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EFFECTS OF BIRCH DIEBACK AND SPRUCE BUDWORM  
ON FOREST DEVELOPMENT, FOREST SECTION L.6, QUEBEC

(Project Q-37)

by

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ON FOREST DEVELOPMENT, FOREST SECTION L.6, QUEBEC

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by R.J. Hatcher

ABSTRACT

An investigation was made of the effects of birch dieback and spruce budworm on 1200 acres of uneven-aged mixedwood and softwood forest during the period 1940 to 1960. Balsam fir took quick advantage of the growing space provided by the death of birch from dieback in the late 1940's but fir was attacked in turn by the spruce budworm in the early 1950's. In two-thirds of the forest fir recovered well after aerial spraying in 1956 and future stands will contain higher proportions of this species than in the past. In the remainder of the forest, fir did not recover nor regenerate well and its place was taken by sugar maple and shrubs.

INTRODUCTION

Success in guiding or altering the natural forest to better satisfy the requirements of industrial forestry often depends on a knowledge of how the natural forest develops. Affecting such development are destructive natural phenomena, two of which have recently caused heavy mortality in Quebec forests. During the latter half of the

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1 Contribution No. to the Forest Research Branch, Dept. of Forestry.

2 Research Officer Forestry, Forest Research Branch, Dept. of Forestry, Que.

1941-1950 decade millions of feet of white and yellow birch<sup>3</sup> succumbed to the affliction known as birch dieback, and in the 1950's large areas of balsam fir forest were attacked by the spruce budworm. Some mixedwood forest of fir and birch suffered the dual attack.

One such forest is the Métis Seigniory of Price Brothers and Co. Ltd., 30 miles southeast of Rimouski, Quebec. Between 1940 and 1960 stands in the Seigniory suffered considerable mortality from the dieback and the budworm but also have exhibited a remarkable capacity of recovery. The study results hereafter presented indicate that in two-thirds of the forest mortality has been balanced in large measure by the rapid growth of balsam fir.

#### THE FOREST

The Métis Seigniory is an area of 131 square miles (48° 30'N, 67° 30'W) in the upland region south of the St. Lawrence River Valley. This upland is a northeastward extension of the Appalachian range which connects the higher and somewhat more rugged sections of the Eastern Townships and the Gaspé Peninsula.

The dominant Forest Section of the upland is B.2 and outliers of L.6 are found at various points of lower elevation along the Gaspé shoreline. A band of L.6 paralleling the Matapédia and Matane rivers divides the two main islands of B.2. Both blocks of the study area,

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3 Botanical names in Appendix.

one south and one north of the western end of Lake Métis, are characteristic of Section L.6 with stands containing large volumes of Sugar maple, yellow birch and cedar. Some stands only a few miles east of the lake are typically boreal.

Drainage of the Seigniory is both southeastward to the Restigouche River and northwestward to the St. Lawrence. Elevation above sea level is from 700 to 1200 feet. The climate is moderate with an annual growing season (above 42°F) of 140 to 160 days, a mean annual temperature of 35.6°F, and a mean temperature for the four warmest months of 52° to 63°F. Annual precipitation averages 39.3 inches and monthly summer precipitation is 3.0 to 4.1 inches.

The Seigniory was logged about 1910 for large cedar and in 1934 a small amount of spruce and fir was cut. Conifer sawlog operations began in 1939 and have continued to the present.

Birch dieback injury, first noted in Quebec in the Matapédia Valley in 1939, had by 1943 been reported throughout the Gaspé region (Daviault, 1953). During the latter half of the 1941-1950 decade the highest incidence of injury and mortality of both white and yellow birch occurred in this region. A spruce budworm outbreak began in 1951 or 1952 and continued until the forest was sprayed from the air in 1956.

The topography of the study area is characterized by a rolling terrain with the gentle to moderate slopes occasionally interrupted by rock ledges. Drainage is mostly subterranean, each of the two blocks

having only one main surface stream. The soil on lower slopes is a deep loam almost free of surface rock but with glacial boulders in the sub-soil. On hill tops the soil is much thinner with boulders only 2 to 3 inches below the humus.

In 1950 the forest was uneven-aged but there was an excess of volume in the older age classes. Age determinations in stands that appeared even-aged revealed that they were, in fact, uneven-aged.

During the 1960 remeasurement vegetation sampling was done on each plot following the method of Braun-Blanquet (1932). Construction of a vegetation table provided a division of plots into five forest types, one of which was subdivided into two sub-types<sup>4</sup>. As no ecological classification exists for Section L.6, each type was assigned a temporary name based on its characteristic vegetation. Unfortunately site index could not be calculated because of a prevalence of butt rot in fir which precluded age counts. Thus the arranging of sites in order of quality was based on a knowledge of differential vegetation and on experience gained in the adjacent L.5 Section (Jurdant, 1959), and was done before any other field data had been compiled. The types, grouped as mixedwood and softwood, are described in descending order of site quality as follows.

#### Mixedwood Types

Fir-Sugar Maple-Dryopteris (bF-M-Dry): This type occupies about one-third of the area almost exclusively on upper slopes and hilltops

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<sup>4</sup> Ecological classification done by M. Jurdant, Research Officer Forestry, Forest Research Branch, Department of Forestry, Quebec District Office.

and is characterized by the presence of sugar maple as 20-25 per cent of the stand. Fir forms 30-40 per cent of the stand volume, white spruce about 20 per cent, yellow birch 20-30 per cent, and the rest is white birch and red maple. Differential plants comprise Dryopteris Phegopteris, Dryopteris disjuncta, Streptopus roseus, Galium triflorum, and Rubus pubescens.

Fir-Red Maple (bF-rM): This type is composed of two sub-types, the typical and the Hylocomium. Although occasionally found on upper slopes, it usually occupies the gentle middle and lower slopes. Fir forms 40-65 per cent of the stand volume, white spruce about 20 per cent, yellow birch 10-20 per cent and the remainder is red maple and white birch plus a small amount of sugar maple. The larger amount of red maple and small amount of sugar maple distinguish this type from the bF-sM-Dry type. Dryopteris, Streptopus, Galium and Rubus pubescens are much less abundant here than in all other types. The typical sub-type is differentiated from the Hylocomium sub-type by an absence of mosses in the former and an abundance in the latter of Hylocomium splendens, Calliergonella Schreberi, and Hypnum Crista-castrensis. This type occupies about 25 per cent of the area.

Fir-Dryopteris (bF-Dry): This type occupies about 16 per cent of the area, on gentle middle and lower slopes. It is differentiated by an abundance of Dryopteris, Rubus pubescens, Streptopus and Galium, and a scarcity of red maple and mosses. Species proportions are similar to the bF-rM type (fir 45-60 per cent, spruce 15 per cent, yellow birch 15-25 per cent) but there is more white birch plus the occasional cedar.



### Softwood Types

Fir-Cedar-Dryopteris (bF-eC-Dry): The presence of cedar as 15 per cent of the stand volume distinguishes this type from the bF-Dry type, as does the presence of Osmunda cinnamomea and Equisetum sylvaticum plus an abundance of mosses. This type, occupying about 17 per cent of the area, is usually found on moist, flat areas at lower elevations and characteristically has a humus layer of 4-10 inches as compared to the one to two inches found in the mixedwood types. Volume consists of 40-50 per cent fir, 25-35 per cent white spruce, 15 per cent cedar, plus scattered yellow and white birch.

Spruce-Fir-Cedar (S-bF-eC): This pure softwood type has 40-50 per cent cedar by volume and about equal volumes of fir and spruce, including some black spruce. It usually occupies small flat areas at lower elevations but occasionally is found in small depressions at higher elevations. This site is moist with heavy moss cover on thick humus. Characteristic plants are Alnus rugosa, Carex, Sphagnum, Mitella nuda, and Gaultheria hispidula. This type occupies less than 10 per cent of the area.

Two shrubs, Acer spicatum, and Corylus cornuta, add appreciably to the density of the lesser vegetation in all types and are particularly abundant in the bF-sM-Dry and bF-Dry types.

### METHOD OF STUDY

In 1950 a 10-chain grid of permanent tenth-acre line plots was established over two blocks having a combined area of approximately 5 square miles. Both undisturbed and cutover areas were represented

in each block but only the uncut stands are reported herein. A total of 155 plots were established in the uncut forest, 118 of which were used in this investigation. Thirty-five of the original plots which were cut in 1959 and two plots which could not be classified by site were omitted.

In 1950, the following data were recorded on each plot: 1) all trees 0.6 inch d.b.h. and larger were tallied by species and one-inch diameter classes; 2) dead trees judged to have died during the previous decade were tallied by species and diameter classes and scribed with an "x"; 3) a stocked quadrat tally was made on 20 milacre quadrats, species being tallied separately and in two size classes, below 0.6 inch d.b.h. and between 0.6 and 3.5 inch d.b.h.; 4) height-diameter measurements were made in order to construct local volume tables; 5) borings at breast height were taken to determine age structure; 6) a general plot description was recorded comprising notes on herb and shrub vegetation, topography, drainage and stand origin.

In 1960 the plots were remeasured and a supplementary study was made of the vegetation using the method of Braun-Blanquet. A stocked quadrat tally of reproduction was made on only 10 milacre quadrats in a strip down one side of each plot.

An estimate of the 1940 volumes was obtained by adding the mortality for 1941-1950 to the 1950 volumes, and subtracting from this sum a gross increment equal to that of 1951-1960.

## RESULTS

The effects of the dieback and budworm attacks were quite different on mixedwood and softwood types. About 75 per cent of the forest is occupied by the three mixedwood types and 25 per cent by the two softwood types.

### Mixedwood Types

During the decade 1941-50, the mortality of white and yellow birch varied from about 720 to 1,025 cubic feet per acre (Table 1), equivalent to 28 to 41 per cent of the living volume of all species in 1940. White birch losses were proportionally much higher than yellow birch (Figure 1). In the bF-sM-Dry type almost the entire white birch volume of over 500 cubic feet per acre was eliminated. However, the reductions in total growing stock were much less than expected because of compensating increases in softwood volumes, particularly fir (Figure 2).

The advantage gained by fir through the death of birch was soon offset by the advent of a spruce budworm attack and wind damage. In 1951 or 1952 the insect began feeding in the area and an epidemic population was present in 1956 when the forest was sprayed with DDT. By this time, the distribution of fir was characterized by an excess of volume in the larger diameter classes, although the stands were uneven-aged.

In view of (1) increased stand vulnerability to wind damage caused by the sudden disappearance of birch, (2) the emergence of an excess of mature and overmature fir, and (3) a budworm attack,

fir volumes in 1960 were surprisingly large. Fir volumes in 1950 ranged from 850 to 1,430 cubic feet per acre, mortality from 1951-1960 was 470 to 555 cubic feet but 1960 volumes were still 580 to 1,310 cubic feet. Obviously the loss of fir was balanced to a large extent by growth of residual trees (Figure 3).

Important differences between forest types are apparent. Growth of fir in sizes below 10 inches d.b.h. exceeded mortality below 10 inches in the bF-rM type, equalled mortality in the bF-Dry type, but fell far short of equalling mortality in the richest bF-sM-Dryp type which represent one-third of the area.

Ba sal areas were reduced proportionately less than volumes (Table 2). The rapid growth of fir in the bF-rM type is reflected in the increased basal area for softwoods in 1960 in spite of about 25 square feet per acre of softwood mortality. Loss of fir in the bF-sM-Dry type was almost balanced by an increase in hardwoods, almost entirely sugar maple.

The proportions of fir mortality due to the budworm and to wind action could not be accurately determined in 1960, although an attempt was made to separate these two causes. Blais (1960) reported 11-25 per cent fir mortality from budworm attack in an area bordering Lac Métis. Assumption of a 20 per cent mortality figure for the study area suggests that budworm and wind were about equally responsible for fir losses.

An examination of gross increment, or production (net increment plus mortality), revealed that the bF-rM type produced more wood per acre than the richer bF-sM-Dry type (Table 3). However, growth is also a function of stocking (or density) and when the gross increments produced for each square foot of basal area in 1950 were calculated, it became evident that the original arrangement of types in order of productivity was justified.

Conifer regeneration stocking dropped during the period 1951-1960 as seedlings moved into the sapling class (Table 4), but the almost complete disappearance of birch seedlings was accompanied by <sup>only</sup> a very small increase in birch saplings.

#### Softwood Types

The S-bF-eC type which had only a 2 per cent hardwood component was almost unaffected by the birch dieback between 1941 and 1950 (Figure 2). Volume increases for fir and cedar exceeded a spruce decrease resulting in a moderate increase in total volume. In the bF-eC-Dry type, an original hardwood component of 18 per cent by volume was reduced to 5 per cent, largely through the loss of 365 cubic feet of birch per acre. This loss was equivalent to 14 per cent of the total 1940 growing stock, much less than the minimum loss of 28 per cent for mixedwood stands. It was more than equalled by the growth of conifers, particularly fir, and in 1950 growing stock had increased slightly.

In softwood stands the budworm and wind damage was comparable to that in mixedwood stands for the decade 1951-1960 (Table 1). As in mixedwood stands, these losses were balanced in part by growth in the smaller size classes (Figure 3). Decrements for both spruce and fir in the bF-eC-Dry type (Table 3) resulted in a reduced total volume. The S-bF-eC is the only type to register an increase in volume for the decade (Figure 2) and is also the only one in which fir net increment was positive. A spruce loss occasioned by wind damage in the large diameters was more than compensated for by the rapid growth of cedar.

Basal areas for softwood types were greater than any of the mixedwood types in both 1950 and 1960 (Table 2). Volume productions per unit basal area were slightly less than the poorest mixedwood type.

Combined spruce-fir regeneration stocking in 1960 shows little change from 1950 (Table 4) but spruce representation has increased. Cedar increased in the S-bF-eC type which suggests a possible further increase in its proportion. Notably yellow birch is represented in both softwood types while it almost disappeared from the mixedwood types.

Table 1. Summary of Mortality, 1941-1950, 1951-1960

Forest Type	Period	Mortality in Total Cubic Feet Per Acre, 4 Inches d.b.h. and Over, by Species:				
		Spruce	Fir	Yellow Birch	White Birch	Other Species All Species
bF-sM-Dry	1941-50	32	99	518	507	23 1,179
	1951-60	21	472	44	4	28 569
Typical Sub-type	1941-50	0	164	408	463	0 1,035
	1951-60	42	487	132	101	0 762
bF-rM Hylocomium Sub-type	1941-50	56	72	517	201	0 846
	1951-60	17	554	12	48	0 631
bF-Dry	1941-50	29	217	435	316	0 997
	1951-60	138	544	27	60	4 773
bF-eC-Dry	1941-50	43	73	277	87	19 499
	1951-60	234	549	41	18	43 885
S-bF-eC	1941-50	139	29	0	38	44 250
	1951-60	111	188	0	6	129 434

Table 2. Summary of Basal Area

Cover and Forest Types	Total Basal Area, Square Feet Per Acre					
	Softwoods		Hardwoods		Total	
	1950	1960	1950	1960	1950	1960
Mixedwood Stands						
bF-sM-Dry	46	38	28	34	74	72
bF-rM						
Typical sub-type	71	72	20	14	91	86
Hylocomium sub-type	84	85	9	8	93	93
bF-Dry	63	52	17	17	80	69
Softwood Stands						
bF-eC-Dry	108	100	6	4	114	104
S-bF-eC	126	144	0	1	126	145



Table 3. Net and Gross Increments, 1951-1960

Forest Type	Increment 1950-1960	Total Cubic Feet Per Acre, One Inch d.b.h. and Over, by Species:					Per Unit Basal Area in 1950
		Spruce	Fir	Cedar	Yellow Birch	Other Hardwoods	All Species
bF-sM-Dry	Net	72	-273	0	30	108	-63
	Gross	93	202	0	74	140	509
Typical Sub-Type	Net	15	-85	6	-84	-76	-224
	Gross	59	412	6	49	26	552
Hylocomium Sub-Type	Net	41	-114	0	2	-22	-93
	Gross	59	460	0	14	26	559
bF-Dry	Net	-86	-268	2	57	-52	-347
	Gross	52	278	3	85	11	429
bF-eC-Dry	Net	-143	-138	-7	-20	-15	-323
	Gross	91	416	36	21	3	567
S-bF-eC	Net	-52	51	219	1	1	220
	Gross	59	250	351	1	7	668

\* Net Increment plus Mortality.

Table 4. Comparison of Stocked Quadrats  
1950 and 1960

Per Cent Stocked Quadrats, Stems Below 0.6 inches D.B.H.

Cover and Forest Type	Spruce or Fir		Yellow Birch		White Birch		Sugar Maple		All Species	
	1950	1960	1950	1960	1950	1960	1950	1960	1950	1960
Mixedwood Stands										
bF-sM-Dry	18	15	6	0	<1	0	41	33	51	40
Typical Sub-Type bF-rM	43	45	15	0	3	0	5	4	50	44
Hylocomium Sub-Type	30	27	9	0	4	0	11	8	38	29
bF-Dry	40	33	9	<1	<1	3	4	1	44	35
Softwood Stands										
bF-eC-Dry	43	44	11	3	3	1	2	2	46	46
S-bF-eC	50	50	3	2	6	0	33	49	55	49
							Cedar			

## DISCUSSION

Balsam fir rapidly utilized the growing space provided by the death of birch in the late 1940's. However, the same upsurge of fir created more favourable conditions for a subsequent spruce budworm attack. Increased light intensity in the crowns of fir increased the attractiveness of this species for the positively phototropic budworm larva and no doubt also stimulated the production of staminate flower buds, the insect's favourite food (Blais 1961). Budworm feeding and wind damage after 1950 resulted in fir losses of up to 6 cords per acre. No doubt the remaining fir was in poor condition when spraying ended insect activity in 1956.

The destruction of fir by the budworm and wind subsequently resulted in a variation of development depending on forest type. In the rich bF-sM-Dry type covering one third of the area apparently fir neither responded to, nor regenerated following, release from the budworm attack. Dense regeneration of sugar and mountain maple plus dense herbaceous growth probably prevented the development of both fir and birch seedlings. Logging with its ground scarification would probably intensify this problem. A profitable field of research would be experimentation to determine the best method of harvesting on such sites.

On the remaining two thirds of the area, fir recovered rapidly after 1956 and a large part of the earlier loss was regained by fast growth in the smaller diameter trees. Fir regeneration was abundant but that of birch almost non-existent. These facts suggest the possibility of a marked increase in the proportion of fir in future

stands. Logging operations in such stands would tend to increase birch regeneration because the scarified seed beds would not be occupied by a dense maple or herbaceous growth. In softwood stands with a cedar component harvesting of only spruce and fir would no doubt lead in future to an increased proportion of cedar.

This record of natural development of the Métis forest may be useful in planning silvicultural treatments for similar forests. Apparently the successful restocking of the rich bF-sM-Dry type with conifers will require stand treatment beyond the harvest operation. A practical solution to the problem of maple domination on this important site may be aerial spraying with herbicides. The mechanics of spray application would be somewhat simplified by the fact that this site is usually restricted to, and is dominant on, the upper slopes and hilltops.

A primary industrial goal would be a per acre increase in the harvest of spruce and fir sawlogs. The birch dieback attack has shown that fir will rapidly increase its volume and regenerate well as a result of decreased stand density. Similar decreases in density brought about artificially would probably achieve the same result. The problem remains of balancing the cost of any treatment with the value of the increase in conifer harvest.

Any such increase of fir in mixedwood stands probably would increase the severity of any subsequent budworm attack. Higher fir volumes would be desirable provided the risk of budworm damage is acceptable. A complete conversion to conifers would not be advisable

because of the high budworm risk and the possible decrease in site productivity caused by the absence of hardwood litter.

#### SUMMARY

A study of stand development was begun in 1950 when a 10-chain grid of tenth-acre line plots was established in uneven-aged mixedwood stands of the L.6 Forest Region of Quebec. The plots were remeasured in 1960. A study of forest types was also made following the method of Braun-Blanquet.

The forest suffered high mortality of birch owing to "dieback" in the period 1941-1950, and high mortality of fir from the spruce budworm and windfall between 1951-1960. Despite these adverse factors, original growing stocks of 2,200 to 2,700 cu. ft. per acre did not drop below 1,700 cu. ft.

Fir in mixedwood stands took quick advantage of the growing space provided by the death of birch. Similar advantage could be gained by an artificial removal of hardwoods. However, increased fir proportions in stands probably raise the risk of severe budworm damage.

On two thirds of the area fir responded quickly to release from the budworm attack after spraying with DDT in 1956, and much of the loss was regained by fast growth of the smaller trees. But fir neither responded nor regenerated after 1956 on one third of the area occupied by stands containing sugar maple. Here sugar maple proved more aggressive than fir. Logging the conifers from this type would probably intensify the problem of conifer regeneration. Research into harvesting methods in this rich type would yield worthwhile results.

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APPENDIX A

List of Common and Scientific Names

<u>Common Name</u>	<u>Latin Name</u>
Balsam fir	<u>Abies balsamea</u> (L.) Mill.
Red maple	<u>Acer rubrum</u> L.
Sugar maple	<u>Acer saccharum</u> Marsh.
Yellow Birch	<u>Betula alleghaniensis</u> Britt.
White birch	<u>Betula papyrifera</u> Marsh.
White spruce	<u>Picea glauca</u> (Moench) Voss
Black spruce	<u>Picea mariana</u> (Mill.) BSP
Mountain maple	<u>Acer spicatum</u> Lamb.
Speckled alder	<u>Alnus rugosa</u> (Du Roi) Spreng.
Witch hazel	<u>Corylus cornuta</u> Marsh.
Beech fern	<u>Dryopteris Phegopteris</u> (L.) Christens
Oak fern	<u>Dryopteris disjuncta</u> (Ledeb.) C.V. Mort.
Cinnamon fern	<u>Osmunda cinnamomea</u> L.
Pink Streptopus	<u>Streptopus roseus</u> Michx.
Sweet-scented bedstraw	<u>Galium triflorum</u> Michx.
Dwarf blackberry	<u>Rubus pubescens</u> Raf.
Naked mitre wort	<u>Mitella nuda</u> L.
Snowberry	<u>Gaultheria hispidula</u> L. (Bigel.)
Fern moss	<u>Hylocomium splendens</u> (Hedw.)
Schreber's Hypnum	<u>Calliergonella Schreberi</u> (Bry. Eur.) Grout.
Plume moss	<u>Hypnum Crista -castrensis</u> L.
Peat moss	<u>Sphagnum</u> spp.
Horsetail	<u>Equisetum sylvaticum</u> L.
Sedge	<u>Carex</u> spp.
Spruce budworm	<u>Choristoneura fumiferana</u> (Clem.)