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**FOREST DEVELOPMENT IN  
NORTHWESTERN NEW BRUNSWICK  
1947-1957**

by

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*Sommaire en français*

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## **Abstract**

The 1957 remeasurement of some 600 permanent tenth-acre line plots established in 1947 in northwestern New Brunswick provides some of the best data available in eastern Canada for a general study of growth and development. New stands of fir with spruce developed rapidly after harvesting in softwood stands. Windfall accounted for 40 per cent of all softwood mortality. Periodic annual net and gross increments for all types averaged respectively 31 and 44 cubic feet of merchantable softwood volume per acre. Yield might be increased to about 60 cubic feet per acre per year by utilizing all species and maintaining well stocked stands.

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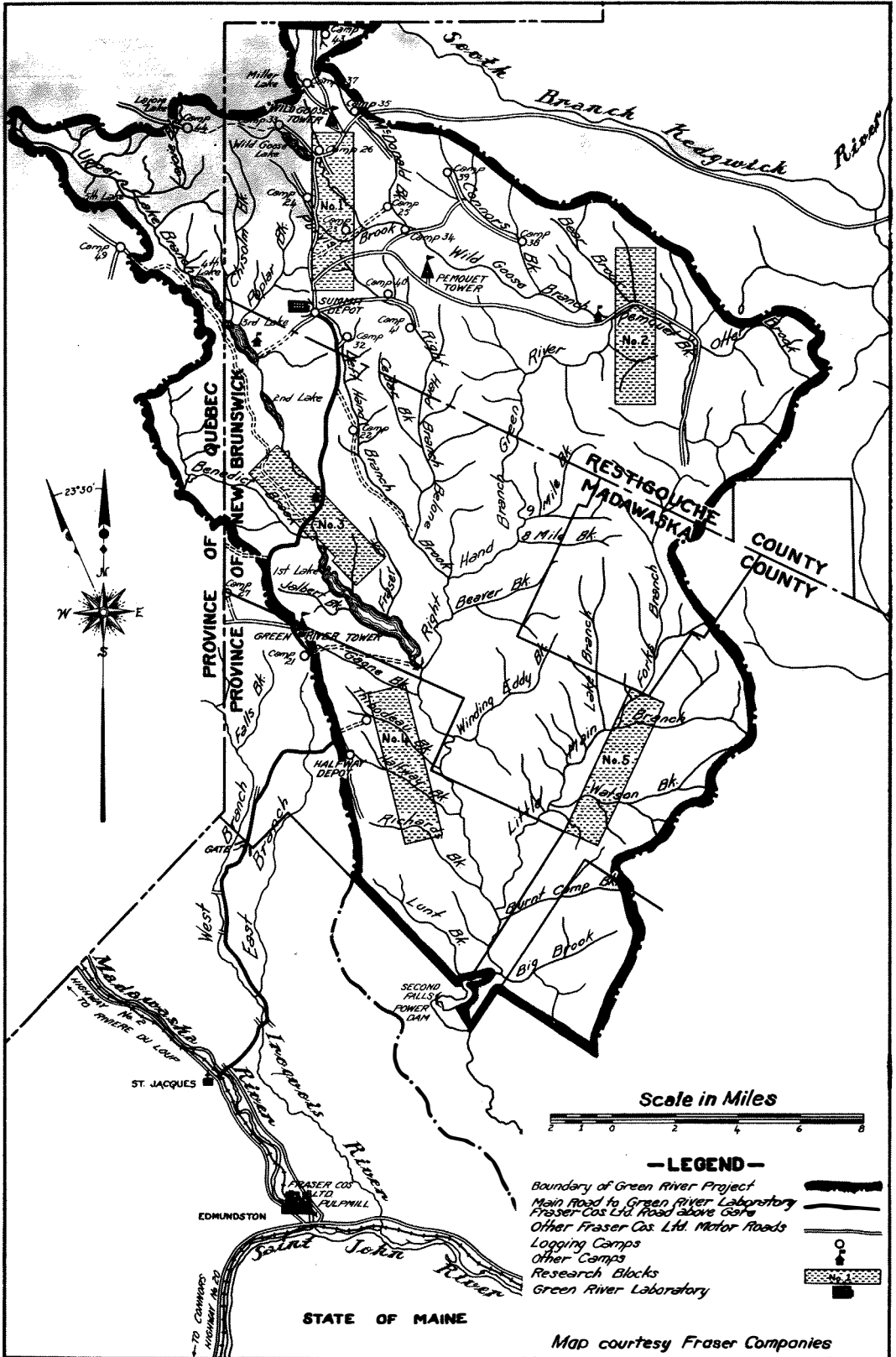


FIGURE 1. Key map of Green River Project

# FOREST DEVELOPMENT IN NORTHWESTERN NEW BRUNSWICK, 1947 to 1957<sup>1</sup>

by

E. L. Hughes<sup>2</sup>

## INTRODUCTION

Currently one of the most difficult problems confronting Canadian foresters is to initiate and improve silviculture in hitherto extensively managed forest areas. An adequate knowledge of stand and forest development is essential as a background for this more intensive management. To this end the Forest Research Branch established between 1945 and 1949 some 3,000 permanent plots in the Green River watershed of northwestern New Brunswick. Although the plots are located in five relatively small blocks, the data obtained from them are among the best available for a general study of growth and development in a watershed in Eastern Canada.

This publication presents the findings from the remeasurement in 1957 of 604 plots established in Block 3 ten years earlier<sup>3</sup>. Stand development data are presented by cover types; the emphasis is on growth and change in species composition. The data are then used to outline the important management and silvicultural problems and to indicate potential yield capacity. It is estimated that yield capacity is about 60 cubic feet per acre per year.

## BLOCK DESCRIPTION

### Location and Physiography

Block 3 is situated in the central-western part of the Green River Watershed in Madawaska County, northwestern New Brunswick (Figure 1).

The topography is rolling. Elevations range from 800 to 1,500 feet but most slopes are gentle to moderate. There are some flats, some steep slopes and three ridges, two in the southern half and one in the northern. The area is underlain by deeply fractured slates and shales and the soil mantle is derived largely from these and similar bedrocks. Most of the soils are stony silt loams of till origin. However there are some water-washed gravels, sands and silts and there are flats with shallow organic soils.

The climate is characterized by long cold winters, short cool summers and abundant precipitation. Meteorological records from Summit Depot, eight miles to the north, indicate an average frost-free period of 111 days and an average annual precipitation of 43 inches; about 18 inches occurs during the growing season.

### Tree Species

This part of the watershed is located within Section L.6 of the Great Lakes—St. Lawrence Forest Region (Rowe, 1959). Rowe lists 17 species as occurring

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<sup>3</sup> Nickerson, D. E. 1948. Report on initial examination of research block 3, Green River Management area, Canada, Dept. of Mines and Resources, Dominion Forest Service, Maritime District. Unpublished report.

in the Section and fourteen of these are present on the block. The most important are: balsam fir, white and black spruce, sugar maple, white birch, yellow birch, and red maple<sup>4</sup>.

Balsam fir and the spruces are found on all sites but are most abundant on lower slopes where they form softwood stands. White birch is a common but minor associate of the softwood type. White birch, yellow birch and red maple with fir and white spruce compose the mixedwood stands on most middle and upper slopes. Sugar maple is largely restricted to upper slope and hilltop locations, and with yellow birch forms hardwood stands on the ridges.

Two trees common in specific locations are eastern white cedar on lower slopes and flats, particularly on sites having organic soils, and trembling aspen on an 1899 burn. Five species are rare: white pine, red spruce, tamarack, beech and balsam poplar. In addition there are five unmerchantable species. Pin cherry and mountain-ash occur chiefly in recently cut softwood stands, mountain maple forms dense thickets on mixedwood slopes, striped maple is scattered on hilltops and upper slopes, and speckled alder is confined to alluvium along streams.

## History

In 1899, a severe fire burned about 480 acres in the south-western part of the block. The stands that developed on this burn contain more spruce than those on similar unburned areas.

About 1900, large spruce, white pine and cedar were cut for logs throughout the softwood and mixedwood types. Then from 1913 to 1919, mature fir were damaged severely by budworm defoliation. The amount of mortality and wind-fall resulting from the attack must have been variable. Although there are patches of immature fir that were released forty years ago, there was sufficient older softwood to provide for a fir-spruce saw log cut in 1935 and two pulpwood operations: one in 1939 in the south-eastern corner and a second during the early 1950's that covered the northern half.

During the last 15 years "dieback" has killed most mature white and yellow birch and many small white birch. Windfall has been neither extensive nor concentrated but it has taken a continuing toll of the older, larger stems of all species. These disturbances have resulted in part in a prolific development of mountain maple on mixedwood slopes.

## METHODS

Six hundred and twenty-six permanent tenth-acre plots were established in a six by ten chain grid in 1947. Information collected on each plot included:

1. Tallies of living and dead trees, 0.5 inches and up, by species and 1-inch diameter classes. Dead trees were blazed so that reliable data on mortality could be obtained at remeasurement.
2. Stocking records of reproduction for each species on 10 milliacre quadrats.
3. Height, diameter, age and radial increment data on mechanically selected spruce and fir. Age and growth were obtained from increment cores taken at breast height.
4. Stand history.
5. Notes on topography and soil.

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<sup>4</sup> Species names are used in accordance with *Native trees of Canada* (Anon. 1961) and *Forest flora of Canada* (Cunningham, 1958).

Six hundred and four plots were remeasured in 1957 when much the same information was obtained as in 1947. However, age counts were taken at a height of one foot rather than at breast height and stump diameters were tallied in those stands which were cut between measurements.

Stand and stock tables for living and dead stems were compiled by cover types. The number of stems, basal area, total volume and merchantable volume were computed for fir and spruce; only the number of stems and basal area were compiled for the other species.

Additional compilations included:

1. The merchantable volume of fir and spruce harvested during pulpwood operations on the northern half of the block between 1951 and 1955.
2. The merchantable volume of softwood windfalls.
3. Stocking to reproduction by cover types.
4. Periodic net and gross increment by cover types.
5. Stand composition for each cover type.

## RESULTS

Six types were recognized on the basis of stand composition and in some instances history. They are: fir—spruce, fir—maple—birch, spruce—fir (burn), fir—spruce—aspens—birch (burn), fir—spruce—cedar and sugar maple. With the exception of the fir—spruce and the sugar maple, the type boundaries also delineate stands having particular structure and age characteristics. Because of frequent changes, no structure and age classes were recognized in the two exceptions.

Stand developments are presented in two parts, (1) development of types uncut since 1939 and (2) development of types cut during the 1950's. No cutting took place between 1939 and 1950 but during the early 1950's pulpwood operations were conducted throughout the northern half of the block. Cutting was concentrated in mature portions of the fir—spruce and in the fir—maple—birch type.

A table is presented for each type showing the basal area of all species, the merchantable volume of fir and spruce, stand composition by species, the merchantable volume of fir and spruce mortality and periodic annual increment in merchantable volume. Basal area includes all species down to 0.6 inches in diameter; merchantable volume figures are for fir and spruce only down to 3.6 inches in diameter. Mortality includes windfall which is comprised of uprooted trees and those broken by wind. Where applicable, cut data for fir and spruce are entered separately. The reproduction data are summarized in Table 16.

### Development of Types Uncut Since 1939

#### *Fir—Spruce*

This type contains a variety of structure and age classes, ranging from mature to immature stands (Figures 2 and 3). Generally the stands are uneven-aged. Most stems are 30 to 45 years old but some are as old as 90 years. A few pockets of spruce with fir on an esker and on several steep slopes are included. The type occupies 623 acres of the southern half, 16.0 per cent of the block.

The merchantable volume of living fir and spruce, and the basal area of all species increased rapidly during the decade (Table 1).

TABLE 1. SUMMARY DATA FOR UNCUT FIR—SPRUCE TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.) . . . . .	94.6	117.1
Merchantable volume per acre, fir and spruce (cu. ft.) . . . . .	1,077	1,491
Stand Composition (per cent of basal area)		
Balsam fir . . . . .	69	76
Spruce . . . . .	8	10
White cedar . . . . .	4	2
White and yellow birch . . . . .	15	9
Red and sugar maple . . . . .	2	2
Other hardwoods . . . . .	2	1
Annual mortality and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses) . . . . .	15 (5.6)	
Net periodic increment . . . . .	41	
Gross periodic increment . . . . .	56	



FIGURE 2. Patch of mature fir, rare on Block 3.





FIGURE 3. Thirty- to fifty-year-old fir, released following the 1913-1919 budworm outbreak.

Mortality of merchantable softwood was high and about one-third of this mortality was windfall. Periodic annual net and gross increments of softwoods were 41 and 56 cubic feet per acre, respectively.

The proportions of both fir and spruce increased through the period while that of birch decreased, mainly because of "dieback". Fir is the dominant species and comprises about 85 per cent of the merchantable volume. Although softwood reproduction is plentiful in most of this type (Table 16) a few open portions have a dense growth of hazel and mountain maple which prevents the establishment of reproduction.

#### *Fir—Maple—Birch*

This type is still open because of logging in the 1930's and the mortality of birch. It is uneven-aged with an age range of from 30 to 90 years and usually has a dense understorey of mountain maple (Figure 4). The type occupies 355 acres or 9.1 per cent of the block.

The basal area of all species was low at both measurements (Table 2). Although the merchantable volume of softwood increased by more than 30 per cent, periodic annual gross increment of fir and spruce was low at 27 cubic feet per acre. Mortality of merchantable softwoods was moderate and little timber was lost in windfalls.



FIGURE 4. Open mixedwood with a dense understorey of mountain maple.

TABLE 2. SUMMARY DATA FOR UNCUT FIR—MAPLE—BIRCH TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.) .....	68.0	80.8
Merchantable volume per acre, fir and spruce (cu. ft.) .....	556	732
Stand composition (per cent of basal area)		
Balsam fir .....	41	47
Spruce .....	3	3
Yellow and white birch .....	23	17
Sugar and red maple .....	32	32
Other hardwoods .....	1	1
Annual mortality and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses) .....	10 (0.3)	
Net periodic increment .....	17	
Gross periodic increment .....	27	

The proportion of fir increased while that of birch declined, a result of the mortality of birch to "dieback". Other species were unchanged. Reproduction of all species combined is sufficient to rebuild the stocking, but that of fir and spruce is inadequate to maintain the softwood content. The reproduction competes with dense mountain maple and the scarcity of softwood, particularly on upper slopes, indicates that some of the mixedwood may become hardwood.

*Spruce—Fir (burn)*

The softwood type that developed on most of the 1899 burn is composed principally of white spruce and balsam fir. The total age of the dominant stems averaged 53 years in 1957. The type occupies some 329 acres or 8.5 per cent of the block.

The basal area, the highest for any type, increased from 154 to over 170 square feet per acre (Table 3). The merchantable volume of softwoods is the highest for any type and this volume increased from 1,590 to 2,540 cubic feet per acre. Mortality of merchantable softwoods was negligible. Periodic annual gross

TABLE 3. SUMMARY DATA FOR SPRUCE—FIR (burn) TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.) . . . . .	153.6	172.0
Merchantable volume per acre, fir and spruce (cu. ft.) . . . . .	1,587	2,543
Stand composition (per cent of basal area)		
Balsam fir . . . . .	32	36
Spruce . . . . .	50	48
White and yellow birch . . . . .	9	7
Red and sugar maple . . . . .	1	1
Other hardwood . . . . .	8	8
Annual mortality and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses) . . . . .	3 (0.5)	
Net periodic increment . . . . .	96	
Gross periodic increment . . . . .	99	

increments of softwoods was 99 cubic feet per acre, and the stands are probably in a peak period of volume growth. Mean annual increment has been 37 cubic feet per acre to 1947 and 48 cubic feet to 1957. Since mean annual increment at age 53 is only about half the current annual increment, it appears that mean annual increment has not yet reached a peak. Although growth per acre is high, the growth rate of individual stems is restricted by the extreme density.

The proportion of fir increased while that of spruce declined. If the current rate of change continues, there will be more fir than spruce within 20 years. Nearly all the reproduction is fir and any major disturbance except fire will probably result in new stands having a high fir content.



FIGURE 5. Stand of fir, white spruce and trembling aspen, 1899 burn.

*Spruce—Fir—Aspen—Birch (Burn)*

The mixedwood that developed following the 1899 burn is primarily white spruce, balsam fir, trembling aspen and white birch with some red and sugar maple on the upper slopes (Figure 5). The type is even-aged (53 years) and covers 150 acres, 3.8 per cent of the block.

The basal area of all species showed a moderate increase for the period and the merchantable volume of softwoods increased rapidly (Table 4). Mortality in merchantable trees was small and estimates of net and gross increment are similar. Despite the fact that hardwoods comprise 40 per cent of the basal area, the type had the second largest periodic gross increment of softwoods.

By proportion fir increased, birch declined, while spruce and maple remained about the same. The proportions of other hardwoods, mainly trembling aspen, decreased. This type is similar to the spruce—fir in that most of the reproduction is fir. Hardwood reproduction is confined largely to the extremities of the burn on the upper slopes.

TABLE 4. SUMMARY DATA FOR SPRUCE—FIR—ASPEN—BIRCH (Burn) TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.) . . . . .	129.4	138.8
Merchantable volume per acre, fir and spruce (cu. ft.) . . . . .	894	1,502
Stand composition (per cent of basal area)		
Balsam fir . . . . .	35	42
Spruce . . . . .	18	18
White and yellow birch . . . . .	23	17
Red and sugar maple . . . . .	7	8
Other hardwood . . . . .	17	15
Annual mortality and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses) . . . . .	3 (0.8)	
Net periodic increment . . . . .	61	
Gross periodic increment . . . . .	64	

*Fir—Spruce—Cedar*

This type occupies the wetter bottomlands near the brooks. The stands are mature and uneven-aged with older stems as much as 130 years in age. The type covers 295 acres, some 7.6 per cent of the block.

Both the basal area of all species and the merchantable volume of fir and spruce increased during the decade (Table 5). The stands are located on sites which have a high growth capacity. Only 54 per cent of the basal area was comprised of fir and spruce in 1947, but these species show a periodic gross increment of 44 cubic feet per acre per year.

Although the mortality value looks high it is to be noted that mortality includes some wood removed during the recent pulpwood operations. Loss to windfall was light.

The proportion of spruce and fir increased slightly during the period while that of cedar declined; the amount of hardwood is negligible. Again there is adequate softwood reproduction to form new stands and although there is a higher proportion of spruce than in the other types, fir reproduction is dominant.

TABLE 5. SUMMARY DATA FOR FIR—SPRUCE—CEDAR TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.) . . . . .	97.4	115.3
Merchantable volume per acre, fir and spruce (cu. ft.) . . . . .	1,050	1,241
Stand composition (per cent of basal area)		
Balsam fir . . . . .	37	38
Spruce . . . . .	17	20
Cedar . . . . .	43	40
White and yellow birch . . . . .	3	2
Annual mortality and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses) — includes 13 cubic feet removed by cutting . . . . .	25 (2.6)	
Net periodic increment . . . . .	19	
Gross periodic increment . . . . .	44	

### *Sugar Maple*

The hilltop hardwood stands are primarily either all-aged or uneven-aged and mature. Sugar maple is the dominant species and the type covers 300 acres, about 7.7 per cent of the block.

Basal area of all species changed little between 1947 and 1957, remaining at about 100 square feet per acre (Table 6). Merchantable volume of softwoods decreased and windfall was mainly responsible.

TABLE 6. SUMMARY DATA FOR SUGAR MAPLE TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.) . . . . .	96.6	101.9
Merchantable volume per acre, fir and spruce (cu. ft.) . . . . .	229	165
Stand Composition (per cent of basal area)		
Balsam fir . . . . .	10	8
Spruce . . . . .	1	1
Yellow and white birch . . . . .	9	7
Sugar and red maple . . . . .	78	82
Beech . . . . .	2	2
Annual mortality and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses) — includes 2 cubic feet removed by cutting . . . . .	12 (7.4)	
Net periodic decrement . . . . .	— 6	
Gross periodic increment . . . . .	6	

Much of the type is poorly stocked and periodic annual gross increment of all species in terms of basal area was low at 2.0 square feet per acre (Table 15).



During the 10-year period, the proportion of maple increased to over 80 per cent of the total basal area. The type is reproducing well to hardwoods, but has little softwood reproduction.

### Development of Types Cut During the 1950's

From 1951 to 1955 merchantable fir and spruce were harvested for pulpwood throughout the northern half of the block. The discussion below presents data for the cut-over fir—spruce and fir—maple—birch types.



FIGURE 6. Recent clear cut of a softwood stand.

#### *Cut-over Fir—Spruce*

The operations in this type varied from a clear cut of mature stands to partial cutting in two-storied stands to light or no cutting in patches of immature fir released 40 years ago by the 1913-1919 budworm attack. The type occupies 1,309 acres of the northern half, nearly 34 per cent of the block. An example of open clear cut is shown by Figure 6.

Because of cutting and mortality the basal area of all species and the merchantable volume of softwoods was reduced (Table 7). However, the amounts of cut and mortality together exceeded the decrement, and the periodic annual gross increment of softwoods was 44 cubic feet per acre. There was a large decrease

in the proportion of hardwoods because of logging damage and "dieback". Despite the fact that cutting was restricted to fir and spruce, the proportion of fir increased.

TABLE 7. SUMMARY DATA FOR CUT-OVER FIR—SPRUCE TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.)	106.0	81.7
Merchantable volume per acre, fir and spruce (cu. ft.)	1,380	817
Stand composition (per cent of basal area)		
Balsam fir	68	77
Spruce	11	9
White and yellow birch	20	12
Other species	1	2
Annual mortality, cut and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses)	14 (6.0)	
Net periodic decrement	— 56	
Cut, 1951 to 1955 — 863 cubic feet	86	
Gross periodic increment	44	

Stocking to fir and spruce reproduction in this type is only 45 per cent. Where advance growth was scarce at the time of cutting, new seedlings compete with a dense growth of raspberry, mountain-ash and pin cherry (Figure 7).





FIGURE 7. Heavy cut of softwoods where there was little advance growth: softwood seedlings compete with dense raspberry, mountain-ash, and pin cherry.

#### *Cut-over Fir—Maple—Birch*

This type is uneven-aged and has a mountain maple understory (Figures 4 and 8). Some 452 acres, 11.6 per cent of the block, are contained in the type. Fir and spruce pulpwood was harvested from most of this area between 1951 and 1955.

Cutting and mortality reduced the basal area of all species by about 20 per cent (Table 8). The decrease in the merchantable volume of softwoods was more marked. Periodic annual gross increment of softwoods was lower than that for the uncut mixedwoods. On a per acre basis, mortality of merchantable softwood was higher than in any other type. Also, except for the sugar maple, this type had the highest proportion of mortality in windfall. Not all the merchantable softwoods were cut and these residuals were exposed to severe wind damage.



FIGURE 8. Recent cut of softwoods on a mixedwood slope. Mountain maple is prevalent and few of the birch are living.

TABLE 8. SUMMARY DATA FOR CUT-OVER FIR—MAPLE—BIRCH TYPE

Item	Year or Period	
	1947	1957
Basal area per acre, all species (sq. ft.)	73.0	57.5
Merchantable volume per acre, fir and spruce (cu. ft.)	895	458
Stand composition (per cent of basal area)		
Balsam fir	51	44
Spruce	5	2
Yellow and white birch	27	28
Red and sugar maple	17	26
Annual mortality, cut and increment of fir and spruce in merchantable cubic feet per acre	1947 to 1957	
Mortality (windfall in parentheses)	20 (13.4)	
Net periodic decrement	— 43	
Cut, 1951 to 1955—423 cubic feet	42	
Gross periodic increment	19	

Cutting reduced the proportions of both fir and spruce; the proportion of birch remained the same, while that of maple increased. However, fir increased in relation to spruce and now makes up over 90 per cent of the merchantable softwood volume (Table 11).

Reproduction is moderate for all species combined but the softwood component is inadequate to rebuild stocking to fir and spruce. Mortality of birch and cutting of softwoods have allowed mountain maple to develop rapidly and several decades will probably elapse before a reasonable level of stocking is prevalent in this type.

## Comparisons Between Types

### *Growth*

The cover types are shown in Table 9 arranged according to the magnitude of their periodic annual gross increments of merchantable softwood volume. The two even-aged types on the 1899 burn have the highest annual increments, but these periodic growth figures are higher than the sites can average over a long period. Mean annual increment provides a better indication of growth for these even-aged stands. For the spruce—fir (burn), mean annual increment was 48 cubic feet of fir and spruce to 1957; the comparable figure for the spruce—fir—aspens—birch (burn) was 28 cubic feet of softwood per acre.

TABLE 9. PERIODIC ANNUAL NET AND GROSS INCREMENT BY COVER TYPES, 1947 TO 1957

Cover Type	Periodic Increment of fir and spruce in cubic feet of merchantable volume per acre		Periodic Increment of all species in square feet of basal area per acre	
	Net	Gross	Net	Gross
Spruce—fir (burn) . . . . .	96	99	1.8	3.4
Spruce—fir—aspens—birch (burn) . . . . .	61	64	0.9	2.8
Fir—spruce, uncut . . . . .	41	57	2.3	3.7
Fir—spruce—cedar . . . . .	19	44	1.8	3.3
Fir—spruce, cut . . . . .	— 56	44	— 2.5	3.2
Fir—maple—birch, uncut . . . . .	18	27	1.3	2.4
Fir—maple—birch, cut . . . . .	— 44	19	— 1.6	1.9
Sugar maple . . . . .	— 6	6	0.5	2.0
All Types . . . . .	— 4	44	— 0.3	2.9

In terms of basal area, the softwood types had a high periodic gross increment of over three square feet per acre per year, and growth for the spruce—fir—aspens—birch on the burn has been almost as much. But the low periodic growth in the fir—maple—birch and sugar maple types reflects the low stocking that prevails. Growth potentials for the latter two types are much higher than the data indicate.

### *Species Composition*

Estimates of species content expressed as a percentage of basal area show that in most types, the proportion of fir increased, that of spruce and maple

TABLE 10. AREA CLASSIFICATION BY COVER TYPES

Description	Area in Acres	Percentage
<i>Forested Area</i>		
<i>Types Uncut Since 1939</i>		
Fir—spruce.....	623	16.0
Fir—maple—birch.....	355	9.1
Spruce—fir (burn).....	329	8.5
Spruce—fir—aspens—birch (burn).....	150	3.8
Fir—spruce—cedar*.....	295	7.6
Sugar maple*.....	300	7.7
All Uncut Types.....	2,052	52.7
<i>Types Cut between 1951 and 1955</i>		
Fir—spruce.....	1,309	33.6
Fir—maple—birch.....	452	11.6
All Cut-over Types.....	1,761	45.2
Total Forested.....	3,813	97.9
<i>Non-Forested Area</i>		
Water.....	22	0.5
Road.....	50	1.3
Open, old camps, gravel pits.....	10	0.3
Total Non-Forested.....	82	2.1
TOTAL FOR BLOCK.....	3,895	100.0

\*Small portions of these types were cut between 1951 and 1955.

TABLE 11. MERCHANTABLE VOLUME IN CUBIC FEET PER ACRE OF FIR AND SPRUCE BY COVER TYPES

Cover Type	Living, 1947			Living, 1957			Mortality, 1947 to 1957		
	Balsam Fir	Spruce	Fir and Spruce	Balsam Fir	Spruce	Fir and Spruce	Balsam Fir	Spruce	Fir and Spruce
<i>Types Uncut Since 1939</i>									
Fir—spruce.....	922	155	1,077	1,281	210	1,491	131	21	152
Fir—maple—birch.....	518	38	556	687	45	732	84	13	97
Spruce—fir (burn).....	694	893	1,587	1,108	1,435	2,543	13	21	34
Spruce—fir—aspens—birch (burn).....	630	264	894	1,066	436	1,502	13	18	31
Fir—spruce—cedar.....	659	391	1,050	722	519	1,241	110	9	119
Sugar maple.....	199	30	229	151	14	165	66	31	97
<i>Types cut between 1951 and 1955</i>									
Fir—spruce.....	1,137	243	1,380	712	105	817	124	11	135
Fir—maple—birch.....	802	93	895	435	23	458	192	11	203
ALL TYPES.....	835	243	1,078	775	260	1,035	110	15	125

TABLE 12. BASAL AREA OF LIVING STEMS, 1947, IN SQUARE FEET PER ACRE BY SPECIES AND COVER TYPES

Cover Type	Species								All
	Balsam Fir	Spruce <sup>1</sup>	Other <sup>2</sup> Softwood	Total Softwood	Birch	Maple	Other Hardwood	Total Hardwood	
<i>Types Uncut Since 1939</i>									
Fir—spruce.....	64.9	8.2	3.6	76.7	14.4 <sup>3</sup>	1.8 <sup>5</sup>	1.7	17.9	94.6
Fir—maple—birch.....	27.6	1.9	0.3	29.8	15.4 <sup>4</sup>	21.9 <sup>6</sup>	0.9	38.2	68.0
Spruce—fir (burn).....	49.5	76.0	0.6	1,26.1	13.3 <sup>3</sup>	2.0 <sup>5</sup>	12.2 <sup>8</sup>	27.5	153.6
Spruce—fir—aspens—birch (burn).....	45.9	23.1	0.1	69.1	29.7 <sup>3</sup>	8.3 <sup>7</sup>	21.8 <sup>8</sup>	60.3	129.4
Fir—spruce—cedar.....	35.5	16.7	42.2	94.4	2.8 <sup>3</sup>	trace	0.2	3.0	97.4
Sugar maple.....	9.4	1.0	—	10.4	8.7 <sup>4</sup>	75.4 <sup>6</sup>	2.1 <sup>9</sup>	86.2	96.6
<i>Types Cut between 1951 and 1955</i>									
Fir—spruce.....	71.5	12.0	0.5	84.0	20.7 <sup>3</sup>	0.3 <sup>5</sup>	1.0	22.0	106.0
Fir—maple—birch.....	36.9	3.6	—	40.5	19.9 <sup>4</sup>	12.5 <sup>7</sup>	0.1	32.5	73.0
ALL TYPES	51.6	14.9	4.1	70.6	16.4	10.4	2.8	29.6	100.2

<sup>1</sup> Mainly white spruce in all types

<sup>2</sup> Mainly cedar

<sup>3</sup> Mainly white birch

<sup>4</sup> Mainly yellow birch

<sup>5</sup> Mainly red maple

<sup>6</sup> Mainly sugar maple

<sup>7</sup> About equal quantities of red and sugar maple

<sup>8</sup> Mainly trembling aspen and pin cherry

<sup>9</sup> Mainly beech

TABLE 13. BASAL AREA OF LIVING STEMS, 1957, IN SQUARE FEET PER ACRE BY SPECIES AND COVER TYPES

Cover Type	Species								
	Balsam Fir	Spruce <sup>1</sup>	Other <sup>2</sup> Softwood	Total Softwood	Birch	Maple	Other Hardwood	Total Hardwood	All
<i>Types Uncut Since 1939</i>									
Fir—spruce.....	89.3	11.3	3.0	103.6	10.2 <sup>3</sup>	2.2 <sup>5</sup>	1.1	13.5	117.1
Fir—maple—birch.....	37.4	2.4	0.2	40.0	13.6 <sup>4</sup>	26.1 <sup>6</sup>	1.1	40.8	80.8
Spruce—fir (burn).....	61.0	81.6	0.6	143.2	12.3 <sup>3</sup>	2.2 <sup>5</sup>	14.3 <sup>8</sup>	28.8	172.0
Spruce—fir—aspens—birch (burn).....	58.9	24.7	trace	83.6	23.2 <sup>3</sup>	11.6 <sup>7</sup>	20.4 <sup>8</sup>	55.2	138.8
Fir—spruce—cedar.....	44.2	22.5	45.6	112.3	2.8 <sup>3</sup>	trace	0.2	3.0	115.3
Sugar maple.....	8.0	0.7	—	8.7	6.7 <sup>4</sup>	83.9 <sup>6</sup>	2.6 <sup>9</sup>	93.2	101.9
<i>Types Cut between 1951 and 1955</i>									
Fir—spruce.....	62.6	7.3	0.6	70.5	10.1 <sup>3</sup>	0.4 <sup>5</sup>	0.7	11.2	81.7
Fir—maple—birch.....	25.2	1.3	—	26.5	16.2 <sup>4</sup>	14.6 <sup>7</sup>	0.2	31.0	57.5
ALL TYPES.....	54.2	14.5	3.0	71.7	11.0	11.9	2.8	25.7	97.4

<sup>1</sup> Mainly white spruce in all types

<sup>2</sup> Mainly cedar

<sup>3</sup> Mainly white birch

<sup>4</sup> Mainly yellow birch

<sup>5</sup> Mainly red maple

<sup>6</sup> Mainly sugar maple

<sup>7</sup> About equal amounts of red maple and sugar maple

<sup>8</sup> Mainly trembling aspen and pin cherry

<sup>9</sup> Mainly beech

TABLE 14. BASAL AREA OF MORTALITY, 1947 TO 1957, IN SQUARE FEET PER ACRE BY SPECIES AND COVER TYPES

Cover Type	Species								
	Balsam Fir	Spruce <sup>1</sup>	Other <sup>2</sup> Softwood	Total Softwood	Birch	Maple	Other Hardwood	Total Hardwood	All
<i>Types Uncut Since 1939</i>									
Fir—spruce.....	8.4	0.9	0.6	9.9	4.7 <sup>3</sup>	trace	0.2	4.9	14.8
Fir—maple—birch.....	4.1	0.5	0.1	4.7	5.2 <sup>4</sup>	1.2	0.1	6.5	11.2
Spruce—fir (burn).....	2.7	7.8	0.2	10.7	2.3 <sup>3</sup>	0.1	1.9 <sup>7</sup>	4.3	15.0
Spruce—fir—aspens—birch (burn).....	1.8	2.9	trace	4.7	9.1 <sup>3</sup>	0.3	4.7 <sup>7</sup>	14.1	18.8
Fir—spruce—cedar.....	5.9	0.5	1.4	7.8	2.2 <sup>3</sup>	trace	0.2	2.4	10.2
Sugar maple.....	2.9	0.8	—	3.7	3.8 <sup>5</sup>	5.8 <sup>6</sup>	trace	9.6	13.3
<i>Types Cut between 1951 and 1955</i>									
Fir—spruce.....	8.4	0.7	trace	9.1	9.8 <sup>3</sup>	trace	0.2	10.0	19.1
Fir—maple—birch.....	8.0	0.4	—	8.4	6.8 <sup>4</sup>	0.8	—	7.6	16.0
ALL TYPES.....	6.6	1.4	0.3	8.3	6.4	0.7	0.5	7.6	15.9

<sup>1</sup> Mainly white spruce in all types

<sup>2</sup> Mainly cedar

<sup>3</sup> Mainly white birch

<sup>4</sup> About equal amounts of white and yellow birch

<sup>5</sup> Mainly yellow birch

<sup>6</sup> Mainly sugar maple

<sup>7</sup> Mainly pin cherry and mountain ash



TABLE 15. PERIODIC ANNUAL INCREMENTS, 1947 TO 1957, IN SQUARE FEET PER ACRE OF SOFTWOODS, HARDWOODS AND ALL SPECIES BY COVER TYPES

Cover Type	Net Increment			Gross Increment		
	All Softwood	All Hardwood	All Species	All Softwood	All Hardwood	All Species
<i>Types Uncut Since 1939</i>						
Fir—spruce.....	2.7	-0.4	2.3	3.7	trace	3.7
Fir—maple—birch.....	1.0	0.3	1.3	1.5	0.9	2.4
Spruce—fir (burn).....	1.7	0.1	1.8	2.8	0.6	3.4
Spruce—fir—aspens—birch (burn).....	1.4	-0.5	0.9	1.9	0.9	2.8
Fir—spruce—cedar.....	1.8	0	1.8	3.1	0.2	3.3
Sugar maple.....	-0.2	0.7	0.5	0.3	1.7	2.0
<i>Types Cut 1951-1955</i>						
Fir—spruce.....	-1.4	-1.1	-2.5	3.3	-0.1 <sup>1</sup>	3.2
Fir—maple—birch.....	-1.4	-0.2	-1.6	1.3	0.6	1.9
ALL TYPES.....	0.1	-0.4	-0.3	2.5	0.4	2.9

<sup>1</sup> In theory can not be less than zero. Either mortality or cut must be underestimated.

TABLE 16. STOCKING TO REPRODUCTION BY COVER TYPES, 1957<sup>1</sup>

Cover Type	Percent Stocking on Milliacre Quadrats				
	Fir	Spruce	Fir or Spruce	Hardwood <sup>2</sup>	Any Species <sup>3</sup>
<i>Types Uncut Since 1939</i>					
Fir—spruce.....	50	7	53	15	62
Fir—maple—birch...	19	3	21	60	72
Spruce—fir (burn).....	88	2	88	7	89
Spruce—fir—aspens—birch.....	65	1	66	27	80
Fir—spruce—cedar.....	58	10	61	4	64
Sugar maple.....	3	trace	3	87	88
<i>Types Cut 1951 to 1955</i>					
Fir—spruce.....	44	6	45	11	55
Fir—maple—birch.....	19	3	21	39	53

<sup>1</sup> Reproduction includes any size up to 0.5 inches diameter at breast height.

<sup>2</sup> Includes sugar maple, red maple, white birch, yellow birch and beech.

<sup>3</sup> Includes softwoods, hardwoods, mountain ash and pin cherry.

stayed about the same, and that of birch decreased. The proportion of softwood increased in all but two types, the cut-over fir—maple—birch and the sugar maple. Cutting and windfall reduced the softwood component in the former, while windfall was largely responsible for the lower softwood content in the latter.

Fir is the most important species, making up 75 per cent of the merchantable volume of softwood and 56 per cent of the basal area of all species in 1957 (Table 13). Other important species are spruce, maple and birch, which comprise, respectively, 15, 12 and 11 per cent of the average basal area of 97 square feet per acre. While birch was more prevalent than maple in 1947, nearly all the large white and yellow birch are now dead and the quantity of maple surpassed that of birch in 1957<sup>5</sup>. This predominance of maple should continue for several decades.

### *Reproduction*

The summary of reproduction in Table 16 shows that stocking to all species is over 50 per cent in the cut-over types and over 60 per cent in all uncut types. However, reproduction is subjected to severe competition from shrubs in most of the fir—maple—birch and in parts of the fir—spruce and sugar maple types. Many years may elapse before some of these open areas are well stocked to tree species.

Much of the reproduction in the stands on the 1899 burn and in all uncut softwood types is fir. Cutting, without other disturbance, will lead to the development of new softwood stands with a high fir content. As an example, the recently cut fir—spruce has 44 per cent stocking to fir and 46 per cent to fir and spruce. Stocking in this cut-over type should increase rapidly during the next decade, because Vincent (1956) found 90 per cent stocking to softwood reproduction 15 years after cutting in softwood stands.

## DISCUSSION AND CONCLUSIONS

The data from the ten-year remeasurement on the block provide information for an analysis of the important management and silvicultural problems. They also provide the best measure of growth obtained to date for stands in the Green River watershed.

Past logging operations in the softwood type have approximated diameter limit and patch clear cutting, depending on the product taken and the structure and age of the stands. Generally, these harvest cuttings have released softwood seedlings and advance growth, which have developed into new fir—spruce stands.

Clear cutting of the merchantable softwood component in mixedwood stands, associated with the loss of birch to "dieback", has resulted in a rapid influx of shrubs, particularly mountain maple. Vincent (1953) found that once mountain maple forms a canopy, several decades may elapse before reproduction can overcome the competition. Observations on this block substantiate Vincent's conclusion. The mixedwood stands which were cut about two decades ago are still open and there is frequently insufficient reproduction to restock them. To build up the stocking, particularly to softwoods, would require the application of suitable methods for controlling shrub growth.

Average periodic annual net increment for the block (net increase plus volume cut), is 31.5 cubic feet of merchantable volume of fir and spruce per acre. Comparable gross increment is 44 cubic feet. Since the periodic increment values

<sup>5</sup> Hughes, E. L. 1960. Report on the remeasurement of research block 3, 1957. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, Maritimes District, unpublished report.

are based on all types, which together represent a complete range of age classes, these values should approximate available yields. Thus annual yield attainable under present management practices is about 30 cubic feet of fir and spruce per acre. However, the periodic gross increment of merchantable softwood is 44 cubic feet per acre per year, indicating that the yield of fir and spruce could be substantially increased through utilization of wood now lost to mortality. When one considers that average density is approximately 100 square feet of basal area per acre, including 26 square feet of hardwoods, 55 to 60 cubic feet per acre per year is perhaps a conservative estimate of the yield that might be achieved by utilizing all species and maintaining full stocking.

## SUMMARY

Some 600 permanent tenth-acre plots, established in 1947 in a 3,900-acre study area on the Green River Watershed of northwestern New Brunswick were remeasured in 1957. Compilations were made to obtain values for the merchantable volume of fir and spruce, the basal area of each species, net and gross periodic increments, mortality, amount of cut, and stocking to reproduction.

Softwood types cover 60 per cent of the block. Balsam fir makes up 75 per cent of the merchantable volume of softwoods and 56 per cent of the basal area of all species. Spruce, maple and birch are next in importance and in 1957 comprised 15, 12 and 11 per cent of the basal area, respectively.

Periodic annual net increment (including wood harvested) of fir and spruce averaged 31 cubic feet per acre for the block. Periodic annual gross increment for these species averaged 44 cubic feet per acre.

New stands of fir and spruce develop rapidly in most cut-over softwood. But fir and spruce reproduction is not adequate in mixedwood types where cutting of softwoods and mortality of birch have resulted in the rapid development of mountain maple and other shrubs. These shrubs restrict the establishment and development of reproduction.

Windfall accounted for 40 per cent of all softwood mortality and was highest in cut-over stands where the loss for the period amounted to 80 cubic feet of merchantable volume per acre.

Large numbers of birch died during the decade. As a result, the quantity of maple now exceeds that of the birch species. Much of the birch mortality was attributed to "dieback".

Yields from the study area could be increased to about 60 cubic feet per acre per year by utilizing all species, and by applying silvicultural treatments designed to increase stocking.

## SOMMAIRE

Quelque 600 stations d'un dixième d'acre chacune, établies en 1947 dans une forêt de 3,900 acres située dans le bassin de la rivière Verte, dans le nord-est du Nouveau-Brunswick, ont fait l'objet d'un relevé de mesures, en 1957. Des chiffres ont été compilés en vue de calculer la valeur marchande des sapins et des épinettes, la superficie des peuplements de chaque essence, les gains périodiques bruts et nets, la mortalité, le volume des arbres abattus et enfin le nombre d'arbres laissés pour la reproduction.

Les essences résineuses occupent 60 p. 100 de la superficie totale de l'aire à l'étude. Le sapin baumier compte pour 75 p. 100 du volume vendable de résineux

et pour 56 p. 100 de la superficie totale de tous les peuplements. L'épinette, l'érable et le bouleau viennent ensuite par ordre d'importance; en 1957, ces trois essences comptaient pour 15, 12 et 11 p. 100, respectivement, de la superficie totale de l'aire à l'étude.

Les gains annuels périodiques (y compris le bois récolté) du sapin et de l'épinette s'établissaient en moyenne à 31 pieds cubes à l'acre, calculée pour toute l'aire à l'étude. Le gain annuel périodique brut, dans le cas de ces deux essences, s'établissait en moyenne à 44 pieds cubes à l'acre.

Les nouveaux peuplements de sapin et d'épinette croissent rapidement dans la plupart des aires de résineux exploitées. Toutefois, la reproduction du sapin et de l'épinette est assez faible dans les peuplements mixtes où l'abattage des résineux et la forte mortalité du bouleau ont favorisé la croissance rapide de l'érable à épis et d'autres arbustes. Ces arbustes nuisent à l'établissement et à la germination des semis.

Le vent a fait périr 40 p. 100 de tous les résineux compris dans les chiffres de mortalité; les chablis étaient plus graves dans les peuplements soumis à l'abattage, où les pertes, durant la période d'étude, se sont chiffrées à 80 pieds cubes de bois marchand à l'acre.

De nombreux bouleaux sont morts au cours de la décennie. En conséquence, les érables sont aujourd'hui plus nombreux que les bouleaux. La mort d'un grand nombre de bouleaux a été attribuée au dépérissement progressif.

On pourrait augmenter le rendement de l'aire à l'étude dans la proportion d'environ 60 pieds cubes de bois à l'acre par année en utilisant toutes les essences et en mettant à profit des méthodes de sylviculture favorables à la reproduction.

## REFERENCES

- ANON. 1961. Native trees of Canada. Dept. of Forestry, Canada, Bul. No. 61. 6th ed.
- CUNNINGHAM, G. C. 1958. Forest flora of Canada. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, Bul. No. 121.
- ROWE, J. S. 1959. Forest regions of Canada, Canada, Dept. Northern Affairs and National Resources, Forestry Branch, Bul. No. 123.
- VINCENT, A. B. 1953. Mountain maple. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leaflet No. 80.
- . 1956. Balsam fir and white spruce reproduction on the Green River Watershed. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note No. 40.