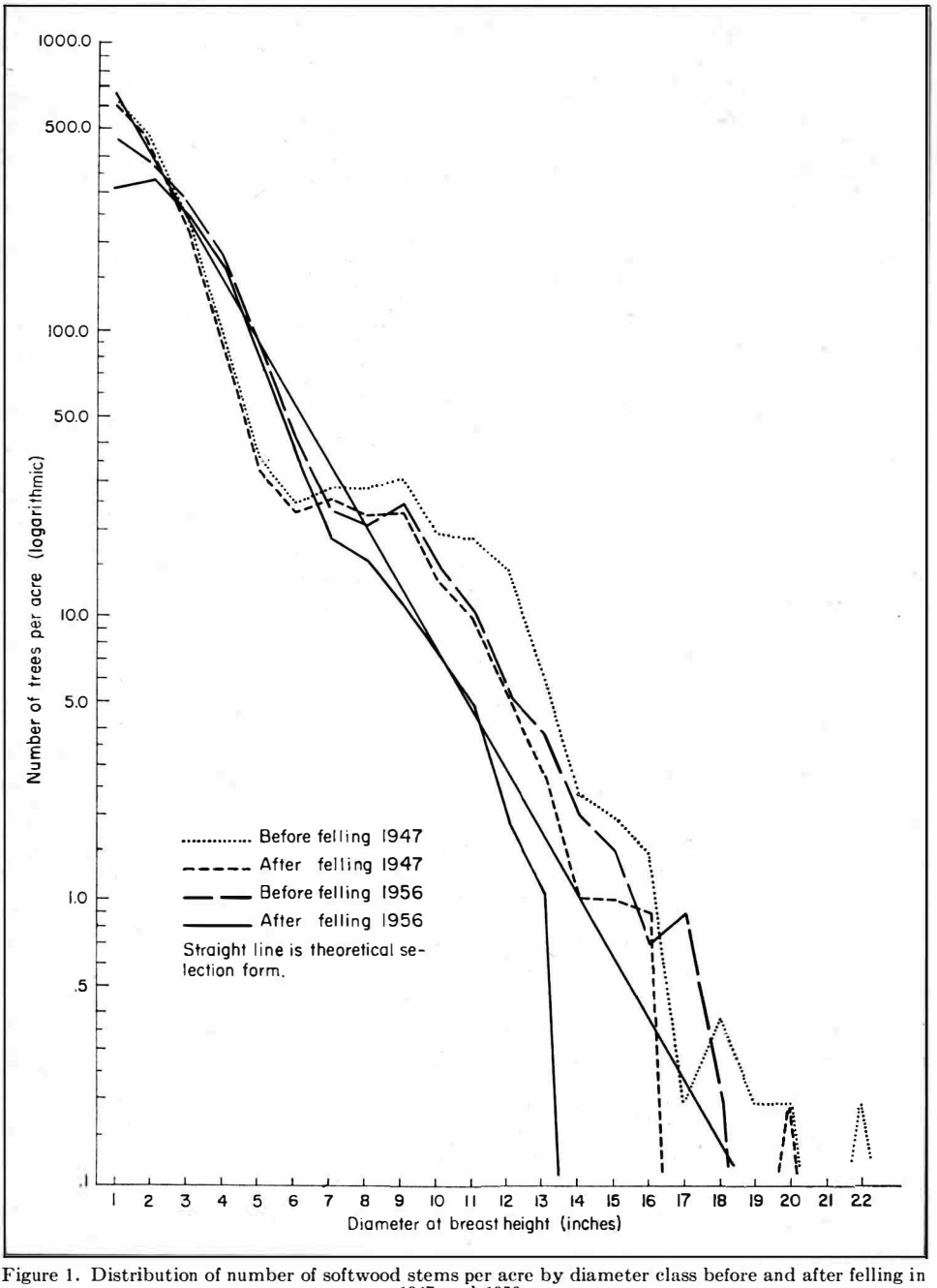

Figure 1. Distribution of number of softwood stems per acre by diameter class before and after felling in 1947 and 1956.

forest comprising several dissociated combinations of age groups into a uniform, balanced, all-aged forest. This is being carried out with appropriately spaced and regulated fellings, but it will take at least two more cutting cycles to complete the conversion. Until this is done, the forest should not be termed a selection forest, nor can the fellings be termed selection.

While the objective is an all-aged forest, the distribution of size classes is equally important. The age of a tree is important mainly from the standpoint of growth capability and pathological deterioration. To assess the progress of conversion, a size distribution based on the theoretical selection form was compiled for comparison with the forest on the study area. This computation was based on de Liocourt's law using one 14-inch tree per acre and a ratio of 1.65 (Knuchel 1949, Meyer 1952) (Figure 2).

The foregoing criteria provide a theoretical stand with few trees larger than 12 inches and with 46 per cent of the trees in the optimum pulpwood range of 6 to 10 inches in diameter at breast height. The basal area of 96 square feet and total volume of 1,545 cubic feet per acre while appearing low are compatible with current conditions. Moreover the distributions of basal area, volume and number of trees per acre in this theoretical stand provide forms on which to base comparisons. The ideal level of growing stock, which produces permanently the highest value in increment, can be determined only after examination of the increment over several cycles.

Existence of the theoretical form does not necessarily indicate that a balanced condition has been achieved. While the selection forest cannot exist without a complete distribution of sizes, it is possible to create a temporary balance of sizes which cannot be maintained because of deficiencies in the range of ages. Conversion is aimed at balancing size and age throughout the forest.

INITIAL FELLING, 1947

Before the felling in 1947 the stand had 1,766 trees per acre with a basal area of 135 square feet and a merchantable softwood volume of 2,147 cubic feet (Table 1). The total softwood stocking was 2,685 cubic feet per acre, of which 18 per cent was in small trees, 41 per cent was in medium trees, and 41 per cent was in large trees [3] (Table 2).

Although all size classes were present, the distribution of diameters deviated from the selection form because of a concentration in large and medium-sized trees (Figure 1). The deviations from the theoretical form are most clearly apparent when expressed in terms of basal area (Figure 2).

The 1947 felling removed 30 per cent of the merchantable softwood volume. Trees marked for felling included: large decadent fir (nearly all over 10 inches), all spruce over 14 inches, smaller spruce with defective tops, and any other trees which appeared unlikely to survive another 10 years. In following these rules, however, no crown openings greater than 0.1 acre were to be made.

The felling removed an average of 54 softwoods per acre, with a basal area of 31 square feet and a merchantable volume of 776 cubic feet (Figure 3). The volume removed was 81 per cent fir and 19 per cent spruce. The average diameter of fir removed was 10.3 inches and that of spruce was 11.6 inches. Trees ten inches and larger comprised 80 per cent of the cut. No birch were felled, but many dead or dying stems were knocked down in the operation.

Felling greatly reduced the concentration of growing stock in larger trees, but the distribution was still weighted in favor of larger, overmature trees (Figures 1 and 2). Many of the older residuals could have been felled, but the need to proceed in such a way that sufficient canopy was maintained to mini-

[3] Small trees include stems between 1 and 5 inches in diameter at breast height, medium trees 6 to 10 inches, and large trees 11 inches and larger.

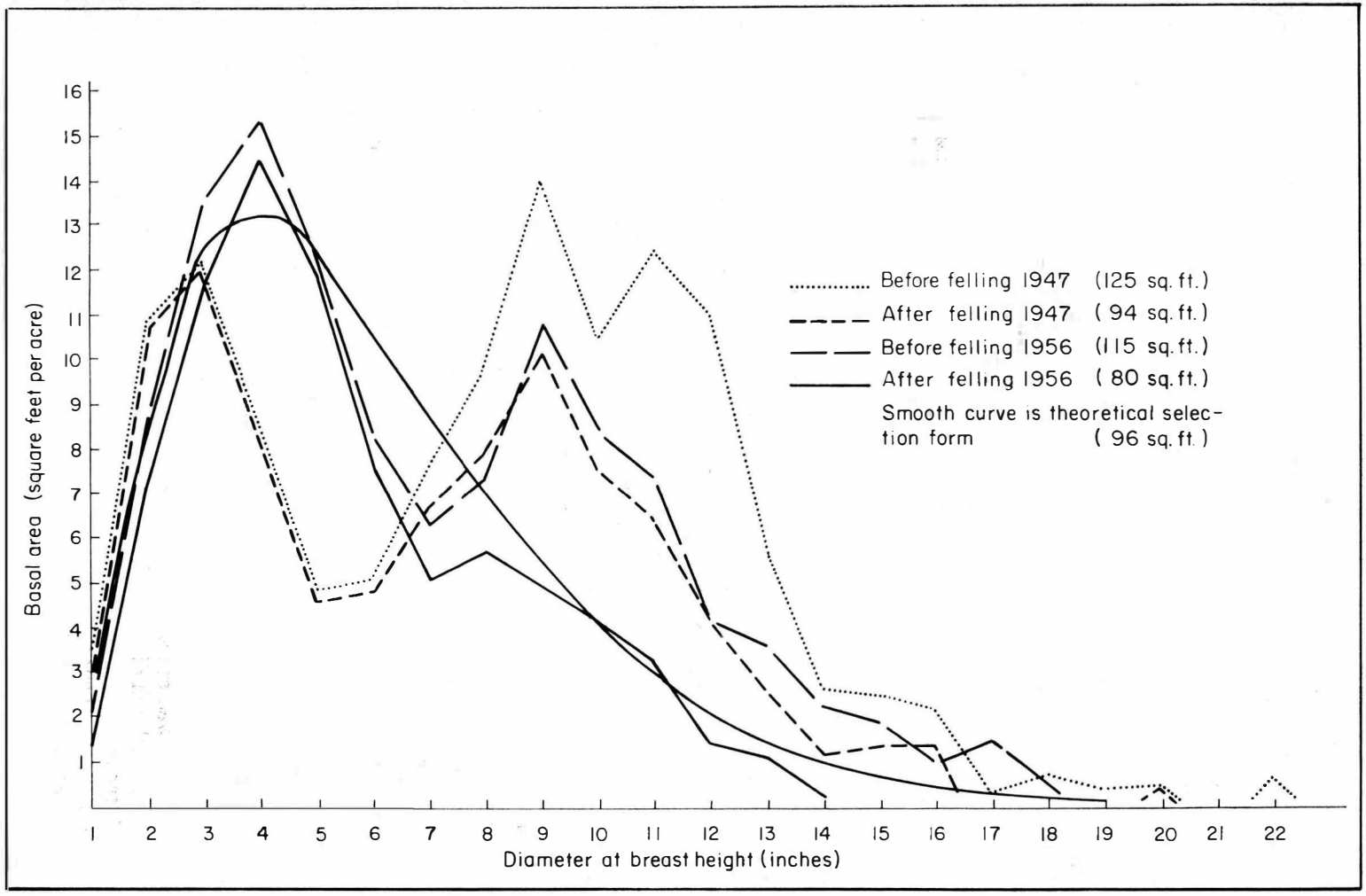

Figure 2. Distribution of growing stock before and after felling in 1947 and 1956.

TABLE 1. SPECIES PROPORTIONS BEFORE AND AFTER FELLING IN 1947 AND 1956

Species	1947 before		1947 after		1956 before		1956 after	
	Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent
	Number trees per acre							
Fir	1,580	89.4	1,531	89.4	1,462	89.7	1,157	89.7
Spruce	102	5.8	97	5.7	96	5.9	74	5.7
Birch	84	4.8	84	4.9	72	4.4	59	4.6
All	1,766	100.0	1,712	100.0	1,630	100.0	1,290	100.0
	Basal area per acre (square feet)							
Fir	102.0	75.7	75.5	73.3	95.0	78.5	69.1	82.7
Spruce	22.7	16.8	18.2	17.6	20.0	16.5	11.0	13.1
Birch	10.0	7.5	9.4	9.1	6.0	5.0	3.5	4.2
All	134.7	100.0	103.1	100.0	121.0	100.0	83.6	100.0
	Total volume per acre (cubic feet)							
Fir	2,041	76	1,365	74	1,584	75	1,009	79
Spruce	643	24	489	26	535	25	268	21
Birch	—	—	—	—	—	—	—	—
All	2,684	100	1,854	100	2,119	100	1,277	100
	Merchantable volume per acre (cubic feet)[1]							
Fir	1,552	72	925	67	1,123	70	625	72
Spruce	595	28	447	33	492	30	240	28
Birch	—	—	—	—	—	—	—	—
All	2,147	100	1,372	100	1,615	100	865	100

[1] Based on trees 4 inches d.b.h. and larger, a stump height of 1.0 foot and a top diameter of 4 inches.

TABLE 2. DISTRIBUTION OF TOTAL VOLUME BY SIZE CLASSES

	Total volume	Small (1 to 5 inches d.b.h.)	Medium (6 to 10 inches d.b.h.)	Large (over 11 inches d.b.h.)
	(cubic feet)		(per cent)	
1947 before	2,685	18.4	40.7	40.9
after	1,854	26.4	46.5	27.1
1956 before	2,119	28.1	41.5	30.4
after	1,277	42.5	44.3	13.2
SELECTION FORM	1,545	36.1	45.6	18.3
1947 felling	831	0.7	27.7	71.6
1956 felling	844	6.3	37.2	56.5
Mortality 1947 to 1956	412	10.5	46.5	43.0

mize windthrow and to thwart shrub development necessitated leaving overmature fir and spruce where their removal would have resulted in too large openings.

After felling, the residual softwood stand contained 1,630 trees per acre, with a basal area of 94 square feet and a merchantable volume of 1,372 cubic feet. There was little change in the species distribution (Table 1). The stand was uniform and well spaced except for the hilltop where there was excessive opening as a result of birch dieback, heavy cutting, and subsequent windthrow.

After felling, 48 per cent of the reproduction quadrats were stocked to fir and 3 per cent to spruce; 50 per cent contained no softwood reproduction. However, there were some 1,000 saplings per acre (Table 3). If the reproduction and saplings are combined, the area is fully stocked to softwoods.

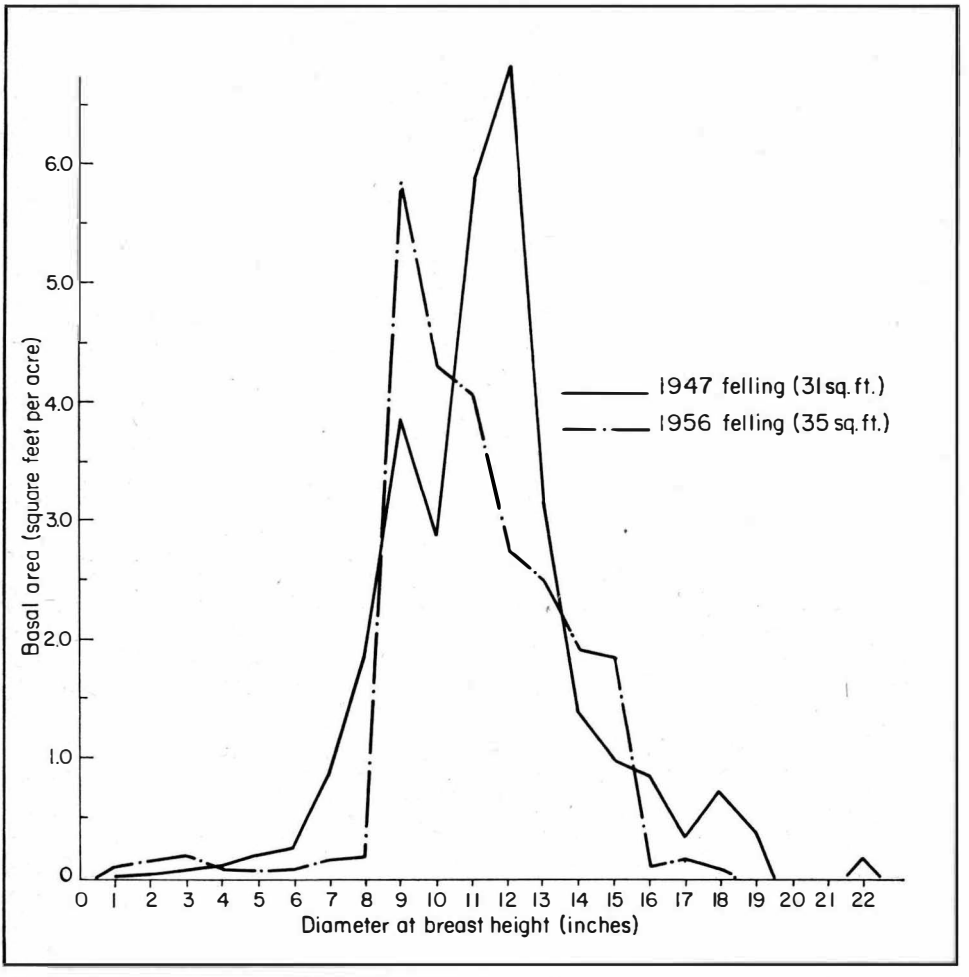

Figure 3. Distribution by diameter classes of the softwood basal area removed in the 1947 and 1956 fellings.

GROWTH AND MORTALITY, 1947 TO 1956

From 1947 to 1956 the forest had a net merchantable softwood growth of 27 cubic feet per acre per year. Annual mortality averaged 39 cubic feet per acre, indicating a total gross merchantable increment of 66 cubic feet per acre per year (Table 4).

Since the forest is not balanced, it is useful to examine growth for the three age structure types. On the open hilltop there was complete loss of the residual softwood stand and a consequent net loss in volume over the nine-year period. However, this hilltop represents only 3 per cent of the productive forest. In the type containing the vigorous 40- to 50-year-old understorey (67 per cent of the area), the net merchantable volume increment was the same as the average for the area while mortality was somewhat higher. In mature stands, with the 1- to 20-year understorey (covering 30 per cent of the area), net and gross volume growth was slightly higher than the average.

TABLE 3. STAND TABLES SHOWING THE NUMBER OF TREES PER ACRE BEFORE AND AFTER FELLING, 1947

d.b.h.	Before			After		
	Fir	Spruce	Birch	Fir	Spruce	Birch
1	598.7	31.1	40.9	597.3	30.8	40.9
2	478.9	15.3	21.1	478.0	15.1	21.1
3	238.9	8.9	5.3	238.2	9.3	5.3
4	92.2	4.0	1.1	91.1	4.2	1.1
5	31.8	3.6	1.8	30.7	3.1	1.8
6	22.0	3.8	2.4	20.7	3.8	2.7
7	24.0	4.2	1.6	21.1	4.0	1.6
8	21.6	6.4	0.9	17.1	5.6	0.9
9	22.7	8.9	2.0	15.3	7.6	2.0
10	14.9	4.2	1.3	9.8	4.0	1.3
11	13.6	5.1	1.1	4.7	5.1	1.1
12	11.1	2.9	0.9	3.3	2.0	0.9
13	4.7	1.6	0.4	1.6	1.3	0.4
14	2.0	0.4	1.1	0.9	0.2	1.1
15	1.1	0.9	1.1	0.7	0.4	1.1
16	1.1	0.4	0.2	0.7	0.2	0.2
17	—	0.2	0.4	—	—	0.2
18	—	0.4	0.2	—	—	0.2
19	—	0.2	0.2	—	—	—
20	0.2	—	—	0.2	—	—
22	0.2	—	—	—	—	—
All.....	1,579.7	102.5	84.0	1,531.4	96.7	83.9

TABLE 4. GROWTH IN TERMS OF CUBIC FEET OF MERCHANTABLE VOLUME AND SQUARE FEET OF BASAL AREA PER ACRE, FROM 1947 TO 1956

Species	After cutting 1947	Before cutting 1956	Net annual change	Annual mortality	Gross annual increase 1947 - 1956
			Merchantable volume		
Spruce	447	492	5	8	13
Fir	925	1,123	22	31	53
Total	1,372	1,615	27	39	66
			Basal area		
Spruce	18.2	20.0	0.2	0.3	0.5
Fir	75.5	95.0	2.2	1.9	4.1
Birch	9.4	6.0	−0.4	0.6	0.2
Total	103.1	121.0	2.0	2.8	4.8

In terms of basal area, the net growth was 2.0 square feet per acre of all species annually; mortality amounted to 2.8 square feet giving a gross increment of 4.8 square feet per acre annually.

On the open hilltop there was a net loss in basal area of both softwoods and hardwoods. Growth of the understorey increased the net and gross basal area increment of two-storeyed stands 25 per cent above the average for the area while in mature stands area growth was 50 per cent below the average. The net effect on the area as a whole is a rapidly growing stand in the 3- to 6-inch diameter range and a rather decadent overwood from 8 to 18 inches as shown graphically in Figure 4.

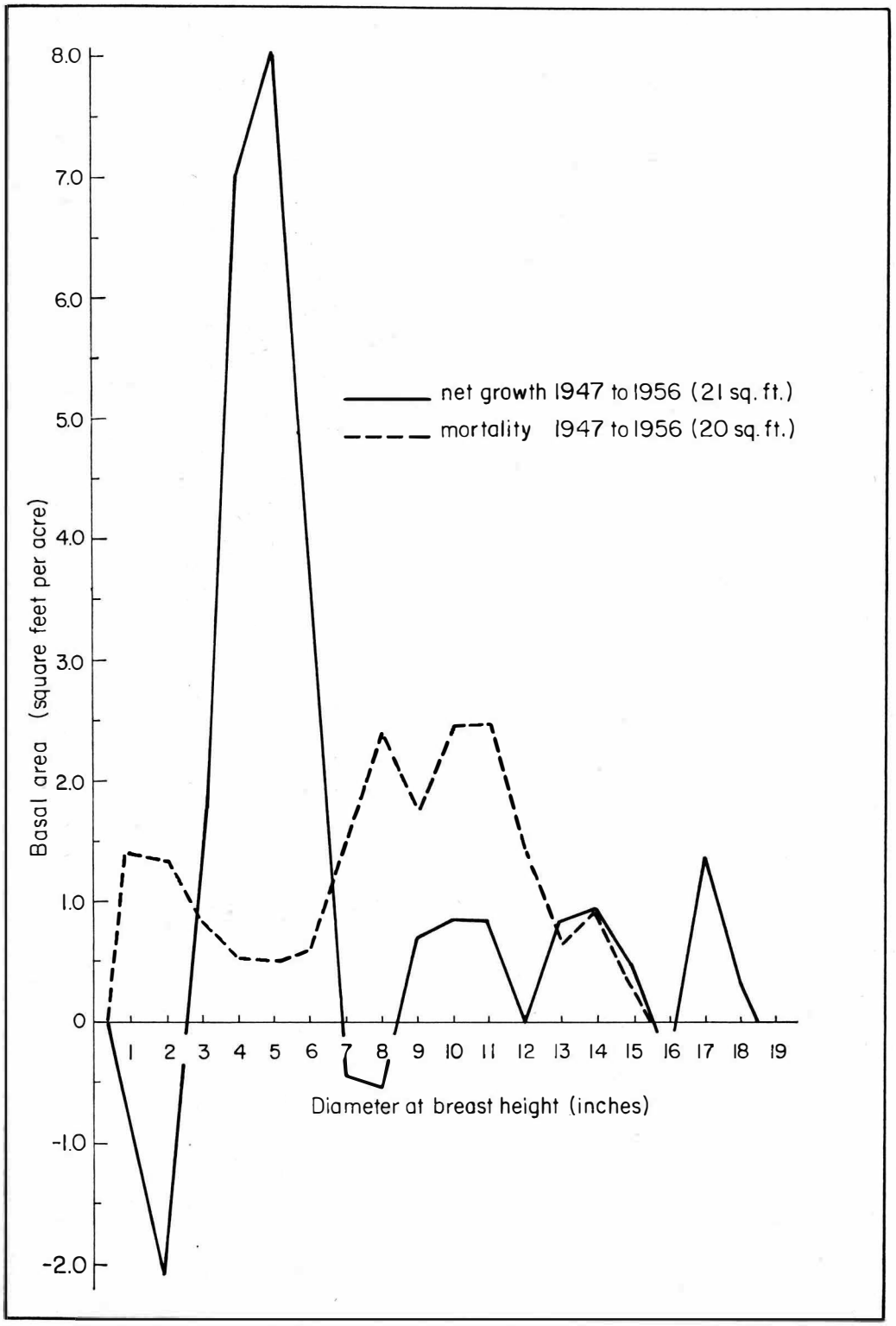

Figure 4. Distribution of net growth and mortality of softwoods in terms of basal area for the period 1947 to 1956.

A portion of the merchantable volume increment resulted from ingrowth and this will continue for at least another two decades. The data given for basal area include all trees larger than 0.5 inch in diameter at breast height and to this extent ingrowth is a negligible factor.

One of the objectives of management is the reduction of mortality. Although current loss is not as large as in originally similar, uncut forests, total mortality from 1947 to 1956 consisted of 423 trees per acre with 25 square feet of basal area and 348 cubic feet of merchantable softwood volume (Table 5). The total volume of 412 cubic feet was 11 per cent in small trees, 47 per cent in medium trees and 43 per cent in large trees (Table 2). The average diameter of dead fir of merchantable size was 8.3 inches and spruce, 8.5 inches. While only 9 per cent of the trees were five inches or larger, this included 79 per cent of the basal area, 91 per cent of the total volume and 99 per cent of the merchantable volume. Thus the high mortality resulted from the loss of a few veterans. Trees below five inches (91 per cent by number), which died as a result of intense competition in the underwood, added little to the volume loss.

With few exceptions, the dead trees over five inches were windthrown. Much of the damage resulted from a severe windstorm in October, 1947, before felling was completed. While wind has been the direct cause of most of the losses, it must be remembered that the trees were decadent. In this respect wind has been listed as the cause of mortality in many studies of partial cutting in mature and overmature stands, but one cannot expect mature trees developed in a closed stand to be windfirm when suddenly left in an exposed position. If partial cuttings are made in old-growth forests, one must be prepared either to accept initially a consequent high loss from windthrow, or attempt to keep it as small as possible.

In the early stages of conversion, mortality, especially that attributed to wind damage, will be high. However, as the young trees develop, their greater degree of exposure will condition them to wind stress. More important, as a balanced forest is developed, no tree will be allowed to reach an age and size where it becomes particularly liable to windthrow.

TABLE 5. TOTAL MORTALITY PER ACRE FROM 1947 TO 1956 BY SPECIES

Species	Trees		Basal area		Total volume		Merchantable volume	
	Number	Per cent	Square feet	Per cent	Cubic feet	Per cent	Cubic feet	Per cent
Fir	382	90	16.7	66	335	81	278	80
Spruce	21	5	3.0	12	77	19	70	20
Birch	20	5	5.6	22	—	—	—	—
All	423	100	25.3	100	412	100	348	100

SECOND FELLING, 1956

Before the second felling in the autumn of 1956, there were 1,630 trees per acre with a basal area of 121 square feet and a merchantable softwood volume of 1,615 cubic feet (Table 1). The total softwood volume of 2,119 cubic feet per acre was 28 per cent in small trees, 42 per cent in medium trees and 30 per cent in large trees (Table 2).

The distribution of softwoods by diameter classes was approaching the theoretical form (Figure 1.) The previous deficiency in the diameter classes below seven inches was largely filled and only moderate increases had occurred in the larger sizes. A concentration of large mature trees was still present, however, and was most evident in the distribution of basal area over diameter (Figure 2).

Thus the marking in 1956 again stressed the elimination of the larger and older stems, particularly fir, which seemed unlikely to survive another cycle. Every effort was made to avoid creating openings with diameters greater than the height of the trees and to insure that a uniform canopy was left. The advance growth, which had grown rapidly since 1947, lessened the possibilities of shrub invasion.

The felling removed an average of 328 softwood stems per acre with a basal area of 35 square feet and a merchantable volume of 750 cubic feet. By volume the felling was 66 per cent fir and 34 per cent spruce. The average diameter of fir of merchantable size was 9.0 inches and the average spruce was 10.1 inches. About 74 per cent of the volume removed was in trees ten inches and larger.

The total volume of 844 cubic feet removed was 6 per cent in small trees, 37 per cent in medium trees and 57 per cent in large trees (Table 2). Trees eight inches in diameter and larger accounted for 13 per cent of the number of trees removed, 79 per cent of the basal area, 90 per cent of the total volume, and 94 per cent of the merchantable volume. No birch were utilized although more were knocked down during the logging.

The net growth from 1947 to 1956 of 244 cubic feet of merchantable softwood accounted for 32 per cent of the volume felled in 1956. Gross volume

Figure 5. The stand from one of the haulroads after the 1956 felling.

increment was 79 per cent of the volume felled. The indicated reduction in growing stock is not overcutting. It was necessary to reduce the concentration of growing stock in the larger sizes towards the accepted form and to prevent further large losses from mortality.

In terms of basal area, net growth accounted for 52 per cent of the amount removed and gross growth was 124 per cent of the basal area felled in 1956.

The 1956 felling has brought the distributions of number of trees and basal area close to the theoretical selection form (Figures 1 and 2). The stand has now 1,290 stems per acre with a basal area of 84 square feet and a merchantable softwood volume of 865 cubic feet (Table 1). The total volume of 1,277 cubic feet is 43 per cent in small trees, 44 per cent in medium trees and 13 per cent in large trees (Table 2, Figure 5).

Reproduction on the area has been excellent. There was 69 per cent stocking to softwoods before the 1956 fellings. Although this was reduced to 47 per cent by logging damage, the distribution of reproduction and saplings combined is such that the area is fully stocked (Table 6).

TABLE 6. STAND TABLES SHOWING NUMBER OF TREES PER ACRE BEFORE AND AFTER FELLING, 1956

d.b.h.	Before			After		
	Fir	Spruce	Birch	Fir	Spruce	Birch
1	441.6	24.9	25.3	278.9	22.7	22.2
2	381.1	16.9	25.8	323.1	14.0	22.4
3	268.2	7.8	7.6	232.7	6.2	7.6
4	169.3	6.9	2.0	160.9	5.3	0.7
5	83.8	5.6	1.3	81.1	4.7	0.9
6	38.7	4.0	0.9	34.9	4.4	0.9
7	19.3	4.2	2.2	15.8	3.1	1.1
8	17.3	3.8	1.1	14.0	2.4	1.1
9	17.3	7.1	2.0	7.1	4.0	0.9
10	9.8	5.6	0.9	4.4	3.1	0.7
11	8.2	2.9	0.7	2.7	2.2	0.2
12	2.2	3.1	0.7	0.7	1.1	0.2
13	2.2	1.6	0.4	0.2	0.9	0.2
14	1.3	0.7	0.2	0.2	—	—
15	1.1	0.4	0.4	—	—	0.2
16	—	0.7	—	—	—	—
17	0.7	0.2	—	—	—	—
18	0.2	—	—	—	—	—
All.....	1,462.3	96.4	71.5	1,156.7	74.1	59.3

The dense 40- to 50-year-old underwood has been thinned appreciably both in the felling and indirectly from logging damage (Figure 6). The overwood now stands with an open but uniform canopy. As conversion towards a balanced selection forest proceeds, various levels of growing stock will be tested to discover what level will give the greatest return.

DISCUSSION

The progress made to date in the conversion towards a balanced selection forest is encouraging. Although the growing stock is somewhat depleted, the present stand structure approximates the theoretical form. However, because of deficiencies in the distribution of ages, this quasi-balanced size-class distribution does not indicate a quasi-balanced forest. Rapid development of the vigorous,

Figure 6. Dense 40- to 50-year-old fir after it had been opened up in 1956. The overwood is moderately dense.

younger trees, compared to the larger less vital, older trees, could lead to an unbalanced distribution of growing stock in favour of smaller stems (Figure 1). This effect is augmented by the proportionately greater mortality in the larger size classes. However, since most of the poor specimens were removed in the 1947 and 1956 fellings, and by windfall, the remaining oldest stems should survive. This cycle should show therefore, a smaller mortality and increased net increment of volume and basal area.

Over the current cycle the distributions of number of trees and basal area will move closer to their respective theoretical forms. Although the forest will be neither all-aged nor truly balanced, an additional age group has been added as a result of several good seed years and disturbance of the forest floor by logging.

The basis for future fellings will continue to be conversion towards a balanced selection forest. For the next two or three cycles, marking for fellings will emphasize reduction of mortality. This will result in appreciable increases in the amounts of gross growth realized as usable volume. The objective is a harvest equivalent to about one cord per acre per year.

Despite the apparent selection structure shown graphically, there are three age-size structure types in the present forest (page 6). Future marking will stress the conversion of each of these three types towards the all-age, all-size selection form. Treatment will not necessarily be uniform throughout the forest during the conversion period. Some irregularities are necessary now, if uniform treatment is to be achieved later.

The next felling is scheduled for 1966. The stand will be reworked then according to the principles just discussed. The amount removed will be less than in the first or second fellings, and will be less concentrated in one size group. A smaller cut is necessary to allow a build-up of growing stock.

There are dangers in implementing too rapidly the process of conversion. In another study on the watershed, 50 acres of even-aged, mature and over-mature fir in a narrow valley were to be converted to selection management by removing 30 per cent of the volume every 20 years. Windfall was so extensive in the five years after the initial felling as to preclude continuation of the study.

For long-term comparisons of selection management and even-aged management with regeneration by clear cutting as commonly practised in this area, developments after a clear felling in a similar stand in 1947 are being followed. Although only one ten-year cutting cycle has elapsed, some comparisons are of interest. While the gross periodic increment of basal area was similar on the two areas from 1947 to 1956, the net increment was 32 per cent higher after the clear felling because of smaller mortality. Wind damage was also less after clear felling because of the smaller size of the residual trees. However, the losses from this and other causes will probably increase as the stand develops, whereas mortality is expected to decrease in the partially-cut stand.

Where advance growth is either small or is lacking, clear felling is usually followed by a rapid development of scrub hardwoods, especially mountain maple. On some sites this aggressive species can overtop softwood reproduction and suppress it for up to 40 years. It is believed that careful partial cutting will maintain a canopy sufficient to prevent the invasion of mountain maple and yet allow development of the underwood. Observations in the partially cut stand and the adjacent clear-felled area substantiate this.

Where advance growth is abundant, past budworm outbreaks and clear felling have led to the development of too-dense fir stands with consequent slow growth of individual trees and high mortality. Partial cutting has prevented formation of these stands and to a considerable extent has opened up those that exist.

Despite two fellings which favoured spruce over fir, there has been no change in the percentage distribution of these species. It seems unlikely that the proportion of spruce can be increased appreciably, except over a long period. Dieback has reduced the number of birch, and as it is intolerant relative to the other species, there will be continued reductions in the proportion of birch in the stand.

The ultimate test of selection management in a fir-spruce-birch forest cannot be started until the conversion is completed, possibly in another two cycles. Then the forest will be maintained as a balanced production unit with a growing stock sufficient to induce the maximum growth rate compatible with minimum mortality. Management of such forests by the periodic selection system appears to be biologically feasible. It remains to be determined if there is any gain in wood production over that of even-aged management, and if selection management is economic in view of all cost factors.

SUMMARY

An 83-acre, fir-spruce-birch forest in northwestern New Brunswick is being converted from a patchy, several-aged condition to a periodic selection system of management. The first felling was made in 1947 and the second in 1956, to

remove a total of 1,528 cubic feet of merchantable softwood volume per acre. Net growth from 1947 after cutting to 1956 before cutting was 27 cubic feet of merchantable softwood volume per acre per year. Some 39 cubic feet per acre per year was lost to mortality, mostly in windfall of decadent fir. Comparison of the present stand structure with that of a theoretical selection form indicates a rapid approach to the selection structure.

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