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PROVENANCES AT THREE SITES IN QUEBEC

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QUEBEC REGION, QUEBEC
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CANADIAN FORESTRY SERVICE
DEPARTMENT OF FISHERIES AND FORESTRY
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#### INTRODUCTION

During the past 15 years numerous provenance trials of both exotic and indigenous coniferous species have been established in Quebec<sup>1</sup>. In 1967 a systematic assessment of a number of these trials was begun. Three red spruce plantations of 15 provenances were measured, and the growth behaviour of the provenances assessed in relation to the ecology of the experimental area. The results, together with an analysis of relevant literature, are presented in this report.

Since this study is only part of a broader investigation of genetic variation in red spruce, it is not presented as a range-wide provenance investigation of the species (see footnote). It is, rather, an evaluation of the growth behaviour of 15 provenances of red spruce at three sites in Quebec, both in relation to the genecology of the species in the province as it is presently understood, and the usefulness of the provenances in practical silviculture and tree improvement.

<sup>1</sup> 

Many of these trials were established by personnel of the Quebec laboratory on the initiative of Mr. Mark Holst, Petawawa Forest Experiment Station, who supplied both the material and the experimental design. The study reported here is part of a broader investigation of genetic variation in red spruce initiated by Mr. Holst.

## RED SPRUCE IN QUEBEC

There is considerable uncertainty concerning the ecology and taxonomy of red spruce (Picea rubens Sarg.) in Quebec, and little attempt has been made to clearly discriminate between this species and black spruce (Picea mariana (Mill.) BSP). Indeed, in Quebec the name red spruce (épinette rouge) is often applied to Tamarack (Larix laricina (Du Roi) K. Koch) rather than to Picea rubens Sarg.

The two earliest papers which deal directly with the Canadian spruces are those of Brunet (1866) and Lawson (1896). Brunet, whose work was principally in Quebec, did not acknowledge the occurrence of red spruce in this province. Nevertheless Brunet's illustration of the cone morphology of black spruce is as close to red as it is to black, and the description he gave of a variety called <a href="Picea nigra">Picea nigra</a> var. <a href="Grisea">Grisea</a> could equally be applied to red spruce. Lawson (1896) who gave a very good description of red spruce, including an account of the growth of the species in Scotland, had no difficulty in acknowledging the specific status of red spruce in Canada. However, his paper did not give detailed information concerning the distribution of the species in this country.

Marie-Victorin, an acknowledged authority on Quebec's flora, stated that he never saw red spruce in Quebec. He also noted that Fernald and his associates, who made a careful botanical survey of the St. Lawrence valley from Rivière du Loup to Gaspé, did not encounter this species (Marie-Victorin 1927 p. 91).

Heimburger (1939) reported the occurrence of red spruce at the south edge of the Laurentide Park near Quebec City, also in the region of the lower Gatineau river, and near Montebello. According to Heimburger all occurrences of red spruce to the north of the St. Lawrence valley are confined to the east portion of the Algonquin-Laurentide section of the Great Lakes-St. Lawrence Forest Region, and he goes on to state: "... This is a distinct natural handicap to Canadian forestry, in that this valuable softwood species is lacking in the forests of northern Quebec and Ontario, for some as yet unknown reason". This author also observed the occurrence of intermediate forms of black and red spruce in New Hampshire, and concluded that they were the natural hybrids of both these species.

Halliday and Brown (1943) suggested a correlation between the distribution of red spruce and high annual rainfall. According to these authors, who cite Heimburger and Porsild (1938), red spruce north of the St. Lawrence valley is confined to an outlier on the lower slopes of the Laurentian hills.

According to Rowe (1959) red spruce occurs extensively in the forests of the Algonquin-Pontiac section of the Great Lakes-St.

Lawrence Forest Region. Rowe also stated that the northern limit of the Laurentian section of the same region coincides roughly with the distribution of red spruce, and that the species is well distributed through the Eastern Townships section, but is virtually absent in the Temiscouata-Restigouche Section. Heimburger (1939) has observed the occurrence of red spruce in areas circumscribed by the Upper and Middle St. Lawrence sections e.g. the south edge of the Laurentide Park near Quebec City, Valcartier, and Shefford mountain.

Morgenstern and Farrar (1964) studied introgressive hybridization in black and red spruce. These authors referring to other authorities, noted that red spruce grows on Prince Edward Island, but does not extend to the Gaspé Peninsula or Newfoundland, and that north of the St. Lawrence river it is confined to a strip less than 100 miles wide from Quebec City westward to Ottawa. In agreement with Halliday and Brown (1943) Morgenstern and Farrar are of the view that within its temperature range, red spruce is restricted to areas where the climate is humid, and that high humidity is a determining factor in the species distribution in Quebec. "At its northern limits in Quebec, red spruce occurs as disjunct populations occupying ecoclimates which are cooler than average, such as north-east slopes. Evidently its northern limit there is not determined by temperature. It is suggested that these cool ecoclimates are the only ones which provide the required high humidity" (Morgenstern and Farrar 1964).

Jurdant (1968) has characterized a pure red spruce-balsam fir association along the southern border of the Laurentians. The association is usually found below 1,700 ft. on dry, thin soils overlying rock and where black spruce does not occur. Since glaciation was from the northeast, many of the northeastern slopes along the southern border of the Laurentians are rocky, and have thin, excessively drained soils. Along a moisture gradiant in these areas red spruce occurs with balsam fir in the convex drier zone, and black spruce in the wetter concave zone at lower elevations. Above 1,700 ft., where the boreal forest intrudes, black spruce is again the predominant species (Jurdant 1968). Since difference in total precipitation

between these two site types is negligible it would appear that other factors besides high humidity determine the occurrence of red spruce at least in the southern Laurentians. As pointed out by Hart (1959) red spruce will grow on many sites unfavourable for other species including steep rocky slopes and thin soils.

Oosting and Billings (1951) in their comparison of virgin spruce-fir forest in the northern Appalachian system, have stated that while it seems possible to distinguish an Appalachian variant of the northern spruce-fir forest, it becomes difficult to separate the two in their region of overlap in southeastern Canada. These authors go on to observe: "A great deal more work is needed in that particular region on the relative distribution and habitat tolerances of the three eastern spruces, and other critical species, before any final statement can be made concerning the northern limits of a truly Appalachian spruce-fir forest". This observation applies with particular force in regard to spruce species indigenous to Quebec.

#### MATERIALS AND METHODS

Fifteen red spruce provenances were planted in the spring of 1959 at three sites in Quebec, Valcartier, lat. 46°45', long. 71°13', elev. 500 ft.; Inc Mégantic lat. 45°40', long. 70°50', elev. 1500 ft.; Drummondville lat. 45°50', long. 72°30', elev. 300 ft. These three sites were originally chosen to represent respectively cold, cool and warm environments for red spruce (Fig. 1).

The Valcartier site lies in a transition zone between the Laurentian and Middle St. Lawrence sections of the Great Lakes - St. Lawrence Forest Region. The Megantic and Drummondville sites lie respectively in the southern extremities of the Middle St. Lawrence and the Eastern Townships sections of the same Forest Region (Rowe 1959).

The provenances (Table 1) were planted in a lattice square design, 6 x 6 ft. spacing, and replicated five times at each of the three test sites. The seedlings were 4 years old (2+2) at the time of planting.

In the spring of 1967, 10 trees of each provenance in each replication were permanently marked. This was done at all three sites. Measurements of flushing and shoot extension were made only on those permanently marked trees, while total height was obtained for all trees.

In the spring of 1968 all three plantations showed very severe effects of winter desiccation. An assessment of the damage was made by scoring all trees which had reddish-brown needles and were partially defoliated. Mortality was also assessed.

Since shoot extension was assessed periodically during the growing season it was possible to construct growth curves for each provenance at each test site. FIGURE 1. Weather data for stations nearest each of the test sites.

The length of the vegetative period at Valcartier is 106 days, Lac Mégantic 118 days and Drummondville 129 days.

(Boughner et al. 1956, Fréchette 1965).

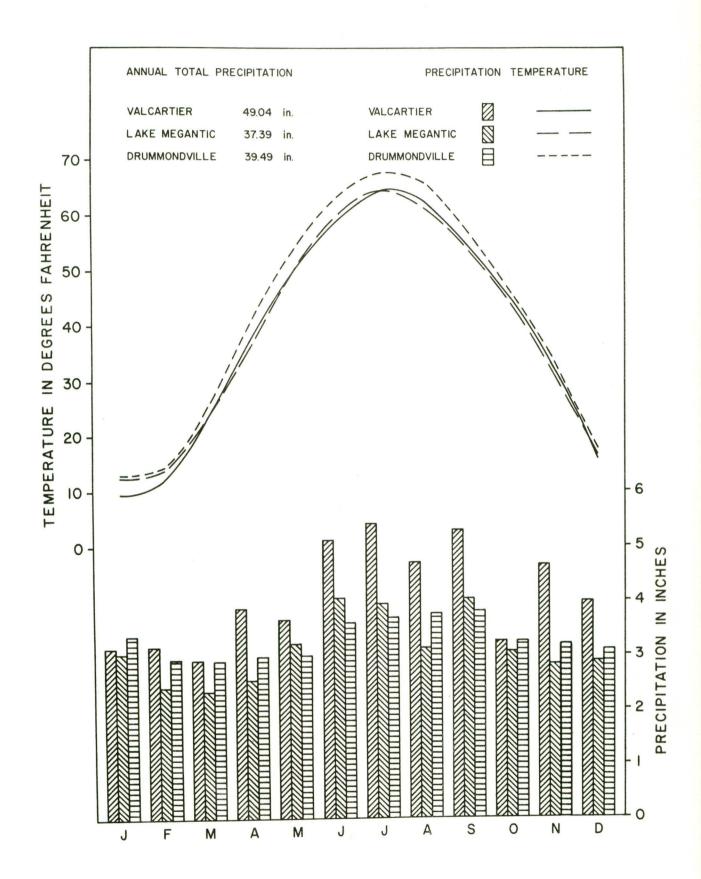


FIGURE 2. Shoot extension during one growing season, and total height for 6 diverse provenances at each of 3 test sites. Note that shoot extension begins earliest in those provenances which are likely to have a hybrid component e.g. 2021, 2505, and 2033. Maximum growth occurred during the first 3 weeks of July; growth cessation and the initiation of dormancy occurred towards the end of this month.

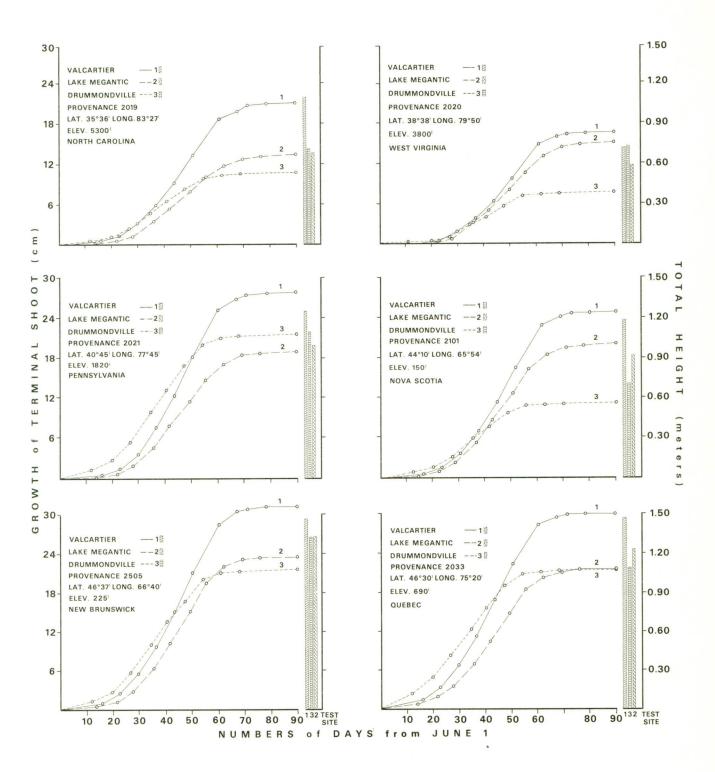


FIGURE 3. Curves for flushing for 6 diverse provenances at each of three test sites. Note that flushing occurred first at Drummondville and that Valcartier holds an intermediate position in regard to time of flushing. Of the southern red spruce provenances, provenance 2020 from West Virginia differed both in its time of flushing, and its general growth behaviour (see text). Although not the most southerly it is the slowest growing of all provenances at each of the 3 test sites. This may be explained by the fact that the growing season (130 days) near its place of origin is less than that (148 days) of 2019, the most southerly provenance (U.S.D.A. Weather Bureau 1933a, 1933b).

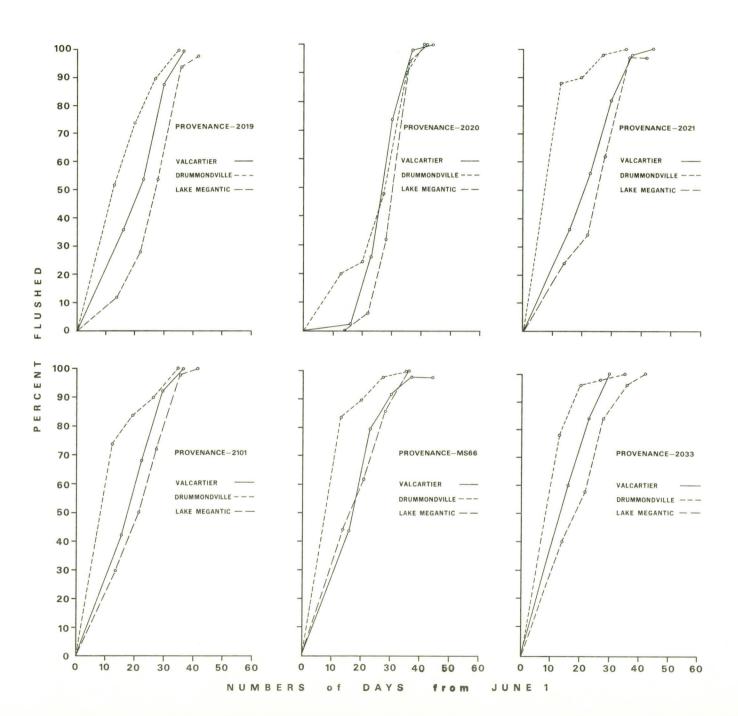
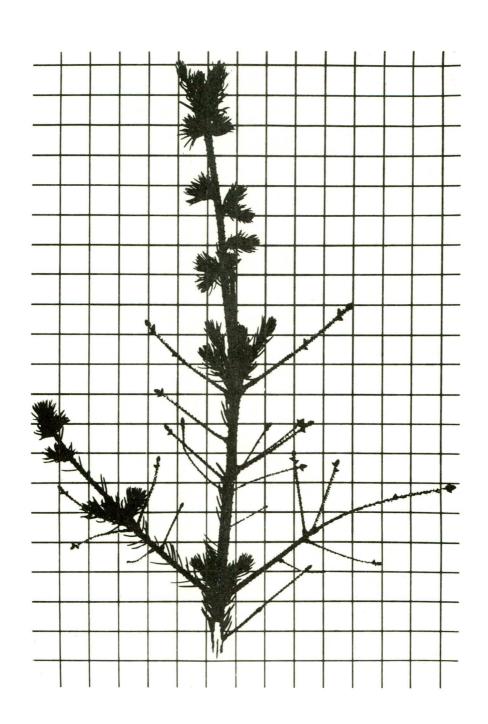


FIGURE 4. Damage to red spruce as a result of winter desiccation.

Note massive defoliation, and the stunted appearance of current year's foliage. Grid is one half inch.



#### RESULTS

Total height growth varies significantly between sites and provenances (Table 2). Height growth for all provenances, except one, is superior at Valcartier (Table 3, Fig. 2). Provenance 2020 (no. 2 Table 1) showed similar height growth at both Valcartier and Drummondville. However, provenance ranking in height growth is not significantly different between sites (Table 2). All provenances, except one, flushed first at the Drummondville site (Table 4, Fig. 3). Provenance 2020, which, as already noted, was exceptional in regard to total height growth, flushed at approximately the same time at Valcartier and Drummondville,

The relationships between time of flushing, total height growth and factors of the environment at each of the three test sites are given in Table 5. The effect of winter desiccation is illustrated in Fig. 4, and the percentage of each provenance thus affected is given in Table 6. Mortal ity at each test site is given in Table 7.

There is a significant correlation between latitude and time of flushing on all three test sites. Flushing and altitude are correlated at Drummondville only. The correlation is positive with latitude and negative with altitude. Southern latitude provenances, therefore, flushed later than northern provenances (Table 5).

Total height is significantly correlated with altitude and latitude at Megantic only, and not at the other two sites. Total height is, however, positively and strongly correlated with time of

flushing of provenances at each of the three test sites. The strongest correlation between total height and flushing is at Valcartier, the least strongest is at Drummondville. The Mégantic site holds an intermediate position. At the Valcartier site, 80 per cent of the variation in total height can be accounted for by differences in time of flushing as determined on June 14 (Table 5).

One defoliating insect (<u>Pikonema alaskensis</u>) was recorded in the Drummondville plantation but caused only minor damage.

### DISCUSSION

The effect of winter desiccation at Valcartier is more severe than at the other two sites. Nevertheless, the best height growth occurred at this site. Mortality is also lowest at Valcartier. It is clear, therefore, that the difference between the three sites in height increment has not been caused by winter desiccation. It is very likely, however, that repeated winter desiccation is partially responsible for the poor growth of all three plantations relative to that of plantations of other species of the same age in the region of the test sites. For example, a white spruce plantation of the same age at Valcartier, and directly adjacent to the test area, shows superior growth and is not affected by winter desiccation. Similarly at Drummondville, a European larch plantation on exactly the same site, and established at the same time as the red spruce provenance trial, is also taller and growing much more vigorously.

In the more susceptible provenances at each of the three test sites, winter desiccation resulted in reddening of the foliage, and subsequent defoliation of the affected branches. Trees thus affected flushed late in the season, and vegetative growth was inhibited, particularly on side branches. Leader growth appeared to be less drastically affected.

Following his assessment of diverse spruce and pine plantations at Pointe Taillon on the north shore of Lake St. John, Boynton (1957) made the following observation: "The number of survivors in the red spruce plantation is only two-thirds of the average for all spruce plantations, and since the site does not appear to be unfavourable it may perhaps be concluded that the species is not suited to the locality. Frost damage to the current year's foliage was much more evident on red spruce than on either of the two other species (white spruce and Norway spruce) and the thin, ragged crowns indicate that this damage occurred repeatedly in past years".

Boyton's reference to thin ragged crowns indicates that the plantation had repeatedly suffered winter desiccation rather than direct frost damage.

Pomerleau (1962), who first observed and described the phenomenon of winter desiccation of red spruce in Quebec, has recorded wide-spread damage in natural stands of this species in southwestern Quebec as a result of exceptionally mild weather in March 1962. This author also noted that white and black spruce, and balsam fir (Abies balsamea (L) Mill.) did not exhibit the same symptoms even when their

branches were close or intermingled with those of the affected red spruces.

It seems clear from the evidence presented here, that red spruce grown in plantations in Quebec is likely to be much more susceptible to winter desiccation than either of the other two spruce species indigenous to the province, that is, white spruce (Picea glauca (Moench) Voss.), and black spruce (P. mariana (Mill.) BSP). The evidence also suggests that repeated winter desiccation has a detrimental effect on the growth and vigour of the species.

Of the three test sites, Valcartier is the coolest and wettest during the growing season, and Drummondville the warmest and dryest (Fig. 1.) Mean height growth and survival (Tables 3 and 7) appear to reflect these differences in climate at each of the three sites, indicating that the Valcartier site provided the most favourable conditions for growth of the species.

Many of the provenances included in this study are also incorporated in an investigation of introgressive hybridization in red and black spruce conducted by Morgenstern and Farrar (1964). Of these provenances, numbers 13 and 15 (Table 1) are respectively from Saint Charles de Mandeville, and Valcartier in Quebec. Morgenstern and Farrar on the basis of taxonomic data, classified the Saint Charles de Mandeville provenance as a hybrid between red and black spruce. The Valcartier provenance was classified as pure red spruce. The differential growth behaviour of these two provenances in Quebec tends to confirm this classification. The Valcartier provenance flushed later, and

showed inferior height growth to the Saint Charles de Mandeville provenance at all three sites. Moreover, the Valcartier provenance, though growing at Valcartier the region where it originated, showed 86 per cent winter desiccation, whereas the Saint Charles provenance showed only 36 per cent at this site.

Two other provenances included in the present study were also previously classified by Morgenstern and Farrar as hybrids. These are numbers 2103 and 2505 (nos. 12 and 14 Table 1). On the basis of its origin (it was collected from a stand growing in a swamp) and relatively vigorous growth rate at all three test sites, it is probable that provenance 2021 (no. 3 Table 1) is also a hybrid. Of the three provenances south of latitude 41°00° this provenance was the first to flush at all three test sites.

On the evidence of the present study, and that of Morgenstern and Farrar, it seems clear that the most vigorous growth at the three test sites in Quebec is exhibited by provenances of probable hybrid origin.

A number of investigators have noted that red spruce exhibits a marked growth periodicity, and that compared to its associates it is one of the latest species to start height growth in the spring (Cook 1941, Hart 1959). The growth curves given in Figure 2 indicate that this characteristic of red spruce in natural stands is also apparent in plantations.

## CONCLUSIONS

A number of tentative conclusions can be drawn from these data and may be enumerated as follows:

- (1) Red spruce is identifiable from black spruce in Quebec not only by taxonomic criteria but also by its growth behaviour in plantations.
- (2) As a plantation tree in pure stands in Quebec red spruce is likely to be of less value on many sites than either white or black spruce, Norway spruce (P. abies L. Karst.), tamarack (Larix laricina (Du Roi) K. Koch), European and Japanese larch (Larix decidua Mill., and L. Leptolepsis Sieb.).
- (3) It is possible that if planted in mixtures of hardwood species with which it is naturally associated in Quebec the silvicultural potential of red spruce would be better exploited.
- (4) The hybrid between black and red spruce is likely to have greater sylvicultural potential as a plantation tree in Quebec than pure red spruce.
- (5) The diverse provenances of red spruce at each of the three test sites in Quebec can be used as breeding stock in a program of interspecific hybridization.
- (6) If many diverse provenances of black and red spruce were used in a breeding program, the possibility of producing a hybrid of silvicultural value in Quebec would be increased.

# ACKNOWLEDGEMENTS

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#### LITERATURE CITED

- Boughner, C.C., R.W. Longley, and M.K. Thomas. 1956. Climatic Summaries,
  Vol. III, Frost Data, Met. Div., Can. Dept. of Transport, Toronto,
  Ont. 94 p.
- Boyton, J.C. 1956. A survey of the Pointe Taillon plantations of the Saguenay Power Company, and the establishment of plantation plots. Project Q-68. Unpublished report Dept. of Fish. and For. For. Res. Lab. Quebec.
- Brunet, 0. 1966. On the Canadian species of the genus <u>Picea</u>. Can. Nat. New Ser. 3: 102-110.
- Cook, D.B. 1941. Five seasons growth of conifers. Ecology 22: 284-296.
- Fréchette, J.G. 1965. Le climat de Valcartier station d'expérimentation forestière. Publication M-17. Ministère des Richesses Naturelles, Québec. 31 p.
- Heimburger, C.C. and A.E. Porsild. 1938. Red spruce in the Lower Gatineau valley. Can. Field Nat. 52: 72-73.
- Heimburger, C.C. 1939. Notes on red spruce. For, Chron. 15: 226-227.
- Halliday, W.E.D. and A.W.A. Brown. 1943. The distribution of some important forest trees in Canada. Ecology 24: 353-373.
- Hart, A.C. 1959. Silvical characteristics of red spruce (<u>Picea rubens</u>).

  Northeast For. Expt. Sta. paper 124. 19 p.

- Jurdant, M.L. 1968. Ecological classification of forest lands: an integrated vegetative-soil-landform approach. Ph.D. thesis Cornell University, 414. p.
- Lawson, G. 1896. Remarks on the distinctive characteristics of the Canadian spruces species of spruce. Can. Rec. Sci. 7: 162-175.
- Marie-Victorin, Frère. 1927. Les gymospermes du Québec. Inst. Bot. Univ. Montréal Contr. 10. 147 p.
- Morgenstern, E.K. and J.L. Farrar. 1964. Introgressive hybridization in red spruce and black spruce. Pub. No. 608. Can. Dept. For., Res. branch. 46 p.
- Oostings, J.H. and W.D. Billings. 1951, A comparison of the virgin spruce-fir forest in the northern and southern Appalachian system. Ecology 32: 84-103.
- Pomerleau, R. 1962. Severe winter browning of red spruce in southeastern Quebec. Bi-monthly progs. rep. 18: 3. Can. Dept. For. Ent. and Path.
- Rowe, J.S. 1959. Forest Regions of Canada, Bulletin 123. Can. Dept. of Northern affairs and Nat. Res. For. Br. 71 p.
- U.S.D.A. Weather Bureau 1933a. Climatic summary of the United States.

  Section 72, northwestern Virginia. 17 p.
- U.S.D.A. Weather Bureau 1933b. Climatic summary of the United States.

  Section 95, western North Carolina. 24 p.

Table 1. GEOGRAPHIC ORIGIN IN ORDER OF INCREASING LATITUDE OF FIFTEEN RED SPRUCE PROVENANCES

No.	Provenance	Origin	Lat.(N.)	Long. $(W_{\bullet})$	Elev.(ft.)
1	2019	Great Smoky Mts., N.C.	35°361	83°271	5300
2	2020	Monongahela Nat. For., W.Va.	38°38 1	79°50 1	3800
3	2021	Bear Meadows, Penn.	40°45 1	77°45'	1820
4	2022	October Mts., Mass.	420221	73°15'	1800
5	2031	Andorra Forest, N.H.	43°05 •	72°07!	1700
6	2101	Digby County, N.S.	44°10'	65°54:	150
7	2024	Essex County, N.Y.	44°25'	73°40 !	2000
8	2023	Paul Smiths, N.Y.	44°25 1	74°15'	1600
9	2030	Amherst, Maine.	44°54 1	68°231	460
10	2100	Halifax County, N.S.	45°12 '	620441	250
11	2102	St. John County, N.B.	45°25 ·	65°241	300
12	2103	Acadia Forest Exp. Sta., N.B.	46°00 •	66°201	225
13	2033	Saint Charles de Mandeville, P.Q.	46°30 •	75°201	690
14	2505	Acadia Forest Exp. Sta., N.B.	46°371	66°401	225
15	2032	Valcartier Forest Exp. Sta., P.Q.	46°551	71°33 '	900

Table 2. POOLED ANALYSIS OF VARIANCE FOR TOTAL HEIGHT OF FIFTEEN RED SPRUCE
PROVENANCES AT EACH OF THREE TEST SITES IN QUEBEC

Sources of Variation	D.F.	S.S.	$M \cdot S \cdot$	F
Test site	2	8.91	4.45	33.29 xxx
Provenance	15	17.15	1.14	8.54 <b>***</b>
Interaction	30	4.01	0.13	N.S.
Pooled error	135	25.87	0.19	

Significant at .001 level of probability, N.S.- not significant

Table 3. HEIGHT OF FIFTEEN PROVENANCES OF RED SPRUCE AT EACH OF THREE TEST IN QUEBEC

No.	Provenance	Lat o(N)	Long.(W)	Elev.(ft.)		Height (meters)	
					Valcartier	Lac Megantic	Drummondville
7.	2019	35°361	83°271	5300	1.09	.68	• 71
2	2020	38°381	79°50 !	3800	.71	.58	• 72
3	202].	40°451	77°451	1820	127	1.01	1.11
14	2022	120221	73°15'	1800	.94	.63	•59
5	2031	43°05 1	72°071	1700	1.03	.62	c 60
6	2101	197 <sub>0</sub> 10 1	65°54'	150	1.17	.91	. 70
7	2024	Lili <sup>0</sup> 25 1	73°40 t	2000	. 98	.80	.69
8	2023	44°251	74°15 !	1600	-	-	٠74
9	2030	44°54 :	68°23 1	460	•94	• 75	•69
10	2100	450121	62°LU:	250	.98	.89	•73
11	2102	45°251	65°241	300	.89	• 72	.54
12	2103	46°00 :	66°20 1	225	1.20	•97	1.04
13	2033	46°30 '	75°201	690	1.45	1.22	1.08
14	2505	46°371	66°40 1	225	1.46	1.32	1.11
15	2032	46°551	71°33'	900	1.17	.88	.86
Andrews and many and	a distribution del condition del condition con en experience del condition con della con-	Mean for	each test s	ite	1.09	0.86	0.79

Table 4. DATE OF FLUSHING OF FIFTEEN PROVENANCES OF RED SPRUCE AT EACH OF THREE TEST SITES IN QUEBEC<sup>1</sup>

No.	Provenance <sup>2</sup>	Valcartier	Lac Megantic	Drummondville
1	2019	21.5	27.0	13.0
2	2020	26.5	30.5	27.5
3	2021	21.0	25.5	7.5
4	2022	24.0	27.5	9.0
5	2031	20.0	29•5	12.5
6	2101	18.0	22.0	9.0
7	2024	24.0	30.0	7.5
8	2023	-	-	7.5
9	2030	25.5	28.5	7.5
10	2100	22.5	28.0	9.0
11	2102	25.0	27.5	9.0
12	2103	17.0	19.0	7.5
13	2033	12.5	19.0	7.5
14	2505	16.0	17.0	7.5
15	2032	16.5	25.5	11.0
Mean i	for each test site	21.0	25.0	10.0

Date of flushing is determined as the number of days after June 1 when 50 per cent of trees scored are flushed.

<sup>&</sup>lt;sup>2</sup> Provenances are listed in order of increasing latitude.

Table 5. RELATIONSHIPS BETWEEN GROWTH, TIME OF FLUSHING, AND FACTORS OF THE
ENVIRONMENT OF FIFTEEN RED SPRUCE PROVENANCES AT EACH OF THREE TEST
SITES IN QUEBEC

				VAL	CARTIER						
		LAT.	LONG.	ALT.	LVP	HT.	$^{\mathrm{F}}$ l	F <sub>2</sub>	F <sub>3</sub>	F <sub>4</sub>	
1	LAT.	1.000	-0.764	-0.909	-0.537	0.424	0.418	0.526	0.365		
2	LONG.		1.000	0.901	0.450	-0.162	-0.055	-0.207	-0.033	-0.008	
3	ALT.			1.000	0.448	-0.385	-0.295	-0.405	-0.240	-0.013	
4	LVP				1.000	-0.218	-0.027	-0.194	-0.243	0.303	
5	HT					1.000	0.893	0.881	0.797	0.302	
6	Fl						1.000	0.949	0.903	0.470	
7	F <sub>2</sub>							1.000	0.888	0.14740	
8	F <sub>3</sub>								1.000	0.373	
9	F <sub>4</sub>									1.000	
				LAC M	ÉGANTIC						
1	LAT.	1.000	-0.764	-0.909	-0.537	0.523	0.560	0.456	0.421	0.408	
2	LONG.		1.000	0.901	0.456	-0.339	-0.240	-0.197	-0.191	-0.485	
3	ALT.			1.000	0.448	-0.526	-0.477	-0.401	-0.400	-0.449	
4	LVP				1.000	-0.338	-0.272	-0.286	-0.185	-0.465	
5	HT					1.000	0,826	0.842	0.817	0.439	
6	Fl						1.000	0.963	0.928	0.368	
7	F <sub>2</sub>							1.000	0.954	0.453	
8	F <sub>3</sub>								1.000	0.433	

Table 5. (continued)

# DRUMMONDVILLE

		LAT.	LONG.	ALT.	LVP	HT.	$F_{1}$	F <sub>2</sub>	F <sub>3</sub>	$F_{4}$
1	LAT.	1.000	-0.744	-0.903	-0.519	0,182	0,519	0.500	0.486	0.397
2	LONG.		1.000	0.894	0.391	0.068	-0.471	-0.404	-0.342	-0.280
3	ALT.			1.000	0.406	-0.191	-0.592	-0.540	-0.479	-0.384
1	LVP				1,000	-0.095	-0.147	-0.148	-0.115	0.149
5	HT .					1,000	0.501	0.507	0.411	0.377
6	Fl						1,000	0.959	0.860	0.776
7	F <sub>2</sub>							1,000	0.930	0.826
8	F <sub>3</sub>	0.497	significan	nt at .	.05 probab:	ility lev	vel		1.000	0.861
9	F4	0.623	significa	nt at .	.01 probab	ility le	vel			1.000

LAT - latitude; LONG - longitude; ALT - altitude; LVP - length of vegetative period; HT - height;  $F_1, F_2, F_3$  and  $F_4$  respectively per cent flushed on June 14, 22, 28 and July 8.

Table 6. PER CENT OF FIFTEEN RED SPRUCE PROVENANCES AFFECTED BY WINTER DRYING AT EACH OF THREE TEST SITES IN QUEBEC<sup>1</sup>

No.	Provenance	Valcartier	Lac Mégantic	Drummondville
1	2019	96	36	64
2	2020	78	46	78
3	2021	86	45	76
4	2022	80	5/1	70
5	2031	82	32	64
6	2101	82	36	60
7	20214	80	30	56
8	2023	-	-	60
9	2030	78	214	56
10	2100	90	30	50
11	2102	78	18	26
12	2103	70	54	46
13	2033	36	32	12
14	2505	56	30	40
15	2032	86	20	34
Mean i	for each test si	ite 77	33	53

<sup>1</sup> A tree was scored as affected if needles were reddish-brown in colour and if defoliation occurred. The assessment was made in the spring of 1968.

Table 7. PER CENT SURVIVAL OF FIFTEEN RED SPRUCE PROVENANCES AT EACH OF THREE TEST SITES IN QUEBEC

No.	Provenance	Valcartier	Lac Mégantic	Drummondville
1	2019	96	65	71
2	2020	90	814	63
3	2021	94	79	77
4	2022	92	88	67
5	2031	96	86	73
6	2101	92	96	69
7	20214	94	92	61
8	2023	-	-	61
9	2030	90	96	73
10	2100	88	86	71
11	2102	94	90	71
12	2103	74	94	82
13	2033	94	94	77
14	2505	96	92	86
15	2032	92	75	77
Mean	for each test are	a 92	87	72

