

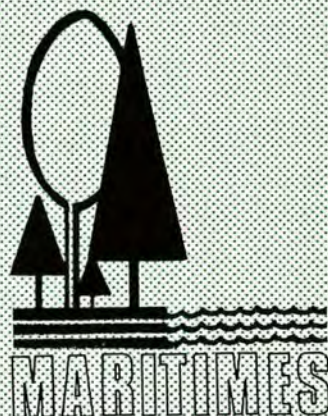
NORWAY SPRUCE
FROM 11 SEED SOURCES
(MD22. EXP. 16)
2x2 STOCK PLANTED SPRING 1961
SPACING: 6x6

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PROVENANCE TRIALS OF NORWAY SPRUCE IN THE MARITIMES

BY
D. P. FOWLER
AND
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CANADIAN FORESTRY SERVICE

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Maritimes Forest Research Centre

Fredericton, New Brunswick

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CONTENTS

	Page
LIST OF FIGURES.	iii
LIST OF TABLES	iv
ACKNOWLEDGMENTS.	vi
ABSTRACT AND RESUME.	vii
INTRODUCTION	1
GEOGRAPHIC VARIATION	3
DAMAGING FACTORS	4
TESTS OF NORWAY SPRUCE IN THE MARITIMES REGION	6
EXPERIMENT 16.	8
Materials and Methods.	8
Experiment 16A, Acadia Forest Experiment Station, Sunbury Co., N.B.	8
Experiment 16C, Green River, Restigouche Co., N.B.	11
Experiment 16 (PFES), Corbett Lake, Annapolis Co., N.S..	11
Results.	11
Experiment 16A	11
Experiment 16C	13
Experiment 16 (PFES),.	13
EXPERIMENT 31 Acadia Forest Experiment Station.	16
Materials and Methods.	16
Results.	16
EXPERIMENT 33 Acadia Forest Experiment Station.	20
Materials and Methods.	20
Results.	20
EXPERIMENT 35.	23
Materials and Methods.	23
Experiment 35A, St. Jacques, Madawaska Co., N.B.	23
Experiment 35B, Acadia Forest Experiment Station	23
Experiment 35C, Caledonia, Guysborough Co., N.S.	23
Results.	25
Experiment 35A	25
Experiment 35B	25
Experiment 35C	28
Experiment 35, Overall Results	28
EXPERIMENT 39-40	29
Materials and Methods.	29
Experiment 39-40A, Acadia Forest Experiment Station.	29
Experiment 39-40B, Cape Breton Highlands, Inverness Co., N.S.	32
Results.	32
Experiment 39-40A.	32
Experiment 39-40B.	36

	Page
EXPERIMENT 41.	36
Materials and Methods.	36
Experiment 41B, Acadia Forest Experiment Station	36
Experiment 41C, Marydale, Antigonish Co., N.S.	37
Results.	37
Experiments 41B and 41C.	37
EXPERIMENT 42 Acadia Forest Experiment Station.	38
Materials and Methods.	38
Results.	40
EXPERIMENT 43 Chipman, Queens Co., N.B.	42
Materials and Methods.	42
Results.	43
EXPERIMENT 70.	49
Materials and Methods.	49
Experiment 70A, Acadia Forest Experiment Station	51
Experiment 70B, Ten Mile Lake, Queens Co., N.S.	51
Results.	51
Experiment 70A	51
Experiment 70B	54
EXPERIMENT 99 Acadia Forest Experiment Station.	54
Materials and Methods.	54
Results.	56
COMPARISON WITH NATIVE SPRUCES	57
Survival	57
Height	57
Damaging Factors	60
EFFECT OF SELECTION WITHIN PROVENANCES	62
SUITABILITY OF NORWAY SPRUCE PROVENANCES FOR EASTERN CANADA.	63
Northern Europe.	63
East of Baltic Sea	63
Sudeten and Carpathian Mountains	64
East Germany	65
Alps and Jura Mountains.	66
Dinaric Alps and Balkan Mountains.	66
Non-native provenances	66
PROVENANCE RECOMMENDATIONS	67
REFERENCES	69

LIST OF FIGURES

	Page
1. Natural range of Norway spruce in Europe after Schmidt-Vogt (1977)	2
2. Location of replicated Norway spruce provenance trials in the Maritimes Region.	7
3. A classification for forest sites on the Acadia Forest Experiment Station after Loucks (1957)	10
4. Experiment 16. Geographic origin and relative height of Norway spruce in experiments 16A - Acadia Forest Experiment Station (O); 16C - Green River, N.B. (□); and 16(PFES) - Corbett Lake, N.S. (Δ).	15
5. Experiment 31. Geographic origin and relative height of Norway spruce in experiment 31 - Acadia Forest Experiment Station	19
6. Experiment 35. Geographic origin and relative height of Norway spruce in experiment 35A - Edmundston, N.B. (O); 35B - Acadia Forest Experiment Station (□); and 35C - Caledonia, N.S. (Δ)	27
7. Experiment 39-40. Geographic origin and relative height of Norway spruce in experiment 39-40A - Acadia Forest Experiment Station.	35
8. Experiment 42. Geographic origin and relative height of Norway spruce in experiment 42 - Acadia Forest Experiment Station	41
9. Experiment 43. Geographic origin and relative height of Norway spruce, grouped by provenance areas, in experiment 43 - Chipman, N.B.	48
10. Experiment 70. Geographic origin and relative height of Norway spruce in experiments 70A - Acadia Forest Experiment Station (O); and 70B - Queens County, N.S. (□)	53
11. Seed zones of the Maritime Provenances of Canada after Fowler and MacGillivray (1967).	68

LIST OF TABLES

	Page
1. Norway spruce provenance trials established in the Maritimes Region	6
2. Experiment 16. Provenance data.	9
3. Experiment 16A, Acadia Forest Experiment Station. Summarized data and analysis for 8-and 17-year measurements and observations.	12
4. Experiment 16C, Green River, N.B. and 16(PFES), Corbett Lake, N.S. Summarized data and analysis for 17-year measurements and observations.	14
5. Experiment 31. Provenance data.	17
6. Experiment 31, Acadia Forest Experiment Station. Summarized data and analysis for 5-and 10-year measurements and observations.	18
7. Experiment 33. Provenance data.	21
8. Experiment 33. Acadia Forest Experiment Station. Summarized data and analysis for 6-and 10-year measurements and observations.	22
9. Experiment 35. Provenance data.	24
10. Experiment 35A, Edmundston, N.B.; 35B, Acadia Forest Experiment Station; and 35C, Caledonia, N.S. Summarized data and analysis of measurements and observations for 8, 6, and 8 years respectively.	26
11. Experiment 39-40. Provenance data	30
12. Experiments 39-40A, Acadia Forest Experiment Station; and 39-40B, Cape Breton, N.S. Summarized data and analysis of measurements and observations for 5 and 6 years respectively	33
13. Experiment 41. Provenance data.	37
14. Experiment 41B, Acadia Forest Experiment Station; and 41C, Marydale, N.S. Summarized data of measurements for 6 and 7 years respectively	38
15. Experiment 42. Provenance data.	39

	Page
16. Experiment 42, Acadia Forest Experiment Station. Summarized data and analysis for 5-year measure- ments and observations	40
17. Experiment 43. Provenance region data	44
18. Experiment 43, Chipman, N.B. Summarized data for 5-year measurements and observations	46
19. Experiment 70. Provenance data.	50
20. Experiments 70A, Acadia Forest Experiment Station; and 70B, Queens County, N.S. Summarized data and analysis for 5-year measurements and observations.	52
21. Experiment 99. Provenance data.	55
22. Experiment 99, Acadia Forest Experiment Station. Summarized data and analysis for 3-and 6-year survival and 6-year height	56
23. Summary of survival of Norway, black, white, and red spruce	58
24. Summary of height of Norway, black, white, and red spruce	59
25. Summary of weevil and winter damage of Norway, black, white, and red spruce	61

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ABSTRACT

From 1961 to 1972, ten Norway spruce *Picea abies* (L.) Karst. provenance experiments were established in the Maritimes Region of Canada. One of these, an 1100 source range-wide trial is the only North American planting of the IUFRO 1964-68 experiment. The others are trials of Norway spruce from provenances considered "promising" for the Region. Native spruce were included as controls in all but one experiment. Results from all 10 experiments are reported in detail, best provenance areas are identified, and recommendations are made concerning their use in the Region.

Norway spruce from eastern Poland and from mid-elevation in the Sudetan and Carpathian Mountains of southern Poland can be expected to perform well when planted over a wide range of moist, cool, acid sites in central and southern New Brunswick, Prince Edward Island, and Nova Scotia. Norway spruce from east of the Baltic Seas, i.e. northeastern Poland, Latvia, Lithuania, western Russia, and White Russia is recommended for use in northern New Brunswick. Norway spruce cannot be recommended for planting on the Cape Breton Highlands.

RESUME

De 1961 à 1972, on a établi des essais de 10 provenances d'Épinette de Norvège dans la région des Maritimes au Canada. L'une d'elles, qui représente un essai de 1100 sujets est l'unique plantation nord-américaine de l'expérience IURFO 1964-68. Les autres sont des essais d'Épinette de Norvège de provenances considérées "prometteuses" pour la Région. Des Épinettes indigènes ont été incluses comme témoins dans toutes les expériences sauf une. Les résultats des 10 expériences sont rapportés en détail, les meilleures régions de provenance sont identifiées et des recommandations sont faites au sujet de leur utilisation dans la Région.

On peut s'attendre à une bonne performance de l'Épinette de Norvège provenant de l'est de la Pologne et d'altitudes moyennes du Sudety et des Monts Carpates au sud de la Pologne, lorsqu'elle est plantée dans une grande variété de stations humides, fraîches et acides au centre et au sud du Nouveau-Brunswick, dans l'Île-du-Prince Édouard et en Nouvelle-Ecosse. L'Épinette norvégienne de l'est de la Mer Baltique, c.a.d. du nord-est de la Pologne, de Lettonie, de la Lituanie, de l'ouest de la Russie, et de la

Average survival of Norway spruce and black spruce, *P. mariana* (Mill.) B.S.P., is the same (86%) in 13 plantings. Norway spruce generally survived better than either white spruce, *P. rubens* (Moench) Voss, (86% vs 79% for 15 plantings) or red spruce, *P. rubens* Sarg., (87% vs 78% for 12 plantings). Black spruce is taller than the best Norway spruce in all but one of 13 plantings, while Norway spruce is generally taller than either white or red spruce. It is suggested, however, that Norway spruce will surpass black spruce in volume growth over rotations of 40 to 50 years or more.

Russie blanche est recommandée pour le nord du Nouveau-Brunswick. Il n'est pas recommandé de la planter sur les hautes terres du Cap Breton.

La moyenne de survie de l'Epinette de Norvège et de l'Epinette noire est la même, soit 86% dans 13 plantations. L'Epinette de Norvège a généralement mieux survécu que l'Epinette blanche (86% vs 79% dans 15 plantations) et que l'Epinette rouge (87% vs 78% dans 12 plantations). L'Epinette noire est plus haute que la meilleure Epinette de Norvège dans 12 plantations sur 13, tandis que l'Epinette de Norvège est généralement plus haute que l'Epinette blanche ou rouge. On avance cependant que l'Epinette de Norvège surpassera la noire en volume de croissance au cours de révolutions de 40 à 50 ans ou plus.

INTRODUCTION

Norway spruce, *Picea abies* (L.) Karst., is a wide-ranging European species native from southern France and Yugoslavia to northern Scandinavia and from central Europe to Russia (Fig. 1). Along the eastern limit of its range, it merges with the closely related species, Siberian spruce, *P. obovata* Ledeb. A broad zone of hybridization exists where the two ranges overlap (Wright 1955) and several authorities consider Siberian spruce to be an eastern variety of Norway spruce. Schmidt-Vogt (1977) recognizes three main varieties of Norway spruce, *Picea abies* var. *accuminata*, *Picea abies* var. *europaea*, *Picea abies* var. *obovata*.

It is generally agreed that Norway spruce survived the last major glacial advances of the Pleistocene in three separate refugia; the southeastern Alps, the eastern Carpathian Mountains of Romania, and central Russia (Lindquist 1948; Wright 1955; Schmidt-Vogt 1977). Following the retreat of the glaciers, the species migrated from the refugia to become established over its present range. This migration has been active at least up to the last 1000 years (Faegri 1950) and may be continuing at present.

Norway spruce is the most important spruce of Europe in both quality and quantity. It has been planted extensively outside its natural range in Europe and was one of the first non-native species introduced to North America. European foresters, trained and nurtured on Norway spruce, planted their old friend as an ornamental or as a plantation species wherever they settled. As a result, Norway spruce has been the most widely planted exotic in eastern

North America. Extensive planting of Norway spruce began in the mid-1800's, and by 1936 over 120,000 acres (48 000 ha) of plantations existed in New England (Hosley 1936). The oldest recorded forest planting of Norway spruce in the Maritimes Region was carried out about 1918 (Hughes and Loucks 1962).

Growth of Norway spruce in eastern North America has generally been reported to be superior to that of native spruce growing on comparable sites (Hosley 1936; Hawley and Lutz 1943; MacArthur 1964; Hughes and Loucks 1962). Hosley (1936) reported on growth and development of 57 plantations in New England, the oldest of which was 70 years. All but one of these plantations had been established on abandoned agricultural lands. He considered the species to be well suited to fresh loam or sandy loam sites. The average yield of the 57 plantations was 85 cunits per acre (591 m³/ha) at 55 years and the best plantation yielded 130 cunits (911 m³/ha) at the same age. Hawley and Lutz (1943) also considered Norway spruce to be a potentially valuable species and reported yields of 43 M board feet per acre (610 m³/ha) at 60 years. Further north in Maine, Ashman (1958) reported yields of 30 cords/acre (269 m³/ha) at 32 years from unmanaged Norway spruce plantations. Information on source of seed used for the New England plantations is generally lacking.

MacArthur (1964) reported on the growth of 12 plantations in the Great Lakes - St. Lawrence Forest Region of Quebec, ranging in age from 30 to 45 years. Most of the plantations were established on abandoned farmland or otherwise disturbed soils. Best growth occurred on a wide range of

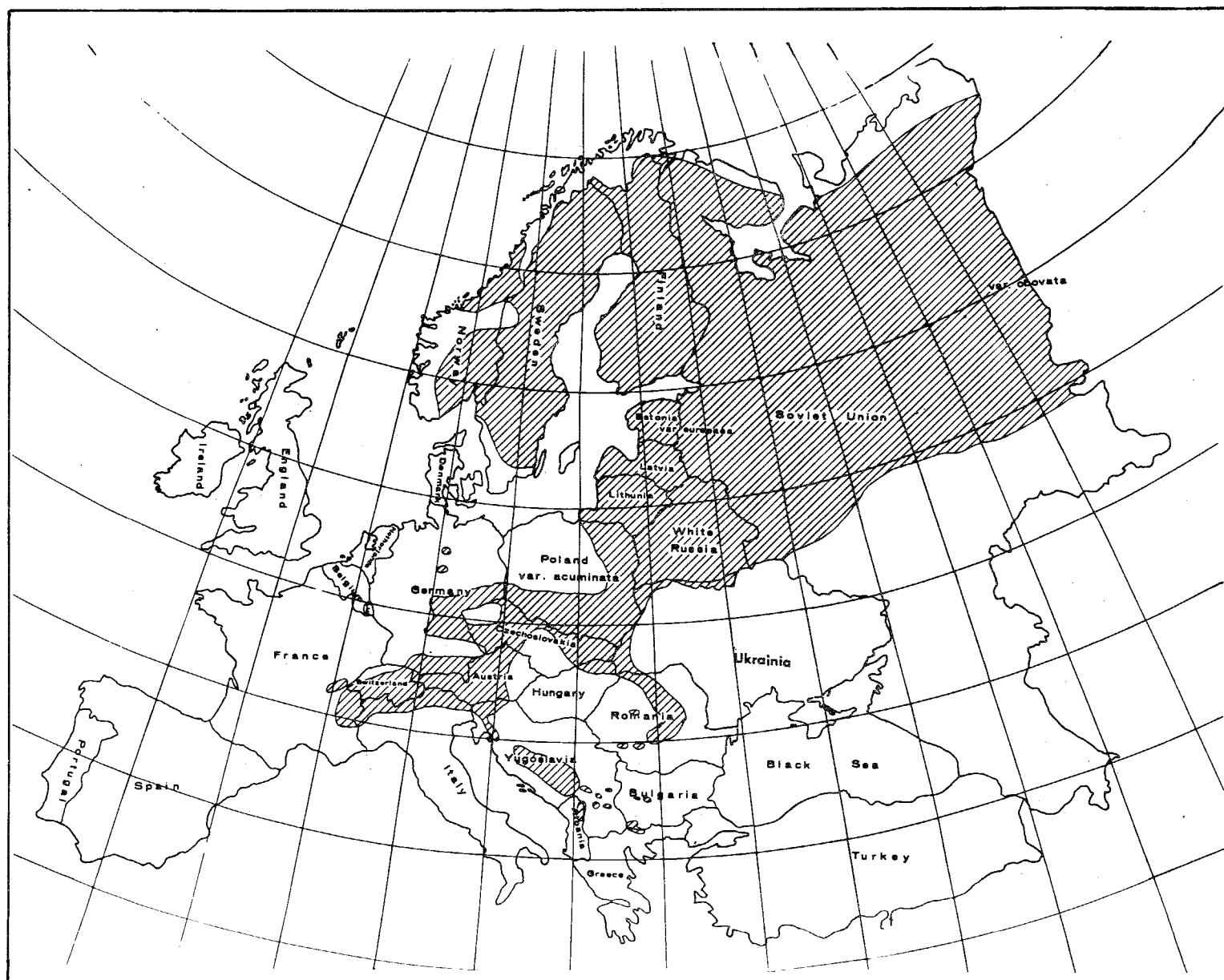


Fig. 1. Natural range of Norway spruce in Europe after Schmidt-Vogt (1977).

soils wherever moisture conditions were favorable. The better stands, although "unmanaged", produced 25-30 cords/acre (224- 268 m³/ha) in 30-40 years. Information on seed origin for the Quebec plantations is unreliable (MacArthur 1964) but it is suggested that Swedish and German sources were most likely used.

The oldest known forest plantings of Norway spruce in the Maritimes Region were carried out by the Pejepscot Paper Company about 1918. Several small plantations were established along the Bay of Fundy in Saint John County, N.B. Development and growth of these plantations were exceptional up to age 50 years. One unmanaged plantation established on an old-field site at Fownes Head had a mean annual increment of 1.7 cords/acre (15 m³/ha) (Hughes and Loucks 1962). These authors suggested that managed plantations of Norway spruce are capable of producing 2.2 cords/acre per year (20 m³/ha) on well-drained sites near the Bay of Fundy. The seed origin of these plantations is not known although Holst¹ suggests a German origin and probably the same provenance as that used near Orono, Maine (also planted by Pejepscot Paper Co.), Petawawa Forest Experiment Station (Hudson's Place) and Grand'Mère, Quebec. Growth of Norway spruce at the Fownes Head plantation is considerably greater than that of good red spruce, *Picea rubens* Sarg., and balsam fir, *Abies balsamea* (L.) Mill., growing on equivalent sites. Farther inland at the Acadia Forest Experiment Station (AFES), Norway spruce is less impressive. McLeod (1956) re-

ported that growth of Norway spruce was slightly less than that of white spruce, *P. glauca* (Moench) Voss, at 10-11 years of age and attributed this to more exacting site requirements of Norway spruce. Holst (1963) reporting on these same plantations, indicated that dominant height but not mean height was greater for Norway than for white spruce. The best Norway spruce in the AFES plantation was from second generation seed from the Proulx Plantations in Quebec; second best was from the Carpathian Mountains.

Bailey (1973) reported on the growth of four Norway spruce and five "hybrid" spruce (probably *P. abies obovata*) plantations in Nova Scotia. Yield of the Norway spruce plantations ranged from 74 to 126 ft³/acre per year (4.7-8.8 m³/ha) while that of the "hybrid" spruce ranged from 47-70 ft³/acre per year (3.3-4.9 m³/ha). The best Norway spruce plantations were clearly more productive than the best comparable plantations or stands of native spruces. No information is available on provenance used for any of these plantations.

GEOGRAPHIC VARIATION

Foresters in both Europe and North America have long recognized the importance of using Norway spruce seeds of proper provenance. However, it has only been during the last 40-50 years that detailed studies have been undertaken to determine the best provenance to use under different environmental conditions. The literature abounds with information on geographic variation in Norway spruce. Unfortunately, most of the information pertains to planting the species in Europe and little information is available

¹Holst, M.J. Pers. Commun. Petawawa Forest Experiment Station, Petawawa Ont.

for northeastern North America and very little for the Maritimes Region of Canada. Only a brief review of available information, with emphasis on eastern North America, will be presented here.

Norway spruce is a genetically variable species. With few anomalies, the pattern of variation is clinal and habitat correlated (Gathy 1960; Krutzsch 1975). The species has been reported to be genetically variable in respect to seed germination (Simak and Kamra 1970), time of flushing and resistance to spring frosts (Langlet 1960; Holzer 1969; Lacaze 1969; Lines 1973), duration of growth period and time of growth cessation (Dietrichson 1969), height and diameter growth (Baldwin 1953; Holst 1963), crown form (Schmidt-Vogt 1977), cone characteristics (Schmidt-Vogt 1977), and isozymes (Bergmann 1973; Tigerstedt 1974; Mejnartowicz and Bergmann 1977). The species is genetically variable at the geographic, population, and individual tree levels and as such is an excellent candidate for genetic improvement by selection and breeding.

Prior to the establishment of detailed provenance trials it was generally accepted that seeds from the south central and central part of the species range in Europe were most satisfactory for use in the northeastern United States (Hosley 1936). The first range-wide provenance trials of Norway spruce in North America were initiated in the late 1930's in cooperation with the International Union of Forest Research Organizations (IUFRO). Unfortunately, World War II, inadequate experimental designs, and a multiplicity of objectives reduced the effectiveness of these tests (Baldwin 1953). Holst (1963) in reviewing the results of the IUFRO trials in

North America, concluded that choice of seed source for use on good spruce sites in New England and eastern Canada was not critical. He suggested that any fast-growing, moderately-hardy provenances such as Crucea and Valdu Rau (Romania), Stolpce (Russia), Sveriosice (Czechoslovakia), Dolina (Ukrainian SSR) and Istebna (Poland) would produce more wood than native red, black, *P. mariana* (Mill.) B.S.P., and white spruces. This generally supports the recommendations of Ashman (1958) for the state of Maine, and Baldwin (1953) for the northeastern United States. Further support for these recommendations comes from an unreplicated 9-provenance trial planted at the Acadia Forest Experiment Station in which provenances from the Carpathian Mountains (Romania) and Riga (Latvia) performed well.

For the more continental parts of eastern Canada, Holst (1963) recommends the use of Norway spruce provenances from the southeast corner of the Baltic Sea, Poland, and White Russia. He considered proper choice of seed source to be critical for continental areas and recommended that this species be planted only on rich, fresh sites within the natural range of white spruce. Northern provenances from Scandinavia and Russia have proven to be slow-growing in all trials and are not recommended for planting in the northeast.

DAMAGING FACTORS

Norway spruce is more susceptible to damage by the white pine weevil, *Pissodes strobi* Peck., than are the native spruces. In areas of high weevil incidence, a large proportion of plantation trees may be damaged. Holst

(1973) points out, and our observations confirm, that there is much variation in the way the weevil damages individual trees. On some trees, the leader is killed back through two whorls giving rise to a pronounced, permanent crook similar to damage in white pine, *Pinus strobus* L. On other trees only the tip is killed, resulting in a small kink that straightens out and is not evident after a year or two. Provenance differences in susceptibility to weevil damage have not been demonstrated although it is highly probable that slow-growing northern provenances are less damaged. Holst (1955) suggests that the possibility of developing weevil resistant strains of Norway spruce are reasonably high. Holst and Heimbürger (1969) emphasize the importance of selecting for weevil resistance (or weevil tolerance) in any tree improvement work with this species.

Published information on the susceptibility of Norway spruce to damage by the spruce budworm, *Choristoneura fumiferana* (Clemens), is not readily available. Our observations of plantations in central and southern New Brunswick indicate that Norway spruce is highly susceptible. We rate Norway spruce in the same susceptibility category as red spruce and somewhat more susceptible to serious damage than white spruce. No evidence of differences in budworm susceptibility has been noted among provenances or among individual trees within provenances, although such variation may exist.

Cold resistance generally is not a serious problem with Norway spruce planted on good spruce sites in coastal parts of the Maritimes Region. In more conti-

nental areas and especially when planted off site or in frost pockets, serious damage can occur. Considerable variation in cold resistance exists among provenances as well as among individual trees. Holzer (1969) suggests that resistance to late spring frosts is closely related to flushing time rather than to cold resistance *per se*. Good opportunities exist to select fast-growing provenances that flush late (Langlet 1960) for areas where late spring frosts are common.

Winter drying or winter browning is generally common on Norway spruce planted on exposed sites and is especially prevalent when the trees first become exposed above the snow. Generally, it is not serious except in extreme situations for, although some foliage is lost, the buds survive and grow normally. Once the plantation has closed, winter drying occurs only on exposed edge trees or under unusually severe climatic conditions.

Ashman (1958) considers the porcupine to be a serious, but controllable, enemy of Norway spruce. Our observations indicate that Norway spruce is not a preferred food of the porcupine, *Erethizon dorsatum dorsatum* L., and while some feeding damage has been noted it usually occurs in areas with high porcupine populations or where plantations are located in the vicinity of porcupine dens. Norway spruce is comparable to red spruce and white spruce in susceptibility to porcupines.

The red squirrel, *Tamiasciurus hudsonicus* (Erxleben), and pine grosbeak, *Pinicola enucleator* L., can, on occasion, cause extensive damage to young Norway spruce trees by debudding. Also, snowshoe hare, *Lepus americanus*

Erxleben, and deer, *Odocoileus virginianus* (Zimm.), may browse young Norway spruce. Although these animals may cause serious damage locally, they do not generally pose great problems.

A branch and stem canker, *Valsa kunzei* Fr. var. *picea* Waterman, has been reported to cause damage to Norway spruce planted on warm, dry sites in Ontario (Jørgensen and Cafley 1961) and Quebec (Ouellette and Bard 1962). This pathogen does not appear to be important on sites where adequate moisture is available and has not been reported as a problem in the Maritimes Region.

TESTS OF NORWAY SPRUCE IN THE MARITIMES REGION

Starting in the late 1950's the Maritimes Forest Research Centre (MFRC), Canadian Forestry Service, embarked on a long-term program of provenance testing Norway spruce. The objectives of this program are to determine the best Norway spruce provenances for use in various parts of the Maritimes Region and to accumulate enough

materials for future selection and breeding work. The experiments and their locations are shown in Table 1 and Fig. 2, respectively.

Several of the experiments represent cooperative undertakings with the Petawawa Forest Experiment Station (PFES Exp. No. listed in Table 1). For these experiments, most of the Norway spruce seeds were acquired by Mr. Mark Holst (PFES) and sent to MFRC. The seeds were sown, along with appropriate "local" controls in the Acadia Forest Experiment Station nursery and field plantings were established in the region by Mr. H.G. MacGillivray.

Except for experiment 43, one replicated plantation of each experiment was planted on the Acadia Forest Experiment Station which is situated in the Bantalor District of the New Brunswick Lowlands Ecoregion (Loucks 1962) in Maritimes Seed Zone 2 (Fowler and MacGillivray 1967). The area characteristically receives adequate precipitation (86-96 cm) well distributed throughout a 110 to 130-day growing season. Topographically, AFES is flat to

Table 1. Norway spruce provenance trials in the Maritimes Region

Experiment Number		Number of provenances (including controls)	Year planted	Locations planted	
MFRC	PFES			Replicated	Observation
16	58	11	1961	2	12
31	265	18	1967	1	2
33	265	12	1967	1	9
35	277	27	1969	4	3
39-40	310, 320, 321	44	1971	1	20
41	321	6 ¹	1970	2	0
42	--	10	1972	1	0
43	--	1100	1967	1	0
70	350	22 ²	1972	2	3
99	--	12	1972	1	1

¹ Includes 20 single tree progenies.

² Includes 45 single tree progenies.

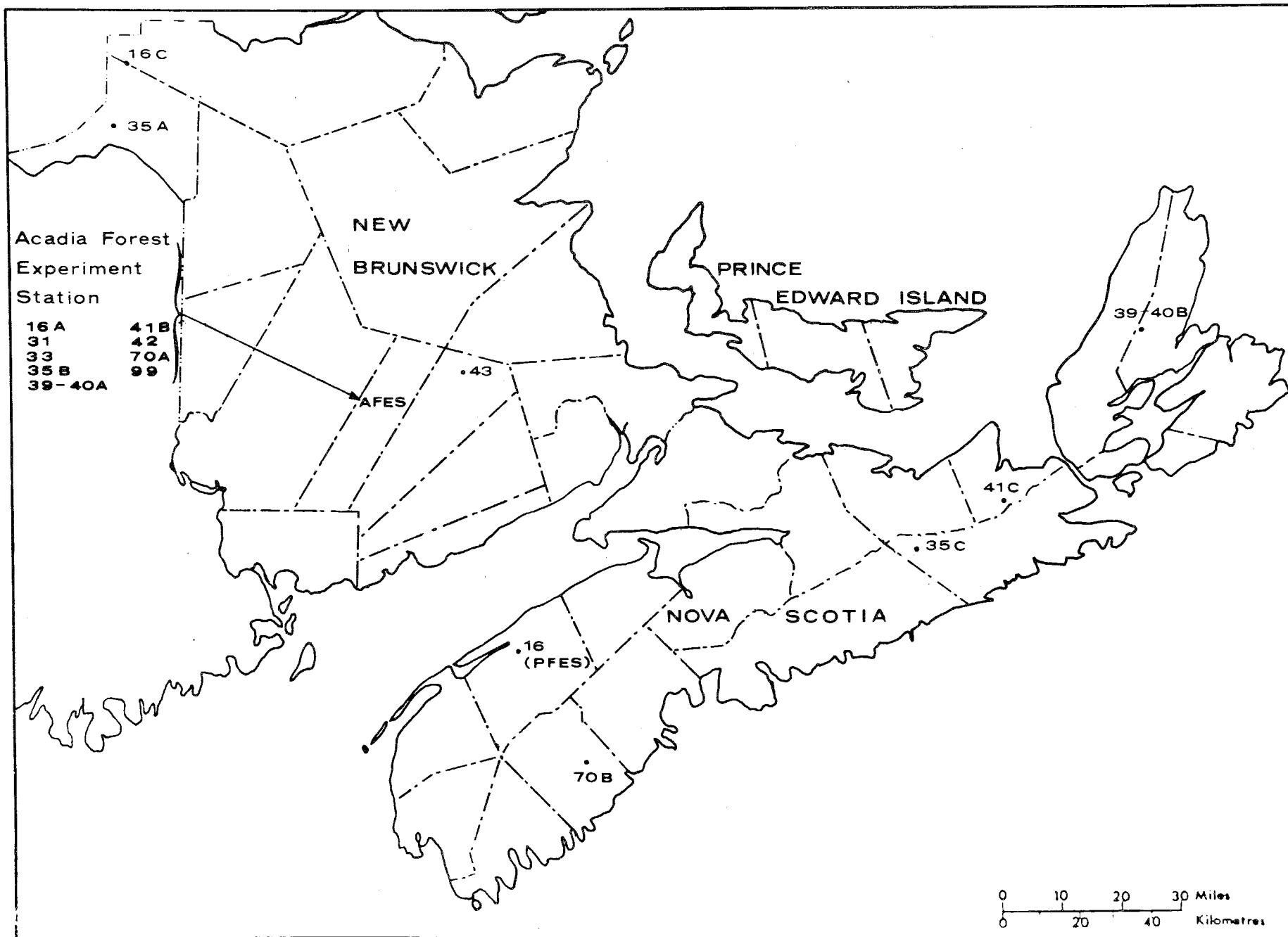


Fig. 2. Location of replicated Norway spruce provenance trials in the Maritimes Region.

undulating with an elevational range of 75-150 m. The soil, usually a heavy, often poorly-drained basal till overlies carboniferous sandstone and mudstone. A forest site classification (Loucks 1957²) for AFES based on moisture, richness, and normal successional trends is presented in Fig. 3 and is used throughout this paper to help describe planting sites at AFES.

Other plantations were established elsewhere in the region in cooperation with provincial and industrial organizations. Also, many unreplicated "observation" plots were established to provide supporting information, but more important, to provide additional material of known origin for future selection and breeding work.

Only one of the experiments (43) is a range-wide study. The others are tests of provenances from parts of the species range that are considered to be promising. Experiment 43 is the only North American planting of the IUFRO 1964-1968 trial.

In this report, we present pertinent information on each of the 10 trials, discuss the implications, and as far as possible, make recommendations as to choice of seed for use in various parts of the Maritimes Region.

EXPERIMENT 16

Material and Methods

The Norway spruce seeds of provenances tested in this experiment were acquired by Mark Holst

² Loucks, O.L. 1957. Site classification during 1957 at Acadia and Green River. Can. Dep. North. Aff. Nat. Resour. For. Br. Marit. Dist. File Rep. 186. Mimeo.

and are listed with pertinent data in Table 2. The seeds were sown in unreplicated nursery beds at the Acadia Forest Experiment Station in the spring of 1957 and raised to 2+2 stock. In the spring of 1961, one designed experiment (16A) was established at AFES and several observation trials (16B-K) were planted elsewhere in the region. Only observation trial 16C was established in a manner suitable for analysis.

Experiment 16A, Acadia Forest Experiment Station, Sunbury Co., N.B.

Norway spruce from eleven Austrian, German, and Polish provenances were included in this test. The experimental design was a rectangular lattice replicated three times. One seed source (MS 85) was included twice to fill out the design. One hundred-tree plots (10 x 10 trees) were planted at 6 x 6 ft spacing (1.8 m) with a single row of local white spruce surrounding each plot. A second row of white spruce was planted as surrounds for the three contiguous replications.

The planting site, a recent clear cut, previously carried an early successional mixedwood cover of red maple, *Acer rubrum* L., white birch, *Betula papyrifera* Marsh. balsam fir, and spruce *Picea* spp. The site, located on a 10° north slope, is moderately rich, moderately fresh, and would normally support a mixedwood succession (AFES site 4; Fig. 3). All logging debris was cleared from the site before planting and in 1968 hardwood stump sprouts and seedlings were sprayed with Brushkill 96, 1.5 lb ai/acre to reduce competition.

Following the dry summer of 1965, annual height growth was

Table 2. Experiment 16 Provenance data

MS ¹	Species	Provenance	<u>Latitude</u>	<u>Longitude</u>	<u>Elevation</u>	<u>Type</u> <u>collection</u>
			°N	°E	m	
85	SN ²	Istebna, Poland	49.6	18.9	600	Stand
86	SN	Nagold Schwarzwald, Germany	48.6	8.7	550	Stand
87	SN	Westerhof, Harzen, Germany	51.8	10.2	200-400	Stand
88	SN	Thuringen, Germany	50.5	11.0	400	Stand
89	SN	Schwäbischen Alb, Germany	(48-49)	(8.9-10.5)	500-600	Stand
90	SN	Millstatt, Austria	46.8	13.1	700	Stand
91	SN	Zwettl, Austria	48.6	15.2	600	Stand
92	SN	Trieben, Austria	47.5	14.5	1000	Stand
93	SN	Vopau, Austria	47.4	15.8	750	Stand
94	SN	Nauders, Austria	46.8	10.5	1400	Stand
95	SN	Kowary, Sudeten Mts., Poland	50.7	15.8		Stand
96	SN	Halifax, Nova Scotia	44.7	63.6°W	--	Plantation
51	Sw	Green River, New Brunswick	47.8	68.3°W	400	
52	Sw	AFES, New Brunswick	46.0	66.3°W	100	Stand
249	Sw	Green River, New Brunswick	47.8	68.3°W	400	Stand

¹ MS = Maritime Seed Number assigned to seeds acquired at MFRC.

² SN = Norway spruce; Sw = white spruce.

		Site Codes									
		← Moisture					Regime →				
		very dry									very wet
		0	1	2	3	4	5	6	7	8	9
Richness	very rich	1				1					
	2				2		3				
	3			4		5		6			
	4		7		8		9		10		
very poor	5	11		12		13		14		15	

These codes indicate mixedwood succession (normal ecoclimate)

Codes 20 units higher than in triangle indicate coniferous succession (cooler ecoclimates)

Codes 40 units higher than in triangle indicate hardwood succession (warmer ecoclimates)

Fig. 3. A classification for forest sites on the Acadia Forest Experiment Station.

considerably reduced. Total height of all trees and periodic height increment for the years 1964-68 were measured in July-August 1968. Observations of winter browning (winter of 1967), mortality caused by shoe string fungus, *Armillaria mellea* (Vahl ex Fr.) Kummer, and overall survival were also recorded. Total height to the end of the 1976 growing season was measured again in June 1977. At this time, observations on survival, weevil damage, and multiple leaders were recorded for 25 trees in the center of each 100-tree plot.

Experiment 16C, Green River, Restigouche Co. N.B.

Twelve provenances of Norway spruce (the 11 provenances of Exp. 16A plus 1 Halifax, N.S. plantation source) were tested in this trial. A randomized block, 2 replications, 100-tree (10 x 10) plot design was used. Seedlings from three provenances of white spruce of which two were "local" sources were planted adjacent to the Norway spruce in a randomized block, 2 replications, 100-tree plot design. The trial was planted at 6 x 6 ft (1.8 m) spacing in June 1961 near Summit Depot, Green River Watershed, N.B. (lat. 47.8°N, long. 68.3°W). The planting site was a new clear cut which had previously carried a mixedwood cover of yellow birch, *Betula alleghaniensis* Britton, sugar maple, *Acer saccharum* Marsh. balsam fir, and spruce. The site is fresh with a 10-15° northeast slope. The logging debris was cleared from the site before planting. Total height was measured and observations on survival, weevil and top damage, frost damage, and budworm damage were recorded in August 1977 for

25 trees in the center of each 100-tree plot.

Experiment 16 (PFES), Corbett Lake, Annapolis Co. N.S.

In the spring of 1956, Mark Holst provided Bowaters-Mersey Paper Co. Ltd. with seedlings of four of the same provenances used for MFRC Exp. 16 A. A trial consisting of four blocks each containing about 200, 2+2 transplants from each of four provenances was established at an elevation of 200 m near Corbett Lake, Annapolis County, N.S. The test site was gently sloping abandoned farmland with a coarse, well-drained sandy loam over granite bedrock. The trees were planted at 5-ft (1.5 m) spacing in plowed furrows 6 ft apart. Data on the establishment and growth of this test are available (Roller and Hunter 1974). Height and diameter were measured for every fifth surviving tree and observations on survival, and damage (porcupine and weevil) were recorded when the test was 17 years old. Data are reported here for comparison.

Results

Experiment 16A:

Survival and height at 8 years, and survival, weevil damage, height, height of tallest 40% of trees, and rankings of all provenances at 17 years from planting are presented in Table 3. Provenance height data at 17 years are presented geographically in Fig. 4. Differences among provenances in survival and weevil damage are not significant. Highly significant differences in height are evident at 8 and 17 years. It should be noted that although considerable change in ranking occurred between 8 and 17 years, four of the five

Table 3. Experiment 16A, Acadia Forest Experiment Station. Summarized data and analysis for 8- and 17-year measurements and observations

MS	Species	8 year			17 year				Tallest 40% m	Rank
		Survival	Height	Rank	Survival	Weevil damage	Height	Rank ¹		
		%	cm		%	%	m			
85	SN	94	130	3	93	20	4.1	2a	5.0	3ab
86	SN	95	123	7	95	13	3.7	8 bcde	4.6	7 cde
87	SN	90	129	4	95	25	3.6	9 cde	4.6	7 cdef
88	SN	86	120	8	79	19	3.8	6 bcd	4.5	9 def
89	SN	92	134	2	81	5	4.1	2ab	4.9	4abc
90	SN	91	115	10	87	17	3.3	11 e	4.3	10 ef
91	SN	86	111	11	87	17	3.4	10 de	4.0	11 f
92	SN	94	141	1	77	22	4.1	2abc	4.8	5 bcd
93	SN	90	126	6	88	27	4.1	2ab	5.2	1a
94	SN	90	120	8	92	19	3.8	6 bcd	4.8	5abcd
95	SN	85	128	5	83	21	4.4	1a	5.1	2a
Mean	SN	90	125		87	19	3.8		4.7	
ANOVA ²		NS	**		NS	NS	**		**	
52	Sw	93	135		96	3	3.2		3.9	

¹ Data not followed by the same letter are significantly different at the 5% level (Duncan 1955).

² Analysis of variance, provenance differences NS = not significant; * significant at 5% level; ** significant at 1% level.

tallest provenances at 8 years remained among the best five at 17 years and four of the five poorest provenances at 8 years are still poorest at 17 years. The correlation between 8- and 17-year heights is significant at the 5% level, ($r = 0.72$).

Four of the five tallest provenances at 17 years are from the most eastern locations tested, i.e. Polish provenances from Kowary and Istebna and Austrian sources from Trieben and Vopau.

Although local white spruce (MS 52) was not included as an integral part of this trial, a comparison can be made between Norway spruce plot trees and the separating rows of white spruce. Survival and early growth (to 8 years) of white spruce are comparable to that of the best Norway spruce provenances and better than the average for Norway spruce. At 17 years, despite 19% weeviling (compared to 3% for white spruce) Norway spruce surpasses white spruce in average height by 19% and the best provenance (MS 95 from Kowary, Poland) is 37% taller. Within provenance variation is considerably higher for Norway spruce than for white spruce and if only the tallest 40% of the trees are considered, at 17 years Norway spruce averages 25% taller than white spruce.

Experiment 16C:

Survival, weevil or top damage, height, height of tallest 40% of trees, and rankings for all provenances at 17 years from planting are presented in Table 4. Height at 17 years is shown geographically in Fig. 4. At Green River, Norway spruce from provenances in Germany, the Sudeten Mountains of Poland, and Millstatt, Austria, are tallest. The second generation Canadian source from Halifax,

N.S. is clearly inferior to all other provenances. The original European source of the Halifax materials is not known and presumably any selection for fitness has been for different site and climatic conditions than those at Green River. Differences among provenances for survival and weevil or top damage are not significant.

Of the three white spruce seed sources planted adjacent to the Norway spruce test, the provenance from AFES is clearly superior in height to the two local white spruce provenances, and to the Norway spruce provenances in both height and top damage. As in experiment 16A, the variability of Norway spruce is considerably greater than of white spruce. When only height of the tallest 40% of the trees is considered, the mean height of Norway spruce is the same as that of white spruce. However, the AFES white spruce is still somewhat taller (4.9 m) than the best Norway spruce provenances from Millstatt, Austria, (4.7 m) and Schwäbischen, Alb, Germany, (4.6 m).

Experiment 16 (PFES):

Only four Norway spruce provenances are compared in this trial. Seventeen-year height and survival data (Roller and Hunter 1974) and height rankings are presented in Table 4 and height is presented geographically in Fig. 4. Provenances from Westerhoff, Germany, and Istebna, Poland, are tallest. The low survival of the Istebna provenance results primarily from damage by porcupines which appear to prefer trees of this provenance. Weevil damage is light and well distributed throughout the plantation and does not appear to be associated with this provenance.

Table 4. Experiment 16C, Green River, N.B. and 16 (PFES), Corbett Lake, N.S. Summarized data and analysis for 17-year measurements and observation

MS	Species	Green River						Corbett Lake	
		Survival %	Weevil or top damage %	Height m	Rank ¹	Tallest 40% m	Rank	Survival	Height m
85	SN	78	25	2.9	8 b	3.4	10 d	67	5.6a
86	SN	84	69	3.2	5ab	4.1	5abcd	82	5.2ab
87	SN	96	46	3.1	6ab	4.1	5abc	81	5.6a
88	SN	96	46	3.3	4ab	4.5	3ab	89	4.7b
89	SN	100	60	3.5	1a	4.6	2a		
90	SN	89	48	3.5	1a	4.7	1a		
91	SN	84	60	2.9	8 b	3.7	9 cd		
92	SN	86	64	3.0	7ab	4.0	7 bcd		
93	SN	98	16	2.9	8 b	3.8	8 cd		
94	SN	66	54	2.8	11 b	3.4	10 d		
95	SN	88	41	3.5	1a	4.3	4abc		
96	SN	80	43	2.2	12 c	2.9	12 e		
Mean	SN	87	48	2.8		3.9		80	5.3
ANOVA ²		NS		**		**		**	**
51	Sw	88	0	3.1		3.8			
52	Sw	86	7	4.1		4.9			
249	Sw	66	0	2.5		3.0			
Mean	Sw	80	2	3.2		3.9			

¹ Data not followed by the same letter are significantly different at the 5% level (Duncan 1955).

² Analysis of variance, provenance differences NS = not significant, *significant at 5% level, ** significant at 1% level.

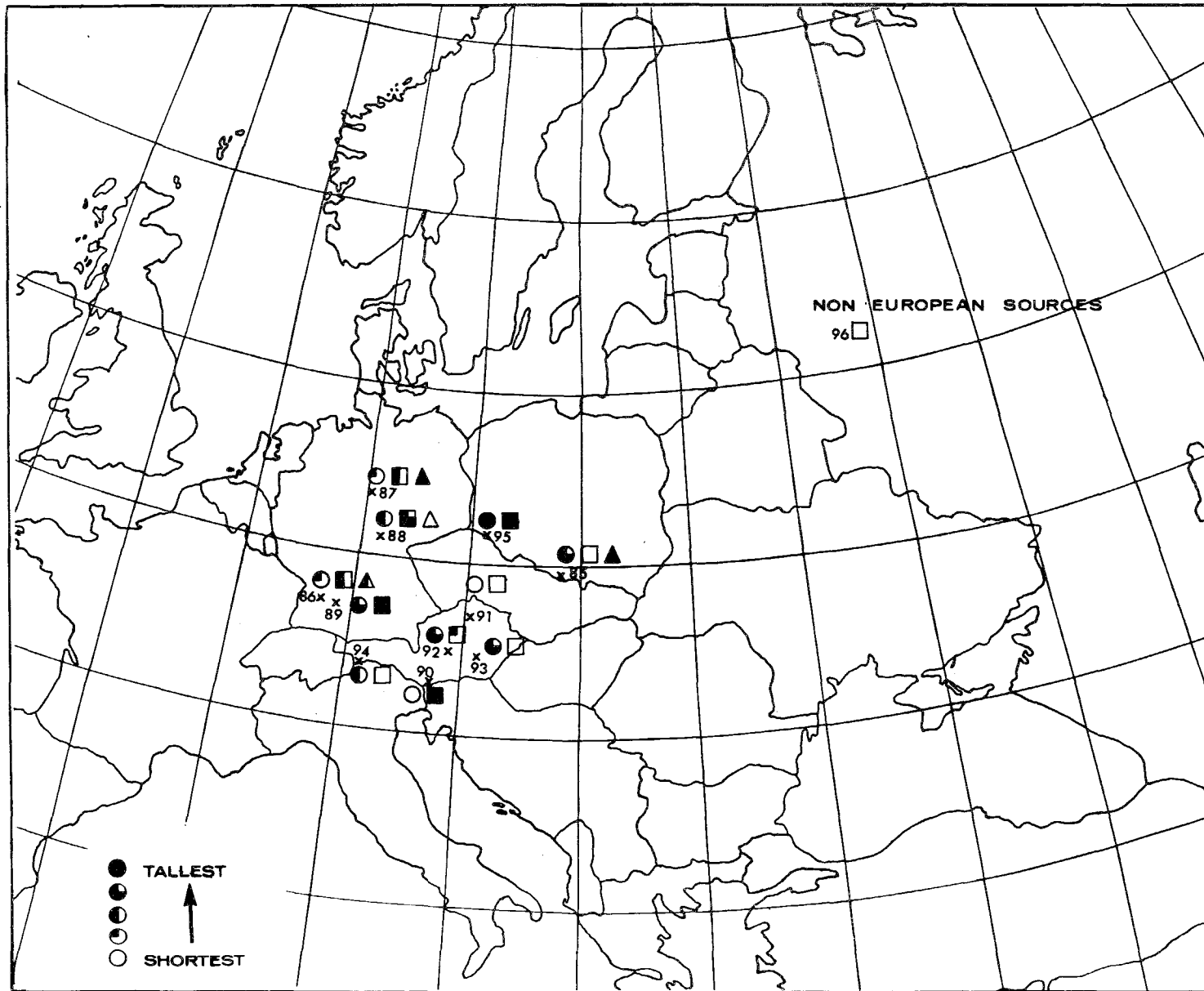


Fig. 4. Experiment 16. Geographic origin and relative height of Norway spruce in experiments 16A - Acadia Forest Experiment Station (0); 16C - Green River, N.B. (□); and 16(PFES) - Corbett Lake, N.S. (Δ).

EXPERIMENT 31

Material and Methods

In this trial, comparisons were made between Norway spruce from eight German provenances, one Polish provenance, three Danish plantations, one second-generation Canadian plantation of Finnish origin, and progenies of four selected trees from Denmark. In addition, "local" white and black spruce provenances were included in the trial. The pertinent provenance data are listed in Table 5.

All the Norway spruce seeds were acquired by Mark Holst. The seeds were sown in unreplicated nursery beds at Acadia Forest Experiment Station in the spring of 1962 and raised as 2+3 stock. In the spring of 1967, one replicated experiment and two unreplicated observation trials were established in the region. Only information from the replicated experiment planted at AFES is reported here.

The experimental design was randomized blocks replicated eight times. Rectangular, 30-tree plots (5 x 6 trees) were planted at 6 x 6 ft (1.8 m) spacing. The trial was established on recently cut-over land from which all logging debris had been removed. Blocks 1-4 were planted on moderately fresh, moderately fertile sites which carried an early successional mixedwood cover (AFES site 4). Blocks 5-7 were planted on rich, fresh sites formerly occupied by a hardwood cover (AFES site 2) although part of block 5 crossed into a somewhat less fertile site (AFES site 44). Block 8 occupied a drier, less fertile site (AFES site 7).

Survival of all seedlings was recorded in 1969. In 1971, total height was measured for all survi-

ving seedlings and observations on survival and damage to terminal leaders were recorded. In 1977, total height was measured to the top of the 1976 shoot and observations on survival and weevil damage were recorded for 18 trees per plot.

Results

The summarized data for all provenances and progenies are presented in Table 6 and 10-yr height is presented by geographic origin in Fig. 5. Data from replication 5 which was planted on two distinct sites are not included.

Differences among Norway spruce provenances and progenies in survival (mean 84%) and weevil damage (6-7%) are not significant. The correlation of 5- and 10-yr heights is highly significant ($r = 0.89$) indicating little change in ranking over this period. The tallest Norway spruce is from northeastern Germany (MS 697, 699, 701) and Poland (MS 726). It should be noted that provenances MS 701 and 702, which differ significantly in height, are from the same area except that MS 701 comes from a 130- to 150-yr-old stand and MS 702 from a 75-yr-old stand. Provenances from "naturalized" Danish sources are generally poor as is the most western German provenance (MS 698). The second-generation Canadian provenance from Manitoba (MS 703) is slow-growing as is expected for trees of northern origin (Finland).

In general, the progenies from the four selected Danish trees compared favorably in height at 10 years with the mean height of the three Danish provenances. The four progenies average 10% taller than the provenances and the best

Table 5. Experiment 31 Provenance data

MS	Species	Provenance	Latitude °N	Longitude °E	Elevation m	Type collection
697	SN	Rungstock, Erzgebirge, Germany	50.7	13.3	570	Stand
698	SN	Oberhof Schlossberg, Thuringia, Germany	50.7	10.7	820	Stand
699	SN	Carlsfeld, Saxony, Germany	50.5	12.6	720	Stand
700	SN	Carlsfeld, Saxony, Germany	50.4	12.6	920	Stand
701	SN	Tellerhauser, Saxony, Germany (compartment 44)	50.4	12.9	960	Stand
702	SN	Tellerhauser, Saxony, Germany (compartment 57b)	50.4	12.9	960	Stand
703	SN	Dropmore, Manitoba; from Finnish source	51.0	101.5°W	500	Plantation
704	SN	Nødebo, Denmark - comp. 60, tree K234				Select tree
705	SN	Nødebo, Denmark - comp. 57, tree K236				Select tree
708	SN	Nødebo, Denmark - comp. 287, tree K243				Select tree
709	SN	Esrumo, Denmark - comp. 322, tree K249				Select tree
722	SN	Bommerlund, Denmark Graasten F334, No. 150				Plantation
723	SN	Fussingø, Denmark - comp. 124 No. 248				Plantation
724	SN	Wedellsborg, Denmark - Ørsjerg No. 435				Plantation
725	SN	Forstant Tennesberg, Germany	50.0	12.5	600-800	Stand
726	SN	Rycerka, Poland	49.5	19.0	560	Stand
52	Sw	AFES, New Brunswick	46.0	66.4°W	100	Stand
711	Sb ¹	Upsalquitch Lake, New Brunswick	47.5	66.5°W	500	Stand

¹ Sb = Black spruce

Table 6. Experiment 31, Acadia Forest Experiment Station. Summarized data and analysis for 5-and 10-year measurements and observations

MS	Species	5 year			10 year					
		Survival %	Height cm	Rank	Survival %	Weevil damage %	Height cm	Rank	Tallest 40% m	Rank
697	SN	88	120	1	83	8	246	1a	277	2ab
698	SN	81	95	11	72	4	202	11 de	229	12 d
699	SN	88	108	3	83	6	246	1a	281	1a
700	SN	84	109	2	83	3	228	6abcd	264	6abc
701	SN	90	102	5	87	4	238	3ab	271	5ab
702	SN	85	99	8	82	10	210	9 cde	246	10 cd
703	SN	83	82	12	83	4	193	12 e	236	11 d
722	SN	87	97	10	79	4	225	7abcd	259	7 bc
723	SN	94	98	9	92	7	208	10 cde	247	9 cd
724	SN	91	100	7	90	7	214	8 bcde	258	8 bc
725	SN	90	102	5	86	8	232	5abc	272	4ab
726	SN	88	105	4	88	8	235	4abc	275	3ab
Mean		86	101		84	6	227		260	
ANOVA					NS	NS	**		**	
704	SN	92	110	3	90	8	235	3 b	271	3 b
705	SN	83	100	4	82	3	206	4 c	246	4 c
708	SN	82	119	2	85	8	240	2 b	281	2 b
709	SN	85	129	1	80	10	270	1a	312	1a
Mean		86	114		84	7	238		278	
ANOVA					NS	NS	**			
52	Sw	55	80		52	0	175		175	
711	Sb	79	100		76	0	267		276	

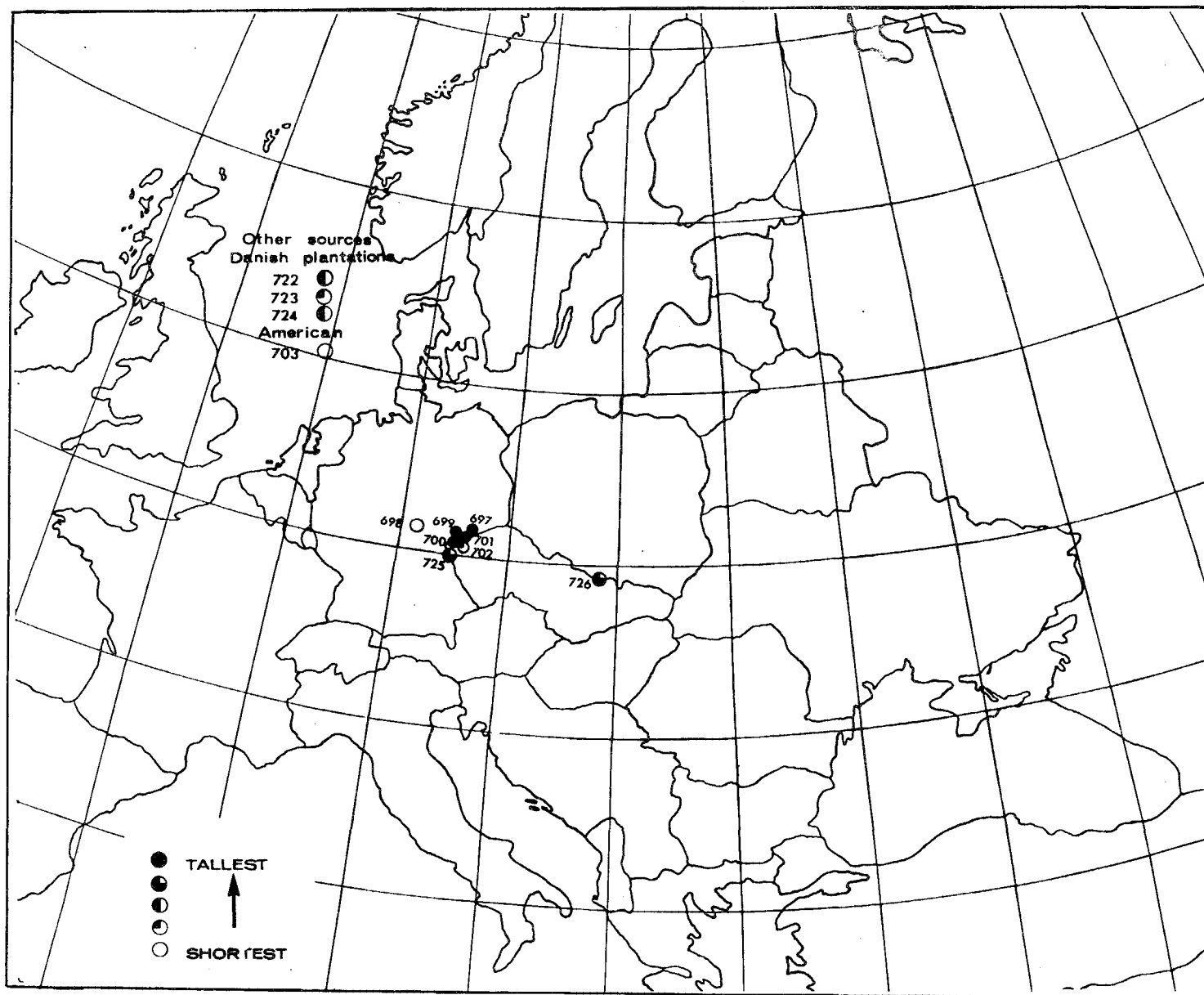


Fig. 5. Experiment 31. Geographic origin and relative height of Norway spruce in experiment 31 - Acadia Forest Experiment Station.

progeny (MS 709) is taller than any other provenance tested and 20% taller than the best Danish provenance. This suggests that there may be an advantage in obtaining seeds from selected trees even if they are to be planted in different environments.

Survival of both white (52%) and black spruce (76%) is unexpectedly poor in this experiment. White spruce is inferior to Norway spruce in height at 5 and 10 years from planting whereas black spruce is equal to Norway spruce at 5 years and somewhat taller at 10 years.

As in experiment 16, Norway spruce provenances are more variable in height growth than either white or black spruce. When only the tallest 40% of the trees planted are considered, the better Norway spruce provenances are as tall as the black spruce.

EXPERIMENT 33

Material and Methods

In this trial, Norway spruce from three Danish plantations, one North American plantation and one each from natural stands in Germany and Poland were compared. Trees from two provenances of local white spruce, three provenances of red spruce and one provenance of black spruce were also included in the test. Provenance data are presented in Table 7. Five of the six Norway spruce seed lots were acquired by Mark Holst and the other was acquired locally. The seeds were sown in unreplicated nursery beds in the spring of 1963 and raised to 2+2 stock. In the spring of 1967, two replicated experiments and eight observation plots were planted in

the region. Most of the Norway spruce in the replicated experiment (33-G), which was planted in heavy sod on an old farm field near Hampton, N.B., were destroyed by meadow voles, *Microtus pennsylvanicus* (Ord), during the winter of 1970-71. Results from the other replicated experiment planted at AFES are reported here.

The experiment was planted in a randomized block design replicated four times. Square plots (7 x 7-trees) were planted at 4 x 4 ft (1.2 m) (Block 1), 6 x 6 ft (1.8 m) (Block 2), 8 x 8 ft (2.4 m) (Block 3), and 12 x 12 ft (3.6 m) (Block 4) spacing. A double row of surrounds was planted around each block.

The planting site is classified as moderately rich and moderately fresh (AFES Site 4) and would normally support a mixedwood succession. The area had recently been clear cut and all logging debris had been removed. Hardwood stumps and suckers were sprayed with Brushkill 96 in the summer of 1962.

Results

The summarized data, results of analysis, and ranking for tree height are presented in Table 8. Spacing is not replicated in this trial and thus it is not possible to statistically separate spacing effects from other block effects, e.g. site.

Winter browning and damage by white pine weevil are light and not related to provenance. Weeviling which averages less than 6% on the Norway spruce appears to be related to spacing in that less than 1% of the trees planted at 4-ft spacing are damaged.

Table 7. Experiment 33 Provenance data

MS	Species	Provenance	<u>Latitude</u> °N	<u>Longitude</u> °E	<u>Elevation</u> m	<u>Type</u> <u>collection</u>
722	SN	Bommerlund, Denmark, Graasten F334 No. 150				Plantation
723	SN	Fussingø, Denmark Compt. 124, No. 150				Plantation
724	SN	Wedellsborg, Denmark, Ørsbjerg No. 435				Plantation
725	SN	Forstamt Tannesberg, Germany	50.0	12.5	600-800	Stand
726	SN	Rycerka, Poland	49.5	19.0	560	Stand
803	SN	Clinton County, N.Y. U.S.	44.8	73.6°W	---	Plantation
783	Sw	Bristol, Carleton Co., N.B.	46.6	67.2°W	150	Stand
785	Sw	Camp Gagetown, N.B.	45.7	66.5°W	100	Stand
220	Sr	Crooked Creek, Albert Co., N.B.	45.7	64.7°W	100	Stand
221	Sr ¹	W. Salmon River, St. John Co., N.B.	45.4	65.4°W	150	Stand
235	Sr	Evans Brook, Annapolis Co., N.S.	44.7	65.4°W	100	Stand
774	Sb	Acadia Forest Exp. Sta., N.B.	46.0	66.4°W	100	Stand

¹ Sr = Red spruce

Table 8. Experiment 33, Acadia Forest Experiment Station. Summarized data and analysis for 6- and 10-year measurements and observations

MS	Species	6 years			10 years		
		Survival %	Height m	Rank	Survival %	Height m	Rank
722	SN	95	109	1	94	2.18	1a
723	SN	90	91	5	87	1.76	5 b
724	SN	90	91	5	87	1.65	6 b
725	SN	94	94	3	94	1.80	3 b
726	SN	89	91	5	82	1.80	3 b
803	SN	97	97	2	94	1.83	2 b
Mean		92	96		90	1.84	
ANOVA					NS	**	
783	Sw	88	82		84	1.56	
785	Sw	88	91		82	1.76	
Mean		88	86		83	1.66	
220	Sr	93	79		83	1.63	
221	Sr	89	79		81	1.66	
235	Sr	83	82		73	1.59	
Mean		88	80		79	1.63	
774	Sb	91	109		87	2.26	

Provenance differences in height at 10 years are significant. Rankings at 5 and 10 years from planting are essentially identical. Trees of the Bommerlund, Danish plantation source (MS 722) are considerably taller than those of all other Norway spruce sources. The black spruce provenance from AFES (MS 774) is 4% taller than the best Norway spruce source and 23% above the Norway spruce mean. By comparison, the white and red spruce sources are not performing well.

Differences in survival are not significant. Survival of trees of

the Bommerlund source is above average for the Norway spruce, all of which are doing well (mean 90%). The black spruce survival is good (87%) and exceeds that of white spruce (83%) and red spruce (73%).

Five of the six Norway spruce provenances tested in this trial are also included in Exp. 31. Trees of the two slowest growing provenances in this trial (MS 723 and 724) are also poor in Exp. 31, but the best Norway spruce in this experiment (MS 722), ranks only 7th in Exp. 31. Trees of Polish origin (MS 726) perform well in both experiments.

Casual observations of Exp. 33G, which was abandoned because of damage by meadow voles, indicate that Norway spruce is more susceptible to damage by voles than any of the three native spruces. Differences among provenances of Norway spruce are not evident. Black spruce is essentially undamaged by voles.

EXPERIMENT 35

Material and Methods

In this trial, comparisons were made among Norway spruce from 14 provenances from central and eastern Europe, six second-generation Canadian Norway spruce plantations and three progenies from selected Canadian trees. In addition, trees from two provenances of black spruce and one each of red and white spruce were included as local controls. The pertinent provenance data are listed in Table 9.

All but five of the Norway spruce seed lots were acquired by Mark Holst (PFES Exp. 277). The remaining five Norway spruce sources and seed lots of native species were acquired locally. The seeds were sown in unreplicated nursery beds in the spring of 1965 and raised to 2+2 stock. In the spring of 1969, four replicated experiments and three observations plantings were established in the region. One replicated experiment planted on Prince Edward Island was destroyed by vandals. Information on the three remaining experiments is reported here.

Experiment 35A, St. Jacques, Madawaska Co., N.B.

All provenances listed in Table 9 were tested in this planting. The experimental design was a

randomized block replicated 10 times. One black spruce source (MS 46) was included three times in each block. Four-tree square plots were planted at 6 x 6 ft (1.8 m) spacing and two rows of red spruce were established as surrounds.

The planting site was abandoned farmland which had previously carried a cover of hay. Seedlings were planted into sod using the "T" slit method. The site is rated as fresh and moderately fertile. In July 1977, total height was measured for all surviving seedlings and observations on survival, weevil and other leader damage, and winter drying were recorded.

Experiment 35B, Acadia Forest Experiment Station.

The materials and design used for this trial were the same as those used for Exp. 35A. The planting site was a recent clear-cut area from which logging debris had been removed. Hardwood stumps and suckers were sprayed with Brushkill 96 the summer prior to planting. The site (AFES site 24) is rated as a moderately rich, moderately fresh site that would normally carry a coniferous forest.

In June 1976, total height of all surviving trees was measured to the tip of the 1975 shoot and observations were recorded on survival, winter drying, and top damage.

Experiment 35C, Caledonia, Guysborough Co., N.S.

The materials and design used for this test were the same as those used for Exp. 35A and 35B except that replications 1-5 and 6-10 were planted on different sites. The planting sites had been burned by a wildfire in 1968

Table 9. Experiment 35 Provenance data

MS	Species	Provenance	<u>Latitude</u> °N	<u>Longitude</u> °E	<u>Elevation</u> m	<u>Type</u> <u>collection</u>
870	SN	Salmon River, N.B. tree ST 329	45.4	65.5°W	180	select tree
871	SN	Salmon River, N.B. tree ST 300	45.4	65.5°W	180	select tree
872	SN	Fownes Head, N.B. tree ST 341	45.4	65.5°W	80	select tree
874	SN	Fownes Head, N.B.	45.4	65.5°W	80	plantation
875	SN	Salmon River, N.B.	45.4	65.5°W	180	plantation
884	SN	Hudson's Place, Chalk River, Ontario	46.0	77.4°W	180	4 select trees
885	SN	Tännesberg Bohemerwald, Germany	50.0	12.5	600-800	stand
886	SN	Rycerka, Poland	49.5	19.0	600-800	stand
887	SN	Proulx Plantations, Grand Mère, Québec	46.7	72.7°W	160	plantation
888	SN	Proulx Plantations, Grand Mère, Québec	46.7	72.7°W	160	22 select trees
890	SN	Proulx Plantations, Grand Mère, Québec	46.7	72.7°W	160	plantation
891	SN	Marginea, Suceava, Romania	47.8	25.8	670	stand
893	SN	Bicaz, Bacau, Romania	46.8	25.9	1150	stand
894	SN	Comanestsi, Bacau, Romania	46.3	26.6	780	stand
895	SN	Turda, Cluj, Romania	46.6	23.8	1110	stand
896	SN	Cimpeni, Cluj, Romania	46.3	23.0	1260	stand
899	SN	Daugavpils, Latvian SSR	55.8	26.5	150	stand
900	SN	Jelgava, Latvian SSR	56.7	23.7	100	stand
901	SN	Skede, Latvian SSR	57.0	27.0	180	stand
902	SN	Tukums, Latvian SSR	57.0	23.1	70	stand
903	SN	Wilno, Lithuanian SSR	54.6	24.3	300	stand
907	SN	Carlsfeld, Erzgebierge, Germany	50.4	12.6	920	stand
908	SN	Rothenkirchen, Frankenwald, Germany	50.3	11.3	470-640	stand
46	Sb	Geary, Sunbury Co. N.B.	45.6	66.7°W	100	stand
235	Sw	Evans Brook, Annapolis Co., N.S.	44.7	65.4°W	100	stand
449	Sw	Acadia Forest Exp. Sta., N.B.	46.0	66.4°W	100	stand
926	Sb	West Branch Badger, Newfoundland	49.0	56.2°W	150	stand

and were relatively free of competing vegetation. A second wildfire in 1976 destroyed blocks 6-10. Blocks 1-5 were planted on a Millbrook soil (Hilchey et al. 1964) which is well drained and moderately fertile.

In August 1977, total height of all surviving seedlings was measured and observations on survival, winter drying, and tip damage were recorded for blocks 1-5.

Results

Table 10 contains the summarized data, results of analysis, and 6- or 8-year height rankings for the three plantings of this experiment. Four-year nursery height data provided by Mark Holst are also presented in Table 10. Tree height by provenance is presented geographically in Fig. 6.

Experiment 35A.

Winter drying is evident on Norway spruce of all provenances and ranges in severity from 40 to 90% of the trees showing some browning of the needles. The differences between provenances are not significant. Bud damage appears to be minimal. The native spruce species are less prone to winter drying than is Norway spruce. Damage from weevils and other causes is not important in this experiment.

Highly significant differences in 8-year height and significant differences in survival are evident. Trees from four of the five Latvian provenances and the Polish source rank among the top five and are 17% above the mean for Norway spruce. Trees of German and Romanian provenances are generally slower growing. The New Brunswick plantation-sources

of Norway spruce are well below average in height growth while the Quebec and Ontario trees are about average. Survival of the Latvian Norway spruce is above average while that of the Polish trees is below average. Survival of all the plantation-source trees is good. Four-year nursery height from PFES is not significantly correlated with 8-year height ($r = 0.25$).

Although survival of progenies of the three single-tree selections from New Brunswick plantations is good, height growth ranges from poor to moderate, and averages somewhat less than the growth of the provenances from which they were selected. Growth and survival of the Proulx plantation spruce from 22 selected trees (MS 888) does not exceed that of the provenances from unselected trees.

Black spruce from Geary, N.B. (average of three plots per replicate) is 15% taller than the best Norway spruce although survival is only 81% compared to 90% for Norway spruce. Growth of the Badger, Newfoundland black spruce is as good as the best Norway spruce, but clearly inferior to the New Brunswick black spruce. White spruce and especially red spruce are inferior to other species in survival and growth.

Experiment 35B

Neither winter drying nor weeviling are important in this plantation. At 6 years from planting there are significant differences in height between Norway spruce of different provenance. Four of the best six provenances are Quebec and Ontario plantations and the average height of these trees is 10% above the mean for Norway spruce. The Polish provenance and one of the

Table 10. Experiment 35A, Edmundston, N.B.; 35B, Acadia Forest Experiment Station; and 35C, Caledonia, N.S. Summarized data and analysis for 8-, 6-, and 8-year measurements and observations

MS	Species	PFES		Edmundston - 8 year				AFES - 6 year			Caledonia - 8 year			
		4 yr Nursery		Winter							Winter			
		Height	Rank	Survival	drying	Height	Rank ¹	Survival	Height	Rank	Survival	drying	Height	Rank
		cm		%	%	cm		%	cm		%	%	cm	
870	SN			100	83	133	12 bcde	80	127	2 a	100	89	101	4 ab
871	SN			95	60	105	22 fgh	85	121	4 ab	95	65	95	7 abc
872	SN			95	63	91	23 h	95	100	20 cde	100	60	72	22 de
874	SN			85	71	116	19 ef	78	92	23 e	100	50	80	20 bcde
875	SN			93	86	124	15 def	80	110	13 abcde	100	80	81	19 bcde
884	SN	31.4	14	90	67	140	7 abcd	83	118	6 abc	95	47	72	22 e
885	SN	38.8	4	90	75	115	20 f	90	117	7 abcd	100	90	96	6 abc
886	SN	38.0	7	75	60	152	2 ab	93	121	4 ab	100	50	106	2 a
887	SN	41.2	2	90	64	132	13 bcde	65	126	3 a	100	90	102	3 ab
888	SN	33.5	12	85	44	126	14 cdef	88	128	1 a	100	70	93	11 abcde
890	SN	37.6	8	95	74	140	7 abcd	83	117	7 abcd	100	80	90	13 abcde
891	SN	38.7	5	90	64	119	17 def	85	102	19 bcde	90	89	84	17 bcde
893	SN	36.7	9	88	67	138	9 abcd	75	111	11 abcde	100	60	88	15 abcde
894	SN	33.5	11	75	57	134	11 bcde	83	99	21 cde	100	75	93	11 abcd
895	SN	41.3	1	85	71	141	6 abcd	85	105	16 bcde	95	68	90	13 abcde
896	SN	41.2	2	88	69	120	16 def	83	106	15 bcde	100	75	109	1 a
899	SN	31.5	13	93	73	157	1 a	78	111	11 abcde	100	90	93	11 abcd
900	SN	30.5	16	95	55	150	4 ab	90	109	14 abcde	100	70	97	5 abc
901	SN	26.5	18	93	38	148	5 abc	95	111	11 abcde	100	75	84	17 bcde
902	SN	31.3	15	95	58	151	3 ab	75	116	9 abcd	95	84	94	8 abcd
903	SN	29.1	17	90	53	137	10 abcde	83	105	16 bcde	100	85	84	17 bcde
907	SN	35.4	10	93	68	107	21 fg	80	104	18 bcde	100	60	76	21 cde
908	SN	38.6	6	98	64	119	17 def	88	97	22 de	95	79	94	8 abcd
Mean		35.3		90	65	130		83	111		98	73	90	
ANOVA ²				*	NS	**		NS	*		NS	NS	**	
46	Sb			90	28	190		78	157		100	5	150	
46	Sb			80	22	168		88	151		100	15	138	
46	Sb			73	31	185		88	171		95	11	120	
Mean				81	27	181		85	160		98	10	136	
926	Sb			90	33	157		90	128		100	15	106	
235	Sr			60	33	61		83	108		95	21	88	
499	Sw			83	33	119		80	96		100	40	91	

¹ Data not followed by the same letter are significantly different at the 5% level.

² Analysis of variance: NS = not significant, * significant at the 5% level, ** significant at the % level.

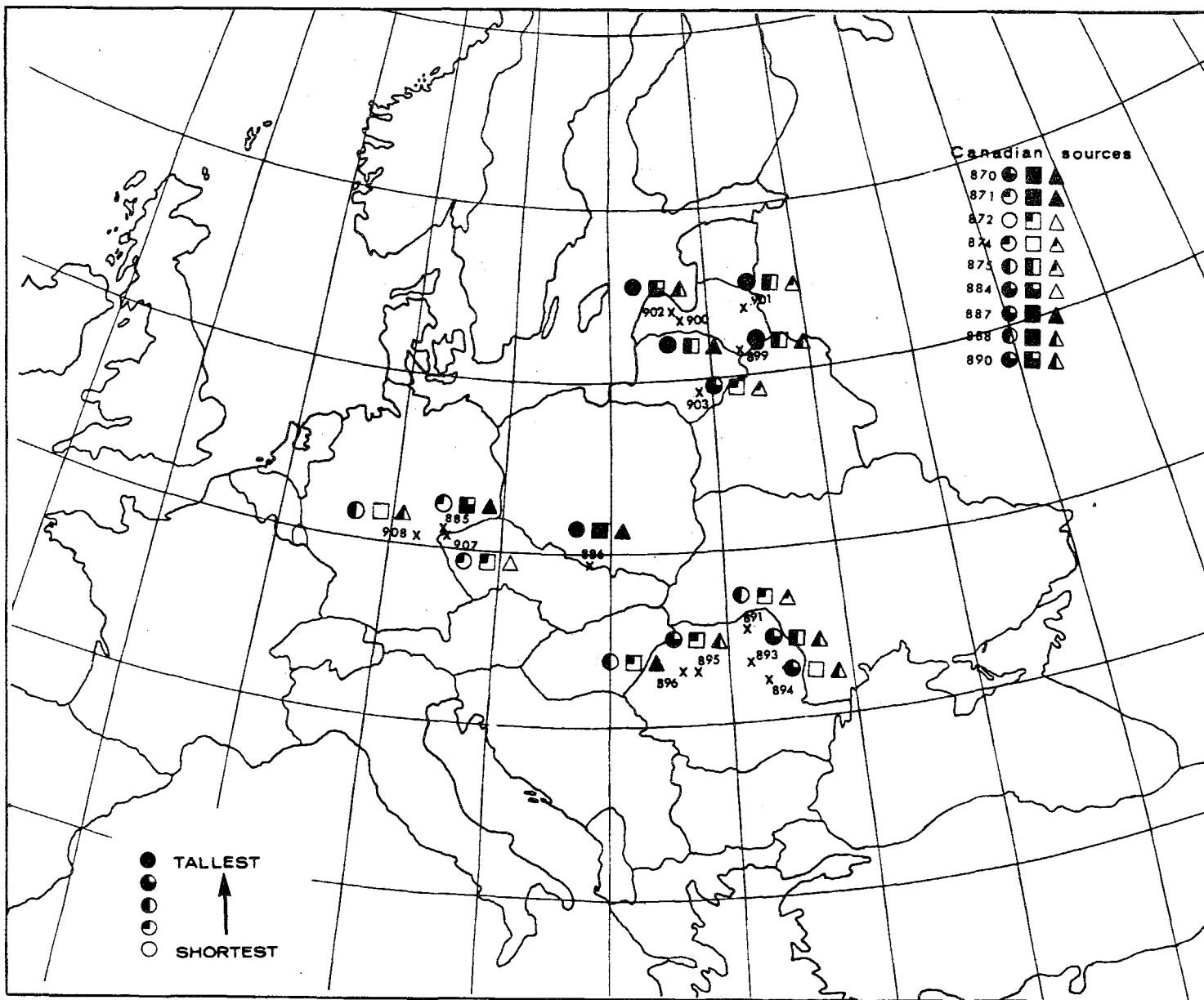


Fig. 6. Experiment 35. Geographic origin and relative height of Norway spruce in experiment 35A - Edmundston, N.B. (○); 35B - Acadia Forest Experiment Station (□); and 35C - Caledonia, N.S. (△).

German provenances (MS 885) also rank in this group. Norway spruce from Latvia, Romania, and Germany are generally below average as are trees from the two New Brunswick plantations. With one exception (MS 887), survival of trees of the most rapid growing provenances is average or above. Four-year height at PFES and six-year height at AFES are not significantly correlated ($r = 0.21$).

In this experiment, selection of parent trees appears to have been successful. The tallest Norway spruce are from 22 trees selected in the Proulx plantation (MS 888). Two of the three progenies from selected New Brunswick trees average 15% taller than unselected populations of the same provenance.

The black spruce from Geary, N.B. has average survival and outstanding height growth. Its height is 44% above the mean for Norway spruce and 25% above the mean of the best Norway spruce. Black spruce from Badger, Newfoundland is clearly inferior to the Geary trees, but about as tall as the best Norway spruce. White spruce and red spruce have average survival but somewhat below average height development.

Experiment 35C

Winter drying is evident on Norway spruce of all provenances and although 47 to 90% of the trees exhibit some needle browning the differences between provenances are not significant. Bud damage resulting from this cause appears to be minimal. The native spruces show less evidence of winter drying than any of the Norway spruce. Weevil damage and other top damage are not important factors in this experiment.

Survival is high for all species regardless of provenance

(range 90-100%) but average growth of Norway spruce is inferior to growth in Exp. 35A and 35B. Highly significant differences in height occur between Norway spruce of different provenances but a consistent geographic pattern is not evident. Norway spruce from Romania (Cimpeni), Poland (Rycerka), Latvia (Jelgava) and Quebec (Proulx plantation) rank among the tallest. The average height of trees from Germany, Latvia, and Romania are essentially the same. New Brunswick plantation-origin trees are slower growing while the Quebec-source trees are slightly faster than average. Norway spruce from Hudson's Place, Ontario which generally performs well wherever planted, is the slowest growing in this experiment. Two of the three progenies from selected New Brunswick trees grow well while the other is poor. The average height of the three progenies from selected trees is 10% greater than the height of unselected populations from the same stands. Offspring from selected Proulx plantation trees (MS 888) are not taller than those from unselected trees. The correlation of 4-year nursery height at Petawawa and 8-year height is higher in this experiment ($r = 0.55$) than in Exp. 35A or 35B.

The Geary, N.B. black spruce again exhibits superior height growth being 51% taller than the mean and 25% taller than the best Norway spruce. The Newfoundland black spruce is as tall as the best Norway spruce while the white and red spruce provenances are about average.

Experiment 35 Overall Results

The most outstanding feature of the combined assessment of these experiments is the large proven-

ance x test interaction. This is not unexpected as the climatic conditions differ considerably between test locations. Norway spruce from only one provenance, Rycerka, Poland, performs well in all three experiments. Another feature is the consistently poor performance of Norway spruce from the two New Brunswick plantations which are located close to the Bay of Fundy and are growing well in the cool maritime climate. Evidently, they are not well adapted to more continental conditions found elsewhere in the region.

As expected the more northern provenances from Latvia rank best in the rigorous climate of north-western New Brunswick. Trees from Canadian plantation sources in Quebec and Ontario did best in central New Brunswick. The absence of any consistent relationship between broad provenance areas and growth at Caledonia, N.S. is difficult to explain. The Caledonia site is obviously a "poor" Norway spruce site. It is possible that Norway spruce of various provenances differ in their ability to utilize the site and that this ability is independent of more general climatic adaptation.

The effects of selection on provenance and progeny performance are not conclusive. Of the three Proulx plantation sources, trees from the provenance represented by 22 selected trees (MS 888) are not significantly different than those from provenances of unselected trees. The progenies from the three selected New Brunswick trees exhibit a high degree of stability with MS 872 being significantly shorter than MS 870 and MS 871, in all tests. The two best progenies compare favorably with the provenances from which they were

selected in that they rank taller in five of six comparisons.

EXPERIMENT 39-40

Materials and Methods

In this trial the performance of Norway spruce from 25 Polish, seven Czechoslovakian, four Romanian, two German and one Latvian provenance was compared. Trees of one Maritime provenance each of white, red, and black spruce were included as "local" controls. The pertinent data on all provenances are presented in Table 11. The Norway spruce seed lots were acquired by Mark Holst and are represented in one or more of the PFES Exp. 310, 320 and 321. Dr. M. Giertych, Konnick Arboretum, Poland, kindly provided seeds of 20 provenances from Poland.

The seeds were sown in unreplicated nursery beds at Acadia Forest Experiment Station in the fall of 1965 and raised to 2+3 stock. In the spring of 1971, one replicated experiment and 20 observation plantings were established in the region. Only two of the observation plantings contained a complete set of provenances, the others contain from one to seven provenances and were established primarily as plantations of known origin in which future selection work could be carried out. One of the complete observation plantings, established at McLeod Settlement, Cape Breton, N.S. was destroyed by rabbits. Data from the other observation planting and the replicated experiment are reported here.

Experiment 39-40A, Acadia Forest Experiment Station

Thirty-nine seed lots (Table 11) of Norway spruce and one lot

Table 11. Experiment 39-40 Provenance data

MS	Species	Provenance	Latitude °N	Longitude °E	Elevation m	Type collection
949	SN	Brody, Poland	51.7	14.9	80	stand
950	SN	Kowary, Poland	50.8	15.9	625	stand
951	SN	Istebna, Poland	49.6	18.9	630	stand
952	SN	Wista, Poland	49.6	18.9	650	stand
953	SN	Rycerka, Poland	49.5	19.0	530	stand
954	SN	Wetlina, Poland	49.1	22.5	700	stand
955	SN	Garbatka, Poland	51.5	21.6	130	stand
956	SN	Blizny, Poland	51.1	20.7	320	stand
957	SN	Konstancjewo, Poland	53.2	19.1	70-115	stand
958	SN	Ilawa, Poland	53.7	19.6	116	stand
959	SN	Nowe Ramuki, Poland	53.7	20.6	126-180	stand
960	SN	Sadlowo, Poland	53.9	21.1	125-160	stand
961	SN	Myszyniec, Poland	53.4	21.2	120	stand
962	SN	Slawki, Poland	53.1	21.1	120-140	stand
963	SN	Borki, Poland	54.1	22.1	155	stand
964	SN	Przerwanki, Poland	54.1	22.1	150	stand
965	SN	Goldap, Poland	54.3	22.4	150	stand
966	SN	Suwalki, Poland	54.0	23.1	170	stand
967	SN	Augustow, Poland	53.9	23.2	130	stand
968	SN	Biatowieza, Poland	52.7	23.8	160	stand
969	SN	Zwierzyniec, Poland	52.7	23.8	160	stand
970	SN	Miedzyrzsce, Poland	52.1	23.0	154	stand
971	SN	Stronie Sl, Poland	50.3	16.9	840-900	stand
972	SN	Dolina, Poland	49.3	19.8	1400	stand

Table 11. Continued

MS	Species	Provenance	Latitude °N	Longitude °E	Elevation m	Type collection
973	SN	Marginea, For. Dist. Suceava, Romania	47.8	25.8	670	stand
974	SN	Bicaz For. Dist. Bicau, Romania	46.8	25.9	1150	stand
975	SN	Comanesti For. Dist. Bicau, Romania	46.3	26.6	780	stand
976	SN	Cimpeni For. Dist. Cluj, Romania	46.3	23.0	1260	stand
977	SN	Daugavpils, Latvian SSR	55.8	22.8	150	stand
978	SN	Carlsfeld For. Dist. Bezirk, Germany	50.4	12.6	920	stand
979	SN	Rothenkirchen For. Dist. Frankenwald, Germany	50.3	11.6	470-640	stand
980	SN	Zokapane, Poland	49.3	20.0	850	stand
981	SN	Zofin, Czechoslovakia	48.6	14.7	83	stand
982	SN	Boubin, Czechoslovakia	49.0	13.8	1000-1200	stand
983	SN	Rasna, Czechoslovakia	49.2	15.4	700	stand
984	SN	Ridelov, Czechoslovakia	49.2	15.4	650	stand
985	SN	Hor Dubenky, Czechoslovakia	49.3	15.3	680	stand
986	SN	Zatan, Czechoslovakia	49.0	13.8	1100	stand
987	SN	Valsuv-Dul, Czechoslovakia	49.8	17.2	440	stand
454	Sw	Indian Harbour, Gysborough, N.S.	45.1	61.9°W	30	stand
467	Sr	Salmon River, N.B.	45.6	65.3°W	100	stand
58	Sb	Queens Co., N.B.	45.8	65.8°W	70	stand
1090	Sw	Acadia Forest Exp. Sta., N.B.	46.0	66.4°W	100	stand
235	Sr	Evans Brook, Annapolis Co., N.S.	44.7	65.4°W	100	stand

each of white, red, and black spruce were included in this experiment. The experimental design is a randomized block replicated 10 times. Four-tree square plots were planted at 6 x 6 ft (1.8 m) spacing. A double row of surround trees was planted. The planting area was a recent clear cut from which logging debris had been removed. The site had formerly supported an early successional mixedwood stand of spruce, white birch, and red maple. Hardwood stumps and suckers were sprayed with herbicides in 1970. The site is a moderately fertile, moderately moist site on which normal succession would be to pure conifers (AFES site 24).

Height of all surviving seedlings to the top of the 1975 shoot was measured in the summer of 1976. Observations on survival and damage by white pine weevil and other causes were also recorded at this time.

Experiment 39-40B, Cape Breton Highlands, Inverness Co., N.S.

Norway spruce from 39 provenances were included in this observation plantation. In addition white, red, and black spruce were planted in adjacent plots. The Norway spruce provenances were planted in one or more unreplicated row plots at 8 x 8 ft (2.4 m) spacing.

The planting area which formerly carried a mature balsam fir stand was clear cut in 1963, control burned in 1965, scarified in 1966 and treated with herbicides from the air in 1968. It was relatively clean of competing vegetation when planted on June 1-3, 1971. The soil is a moderately well-drained, rich, rubbly clay situated on a 5% east slope at 400 m elevation. The site is

extremely exposed being in the center of a large clear cut, measuring several hundred hectares.

On June 14, 1977, total height of 10 surviving trees in each plot was measured and survival, winter browning, and dead tops were recorded. Similar data were also obtained for adjacent plots of white, red, and black spruce.

Results

Experiment 39-40A

The summarized data and results of analysis of variance and rankings of all provenances are shown in Table 12. The geographic location of the provenances and relative height at 5 years are presented in Fig. 7. Overall survival of Norway spruce in this experiment is quite acceptable (86%) and although considerable provenance variation exists (65 to 98%), differences are not significant. Small but significant differences in height growth do exist between trees of different provenances, after 5 years in the field. The most suitable source for this region appears to be southern Poland. Norway spruce from moderate to low elevation provenances (less than 700 m) from the Sudeten and Carpathian Mountains and the Malopolska Hills of Poland all rank among the best 10 and average 12% taller than the mean for Norway spruce. Trees from the four higher elevation sources from this same area are considerably slower growing.

Trees from the northeastern Polish provenances and the one Latvian source, all of which are from low elevations (less than 200 m), are about average in height growth. With one or two exceptions, most notably MS 984 from Ridelow, Czechoslovakia, trees of

Table 12. Experiments 39-40A, Acadia Forest Experiment Station and 39-40B, Cape Breton, N.S. Summarized data and analysis for 5- and 6-year measurements and observation

MS	PFES Nursery ¹			AFES - 5 years			Cape Breton ² - 6 years			
	Frost damage %	Height cm	Rank	Sur- vival %	Height cm	Rank	Sur- vival %	Winter ³ damage %	Height cm	Rank
949	8	34	8	93	105	10 abcdefg	75	100	73	28
950	3	30	14	98	113	3 abc	90	100	84	8
951	16	35	5	80	113	3 ab	90	100	83	11
952	13	37	1	83	110	6 abcde	90	100	86	5
953	13	35	5	83	112	5 abcd	95	90	75	25
954	3	29	17	83	98	20 abcdefg	83	95	72	30
955	5	36	2	65	116	1 a	93	96	83	11
956	7	36	2	78	105	10 abcdefg	83	100	81	13
957	10	35	5	93	106	9 abcdefg	90	89	77	20
958	8	33	9	83	86	36 efg	80	88	84	8
959	3	32	10	85	93	28 abcdefg	60	100	89	1
960	0	26	23	95	103	13 abcdefg	90	89	69	35
961	2	28	20	93	99	18 abcdefg	80	100	86	5
962	1	28	20	95	92	30 abcdefg	90	83	76	22
963	1	28	21	85	99	18 abcdefg	95	100	70	34
964	2	30	14	90	108	8 abcdefg	88	91	74	27
965	7	30	14	78	102	15 abcdefg	90	89	81	13
966	1	30	14	75	110	5 abcdef	77	100	83	11
967	4	32	10	90	100	16 abcdefg	90	100	78	18
968	2	29	17	85	104	12 abcdefg	80	100	72	30
969	1	28	22	73	96	22 abcdefg	95	95	77	20
970	4	30	14	95	103	13 abcdefg	90	100	85	7
971	10	35	5	93	93	28 abcdefg	65	92	68	36
972	0	25	24	83	87	35 defg	80	88	75	25
973				90	86	36 efg	80	88	65	39
974				85	97	21 abcdefg	75	93	66	38
975				83	85	38 fg	85	79	75	25
976				85	93	28 abcdefg	100	100	68	36
977				78	94	25 abcdefg	80	88	87	3

Table 12. Continued

MS	PFES Nursery ¹			AFES - 5 years			Cape Breton ² - 6 years			
	Frost damage %	Height cm	Rank	Sur- vival %	Height cm	Rank	Sur- vival %	Winter ³ damage %	Height cm	Rank
978				73	95	23 abcdefg	90	78	78	18
979				90	84	39 g	90	78	76	22
980				80	93	29 abcdefg	90	100	72	30
981				85	89	33 cdefg	70	100	80	15
982				93	95	23 abcdefg	90	100	79	16
983				88	100	16 abcdefg	90	88	86	5
984				88	114	2 ab	70	93	88	2
985				95	91	32 bcdefg	95	90	72	30
986				93	88	34 defg	90	95	71	33
987				98	92	30 abcdefg	80	88	78	18
Mean				86	99		85	93	77	
ANOVA				NS	*					
454 Sw				65	91					
467 Sr				70	74					
58 Sb				90	134		77	100	101	
1090 Sw							80	96	47	
235 Sr							70	67	36	

¹ Data from Holst, M.J. (1974) Report on file at Maritimes Forest Research Centre, Fredericton, N.B.

² Non-replicated observation plots.

³ Includes winter browning and dead tops; in all cases only small trees were undamaged.

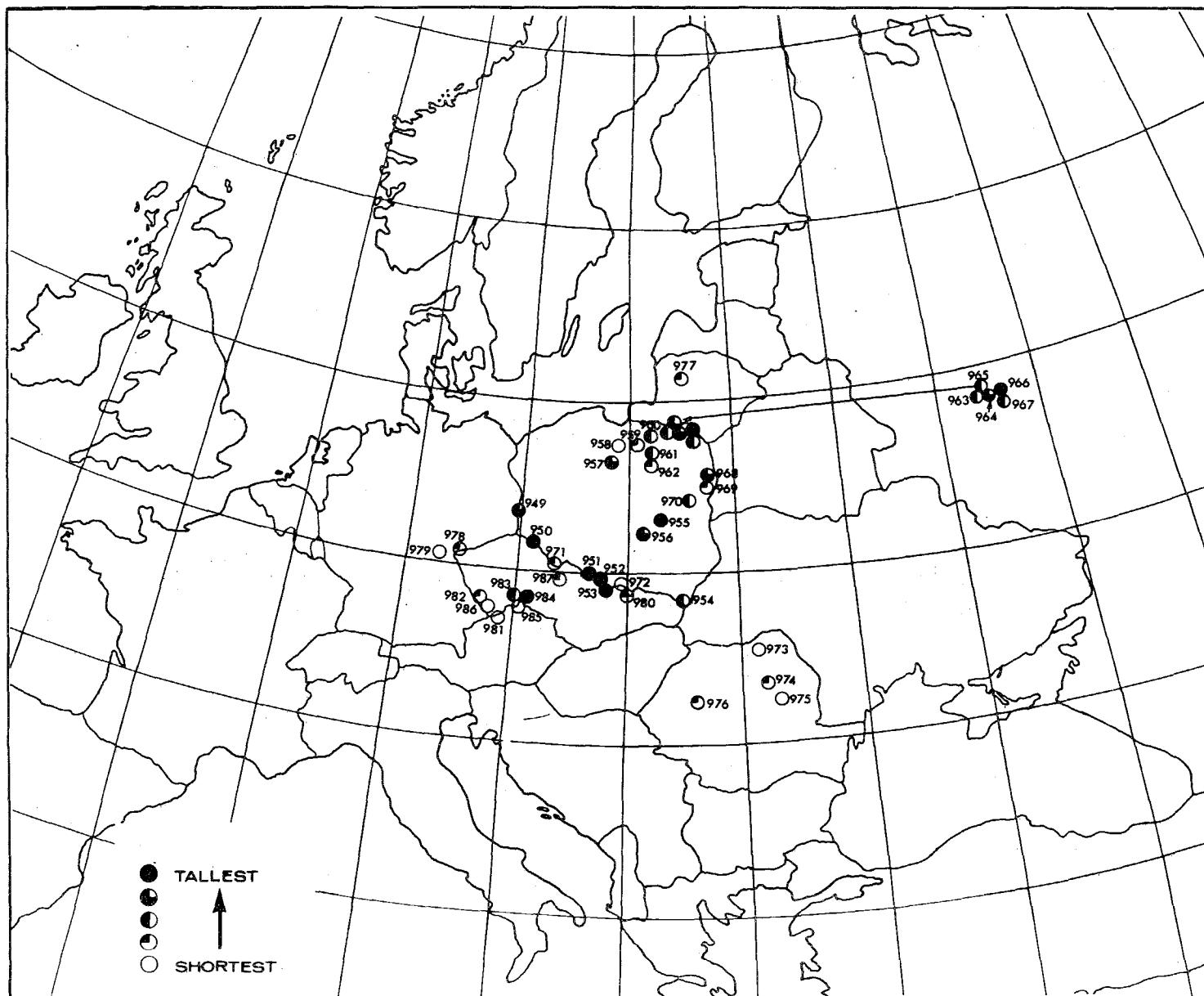


Fig. 7. Experiment 39-40. Geographic origin and relative height of Norway spruce in experiment 39-40A - Acadia Forest Experiment Station.

German, Czechoslovakian and Romanian provenances are below average.

Both white and red spruce are below average in height and survival. Black spruce of the Queens County, N.B. provenance is growing exceptionally well (35% above the mean of Norway spruce) and has above average survival.

Correlation between nursery height at the Petawawa Forest Experiment Station and height after 5 years in the field is not high but is significant at the 5% level ($r = 0.48$).

Experiment 39-40B

The site on which this test was planted is subject to extreme exposure. Strong winds are common, year round, and during the winter drying of foliage above the snow results in browning, subsequent loss of needles, and occasionally death of buds even on hardy species such as balsam fir. A second problem relating to wind exposure is scouring of the stems exposed above the snow line. Evidently, this results when ice crystals are blown along the snow with such force that they scour the bark and often kill the tops.

Virtually all except the smallest Norway spruces are severely damaged by exposure to winter winds which results in multiple leaders, and dead or dying tops. None of the 39 provenances tested appear to be suited to this exposed Highlands site. Red spruce is also severely damaged under these conditions. The white and black spruce, although heavily damaged, exhibit less damage than red and Norway spruce. White spruce are shorter and thus less exposed while black spruce exhibit considerably less bud kill on exposed shoots. Summary of results is found in Table 12.

There appears to be little consistency in the rankings for height growth between Exp. 39-40A and 39-40B other than the Ridelov, Czechoslovakia provenance which ranks second on both test sites. Again, the New Brunswick source of black spruce shows excellent height growth by comparison.

EXPERIMENT 41

Materials and Methods

In this trial, comparisons were made among 10 single tree progenies of Norway spruce from each of two Czechoslovakia provenances. Trees of one provenance of each red and white spruce and two provenances of black spruce are included for comparison. All the Norway spruce seeds were acquired by Mark Holst and were also included as part of PFES Exp. 321A. The seeds of native species were acquired locally. Only the provenance aspects of this experiment are presented here. Pertinent data on the provenances are listed in Table 13.

The seeds were sown in unreplicated nursery beds at AFES in the fall of 1965 and raised as 2+2 stock. Two replicated experiments were planted in the region in the spring of 1970.

Experiment 41B, Acadia Forest Experiment Station

All 20 progenies and the four provenances of "local" spruces were included in this trial. The experimental design was a randomized block with 10-tree row plots, replicated 10 times. A single row of white spruce was used to separate blocks and a single row of black spruce was planted around the experiment. Spacing was 6 x 6 ft (1.8 m).

Table 13. Experiment 41 Provenance data

MS	Provenance	Latitude °N	Longitude °E	Elevation m	Type collection
988-997 SN	Hojna Voda, Czechoslovakia	48.7	14.7	800-940	10 single trees
998-1007 SN	Rabstyn, Czechoslovakia	49.8	14.3	650	10 single trees
454 Sw	Indian Harbour Lake, Guysborough Co., N.S.	45.1	61.9°W	30	stand
467 Sr	Salmon River, Kings Co., N.B.	45.6	65.3°W	300-330	stand
58 Sb	Queens Co., N.B.	45.8	65.8°W	70	stand
926 Sb	West Branch, Badger, Nfld.	49.0	56.2°W	150	stand

The planting site, a recent clear cut, was cleared of logging debris. Hardwood stumps and suckers were sprayed with herbicides the summer before planting. The site (AFES site 24) is moderately rich, moderately fresh, and would normally support a coniferous cover through natural succession.

All surviving trees were measured to the tip of the 1975 shoot in June 1976 (6 years from planting). Observations on survival and damage were also recorded at this time.

Experiment 41C, Marydale, Antigonish Co., N.S.

The materials and design used for this trial were the same used for 41B except no surround trees were planted. The plantation area formerly carried an old-field white spruce stand which was cut in 1963. Logging debris was piled on site before planting. The site,

a Woodburn soil (Cann and Hilchey 1954) is moderately well-drained, moderately rich, and situated on an undulating 1-5% northeast slope at 120 m elevation.

The trial was planted in May 1970 by personnel of Nova Scotia Forest Industries Ltd. In June 1977, height was measured to the top of the 1976 shoot on the first five surviving seedlings in each plot. Observations on survival, weeviling, frost damage, and presence of cones were also recorded at this time.

Results

Experiments 41B and 41C

The summarized data for survival, height, and weevil damage are presented in Table 14. Height, survival, and weevil damage of Norway spruce does not differ significantly by provenance in either test location. In Exp. 41B at

Table 14. Experiments 41B, Acadia Forest Experiment Station and 41C Marydale N.S. Summarized data for 6- and 7-year measurements and observations

MS	AFES - 6 years			Marydale - 7 years	
	Survival %	Height cm	Weevil damage %	Survival %	Height cm
988-997 SN	87	107	7	94	134
998-1007 SN	88	104	6	92	130
MEAN NS	88	106	6	93	132
454 Sw	75	95	0	80	81
467 Sr	83	86	0	44	39
58 Sb	87	146	2	89	111
926 Sb	92	113	0	92	96

¹

Includes other types of tip mortality.

Acadia Forest Experiment Station, black spruce and Norway spruce survive equally well but black spruce is taller after six growing seasons. White spruce and red spruce have lower survival and are not as tall as Norway spruce. Weevil damage on Norway spruce averages 6-7% (range 0 to 13% by families) compared to 0-2% in black spruce and no weeviling in white spruce or red spruce.

In Exp. 41C at Marydale, N.S., Norway spruce is taller, after seven years, than black, white, or red spruce and survival is better than for white or red spruce. Damage by the white pine weevil is negligible on all species.

EXPERIMENT 42

Materials and Methods

In this trial, comparisons were made among Norway spruce from six

provenances from France, one first generation Canadian Norway spruce provenance, and one provenance each of "local" white, red, and black spruce. The French Norway spruce seed lots were provided by the Centre National de Recherches Forestières, Nancy, France. The other seed lots were obtained locally. Pertinent data on all seed lots are presented in Table 15.

The seeds were sown in unreplicated nursery beds at Acadia Forest Experiment Station in the late fall of 1967 and raised as 2+2 stock. A replicated field experiment was planted at AFES in the spring of 1972. The design was a randomized block with 10 replicates and 4-tree square plots planted at 6 x 6 ft (1.8 m). No surround trees were planted. The planting area had previously been clear cut and logging debris had been removed from the site.

Table 15. Experiment 42 Provenance data

MS	I.N.R.A. No.	Species	Provenance	Latitude °N	Longitude °E	Elevation m	Type collection
1132		SN	Fownes Head, N.B.	45.4	65.5°W	50	plantation
1180	N58083	SN	Chamonix, France	45.9	6.9	1080	stand
1182	N58125	SN	Plain Bois, France	46.3	6.5	500	stand
1183	N58126	SN	Passy, France	46.0	6.8	1200	stand
1184	N58172	SN	Lantosque, France	44.0	7.4	1500	stand
1185	N58227	SN	Chateau-Regnault, France	49.9	4.8	480	stand
1186	N62180-189	SN	Mignovillard, France	46.8	6.2	1000-1100	stand
1094		Sw	Acadia Forest Exp. Sta.	46.0	66.4°W	100	stand
1122		Sr	Acadia Forest Exp. Sta.	46.0	66.4°W	100	stand
1301		Sb	Acadia Forest Exp. Sta.	46.0	66.4°W	100	stand

Hardwood stumps and suckers were sprayed with herbicides in the summer of 1971. The planting site (AFES site 24) is a moderately rich, moderately fresh site which would normally follow a coniferous succession.

Total height of all surviving trees was measured in June 1977 to the tip of the 1976 shoot and observations were recorded on survival, winter browning, and weevil and other tip damage.

Results

Data on survival, 5-year height, and winter browning are presented in Table 16. Five-year height is presented by geographic location in Figure 8. Survival of Norway spruce from French provenances ranges from 73% for the most northwestern, low elevation (480 m) source from Chateau-Regnault

to 93% for an eastern, mid-elevation (1080 m) source from Chamonix. Survival of the second generation New Brunswick Norway spruce from Fownes Head and the local white spruce is poor (75%), whereas survival of both red (95%) and black spruce (98%) is good.

Weevil and other tip damage is less than 5% over the whole plantation and is independent of provenance. Winter browning is highly variable among the French provenances and does not appear to be related to location or elevation of the seed source. From 6 to 26% of the seedlings exhibit some desiccated needles, however, there is no evidence of serious bud damage. Winter browning of the local red spruce is also fairly high (8%) whereas the New Brunswick Norway spruce, white spruce, and black spruce are almost free of damage. By 1979 most of the seedlings in

Table 16. Experiment 42, Acadia Forest Experiment Station.
Summarized data and analysis for 5 year measurements
and observations

MS	Species	Survival %	Winter browning %	Height cm
1132	SN	75	3	51 abc
1180	SN	93	16	58 ab
1182	SN	88	9	58 ab
1183	SN	85	26	49 bc
1184	SN	83	6	52 abc
1185	SN	73	14	59 a
1186	SN	80	6	46 c
Mean		82	11	53
1094	Sw	75	3	44
1122	Sr	95	8	54
1301	Sb	98	3	89

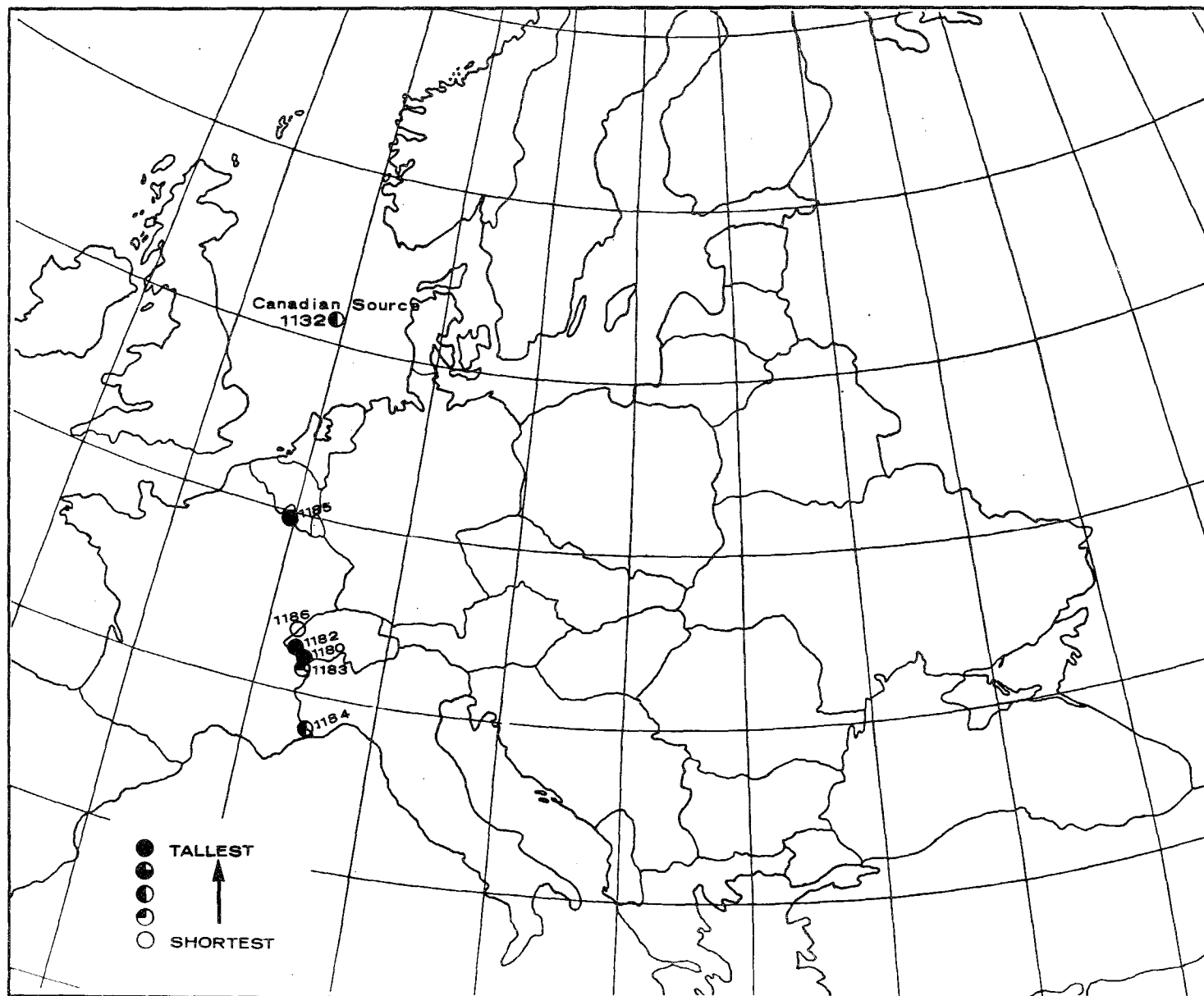


Fig. 8. Experiment 42. Geographic origin and relative height of Norway spruce in experiment 42 - Acadia Forest Experiment Station.

this experiment were beginning to be subjected to winter drying which is most severe when the seedling tops first emerge above the winter snow cover. Further evaluation of the French provenances, over the next 5 years, should provide more meaningful information on adaptability to local climatic conditions.

Differences in 5-year height among the Norway spruce provenances are small but significant. The tallest seedlings are from the northwestern low elevation source from Chateau-Regnault, the source that showed the poorest survival. Chateau-Regnault is a non-native or naturalized provenance from well outside the range of Norway spruce. The poorest growing trees, Mignovillard, also have below average survival. Norway spruce from Chamonix and Plain Bois grow well and have above-average survival. Local black spruce is taller (89 cm) than any of the Norway spruce (mean 53 cm) while local white spruce is shorter after five years.

The only valid conclusion that can be drawn from this trial is that Norway spruce from some French provenances perform better than others in central New Brunswick. Intuitively, we believe that Norway spruce of French provenances is unsuitable for Maritime conditions. The fact that New Brunswick Norway spruce, which generally ranks low in other experiments, is comparable in height with the French spruce, and the much better relative performance of local black spruce support this conclusion.

EXPERIMENT 43

Materials and Methods

This provenance test is part of a cooperative International Union

of Forest Research Organizations study (IUFRO 1964/68) initiated in 1959 under the supervision of Professor Olaf Langlet, Royal College of Forestry, Stockholm, Sweden. Krutzsch (1974) provides a more detailed description of the IUFRO 1964/68 provenance test. The purpose of the trial is to test as many provenances as possible from within the natural range of the species as well as naturalized sources from outside this range. The seeds were acquired through cooperators or by purchase mostly during the crop years 1958 and 1959 and varied from single tree lots to collections from a number of adjacent stands. Seeds representing 1100 sources were used for this trial.

In the spring of 1964, the seeds were sown in the nurseries of Schmalenbeck Institute in Germany. The seedlings were transplanted in the Pein and Pein Nursery, Halstenbeck, Germany, in 1966. Because of the large number of seedlings (1.1 million) and the uniformity of nursery conditions, no replications were used. By 1968, enough seedlings were produced to offer 25 tree samples of each of the 1100 provenances to international cooperators as 2+2 bare root stock. Twenty field trials were established in 13 countries including one near Bronson, N.B.

Canadian import regulations stipulated that the seedlings be washed free of soil. The seedlings were labeled, lifted, sorted, and root washed in Germany. They were shipped by air freight and upon arrival in Canada in May 1968, were subjected to an intense inspection for golden nematode, *Heterodera rostochiensis* Wollen Webber, which can infect potatoes.

The experimental design used for the IUFRO tests was developed by Dr. Klaus Stern, Schmalenbeck,

Germany. The provenances were grouped by stratified randomization into 11 blocks of 100 provenances so that each block contained a wide geographical distribution of seed sources. The blocks were independent of each other and each block was regarded as a complete provenance trial in itself, containing material from the entire range of the collection. Each block of 100 provenances contained 25 single trees per provenance.

Seedlings for each of the 11 blocks were packed separately for shipment, each package contained 25 individually tagged seedlings from each of 100 provenances. The randomization of seedlings from each provenance within blocks was completed in a large cold room. The 11 blocks of 2500 seedlings were hand-planted at 6 x 6 ft (1.8 m) spacing by Canadian Forestry Service personnel in late May of 1968. If a provenance contained more than 25 seedlings, the extras were used as fillers for provenances with less than 25 seedlings.

One set of provenances (11 blocks) was outplanted on a 10 ha site near Chipman, New Brunswick.

Latitude	46° 11' N
Longitude	65° 47' W
Elevation	61 m
Slope	flat to very gently rolling
	Soil poorly drained clay of glacial origin.
Mean daily temperature	4.9°C
Mean daily maximum temperature	11.6°C
Mean daily minimum temperature	-1.8°C
Length of growing season	188 days
Frost free period	120 days
Normal annual precipitation	1003 mm
Distance to sea	89 km

History of site

1964 - the softwood, predominantly red spruce was cut leaving *Betula*, *Populus*, and *Acer*.

1965 - a wildfire burned through the area.

The planting site is in the Bantalor District of the Maritime Lowland Ecoregion (Loucks 1962) which is extremely flat permitting cold air to accumulate, thus simulating boreal forest conditions. In August 1969, a 2,4,5-T and 2,4-D ester (Brushkill) was applied to release the spruce from a hardwood brush canopy that had developed. Mortality was assessed in the fall of 1969. Average survival by block was 81.8% (86.2% to 76.9%) which is reasonable considering the extensive handling to which the seedlings were subjected. In July 1970, one tablespoon of a 10-10-10 fertilizer was applied to one side of each tree. In September 1974, the height of each surviving seedling was measured to the nearest centimetre.

To facilitate handling the assessment information, the 1100 provenances were sorted into 96 regions based on past experience with the natural variation of the species. Pertinent data on the 96 provenance regions are presented in Table 17.

Results

Pertinent information on height and survival after five years in the field is summarized by the 96 provenance regions in Table 18 and information on height is presented graphically in Figure 9. Overall survival in this experiment is considerably poorer (mean 56.3%) than expected for Norway spruce planted in the Maritimes Region. It is probable that the rigorous preplanting treatment of the seedlings is in part responsible.

Table 17. Experiment 43. Provenance region data

IUFRO Region no.	Country	Provenances no.	Latitude °N	Longitude °E	Elevation m
1	France	5	44.9	5.4	1170
2	"	13	46.1	6.8	1110
3	"	5	46.8	6.3	950
4	"	5	49.8	6.4	540
5	Germany	9	51.5	8.5	430
6	"	7	51.8	10.2	260
7	"	12	51.8	10.5	550
8	"	12	53.7	12.5	90
9	"	2	51.9	14.3	70
10	"	11	50.3	12.8	730
11	"	9	50.7	10.8	690
12	"	7	49.5	9.0	370
13	"	19	48.5	8.4	620
14	"	16	47.8	8.2	1000
15	Switzerland	18	46.5	8.8	1190
16	Germany	15	47.9	9.5	610
17	"	28	48.3	9.2	670
18	"	11	49.0	10.7	480
19	"	11	49.9	11.8	590
20	"	7	48.9	12.9	630
21	"	58	49.0	13.4	950
22	"	31	48.3	12.0	540
23	"	35	48.1	10.5	640
24	Austria	13	47.7	10.3	870
25	Germany	14	47.6	11.1	1060
26	"	26	47.7	12.6	960
27	Austria	16	47.2	10.9	1290
28	"	21	47.3	12.6	1110
29	"	5	46.5	12.5	1290
30	"	24	47.4	13.9	1000
31	"	24	47.1	14.3	1100
32	"	49	47.4	15.2	950
33	Yugoslavia	7	46.7	15.1	740
34	Austria	12	47.8	15.8	870
35	"	3	48.0	13.4	710
36	"	17	48.8	14.9	590
37	Czechoslovakia	12	49.7	13.2	610
38	"	8	50.1	14.3	400
39	"	7	50.6	15.8	700
40	"	9	49.3	14.3	540
41	"	19	49.6	14.9	550
42	"	25	49.5	16.1	600
43	"	10	50.0	17.4	660
44	"	11	49.4	17.2	420
45	"	24	49.4	18.1	640
46	"	5	49.0	19.0	730
47	"	23	48.9	20.2	980
48	"	25	49.2	20.2	1090

Table 17. Continued

IUFRO Region no.	Country	Provenances no.	Latitude °N	Longitude °E	Elevation m
49	Czechoslovakia	3	49.1	20.7	770
50	"	7	48.7	20.4	660
51	"	1	48.5	19.0	540
52	Hungary	7	46.9	16.4	390
53	"	4	48.2	20.8	610
54	Yugoslavia	2	44.8	15.0	1120
55	"	3	42.9	20.2	1280
56	Bulgaria	10	41.9	23.9	1530
57	Romania	5	45.5	25.2	1220
58	"	6	46.5	23.5	1220
59	"	25	47.2	25.5	990
60	Poland	4	48.5	23.9	850
61	"	5	50.9	21.2	230
62	"	6	49.6	20.0	740
63	"	15	49.6	19.0	640
64	"	9	50.4	16.6	600
65	"	10	51.6	16.8	160
66	"	17	53.9	16.3	100
67	"	8	53.7	19.0	140
68	"	7	54.1	22.2	170
69	"	8	53.7	23.1	130
70	"	7	52.7	23.7	140
71	Lithuania SSR	9	55.2	25.3	130
72	Latvia SSR	8	57.1	22.4	70
73	Estonia SSR	5	57.5	24.6	70
74	"	8	57.0	27.5	120
75	White Russia SSR	6	53.7	28.5	180
76	Russia	5	56.5	31.8	170
77	"	5	60.1	40.7	100
78	"	7	54.6	36.8	170
79	"	4	57.3	54.2	230
80	"	3	57.6	73.0	110
81	"	3	-	-	-
82	Denmark	5	44.5	7.7	60
83	Norway	10	60.0	10.7	160
84	"	5	60.0	10.6	260
85	"	5	63.6	10.9	200
86	Sweden	7	55.8	13.8	110
87	"	9	57.7	13.1	140
88	"	8	57.3	14.1	200
89	"	4	58.7	16.6	110
90	"	18	59.6	14.4	110
91	"	9	62.5	14.6	400
92	"	9	63.4	16.4	220
93	"	6	64.1	20.0	160
94	Finland	6	61.5	24.2	100
95	"	4	62.0	28.2	120
96	Canada	1	46.0	77.4°W	180

Table 18. Experiment 43, Chipman, N.B. Summarized data for 5 year measurements and observations

Region no.	Country	Prov- enance no.	Survival			Height		
			Mean %	Standard deviation	Rank	Mean cm	Standard deviation	Rank
1	France	5	38.3	12.5	93	48.8	8.2	78
2	"	13	53.0	19.4	70	48.9	9.9	77
3	"	5	57.7	4.4	46	44.2	4.7	93
4	"	5	46.3	8.7	88	63.3	8.8	7
5	Germany	9	53.4	19.5	66	51.3	6.9	64
6	"	7	38.0	19.0	94	50.3	8.9	71
7	"	12	52.4	13.3	73	59.0	13.1	22
8	"	12	52.8	13.1	72	51.4	11.1	61
9	"	2	37.8	9.9	95	67.5	10.0	1
10	"	11	51.7	12.8	77	59.4	9.4	18
11	"	9	54.5	9.8	11	53.2	5.0	50
12	"	7	42.2	15.1	92	56.6	12.2	32
13	"	19	47.2	12.7	86	54.4	9.8	44
14	"	16	56.3	13.0	50	50.1	12.6	72
15	Switzerland	18	60.9	14.3	35	47.5	5.1	84
16	Germany	15	53.4	12.0	65	52.4	7.3	52
17	"	28	47.3	14.8	85	50.7	8.4	68
18	"	11	52.4	12.0	74	56.6	6.4	33
19	"	11	52.9	11.2	71	51.4	8.1	63
20	"	7	45.7	11.2	89	48.8	8.5	79
21	"	58	55.3	14.6	56	50.1	8.3	73
22	"	31	44.1	14.0	91	53.8	10.4	48
23	"	35	48.7	12.6	84	51.6	10.5	58
24	Austria	13	49.2	14.6	82	55.2	15.5	41
25	Germany	14	56.7	11.4	48	48.8	6.0	80
26	"	26	57.8	13.3	44	52.4	8.7	53
27	Austria	16	58.4	14.2	41	47.1	7.6	86
28	"	21	55.3	12.0	55	51.5	9.6	59
29	"	5	60.4	8.7	37	51.8	19.0	56
30	"	24	50.0	15.1	81	49.6	7.9	76
31	"	24	56.3	11.8	51	50.8	8.1	67
32	"	49	53.9	14.6	63	49.9	7.8	74
33	Yugoslavia	7	46.5	7.1	87	46.1	9.0	90
34	Austria	12	58.8	12.5	40	47.2	8.7	85
35	"	3	44.4	10.4	90	48.4	7.7	81
36	"	17	54.9	10.8	58	55.4	8.4	38
37	Czechoslovakia	12	54.1	13.3	61	57.9	8.1	25
38	"	8	57.9	8.4	43	59.2	10.0	20
39	"	7	53.1	25.0	68	64.6	6.5	4
40	"	9	52.3	14.0	75	57.8	8.1	26
41	"	19	57.8	10.0	45	54.9	10.6	42
42	"	25	51.7	13.4	78	51.5	6.6	60
43	"	10	53.1	15.6	69	57.4	9.3	28
44	"	11	48.8	18.9	83	55.6	9.1	37
45	"	24	54.9	13.1	57	52.2	9.5	55
46	"	5	58.3	13.2	42	63.2	12.6	8
47	"	23	65.3	12.7	22	59.4	10.4	19
48	"	25	65.6	12.8	19	59.6	15.4	17
49	"	3	65.7	16.4	18	50.5	4.4	69
50	"	7	59.2	12.2	38	55.3	6.1	40

Table 18. Continued

Region no.	Country	Prov- enance no.	Survival			Height		
			Mean %	Standard deviation	Rank	Mean cm	Standard deviation	Rank
51	Czechoslovakia	2	72.0	5.7	7	53.6	20.3	49
52	Hungary	7	63.6	8.7	26	50.3	8.0	70
53	"	4	71.3	10.8	8	51.6	12.4	57
54	Yugoslavia	2	70.2	18.5	9	53.9	8.2	47
55	"	3	74.0	6.0	5	46.5	9.4	89
56	Bulgaria	10	63.5	18.5	27	50.8	7.1	66
57	Romania	5	74.4	7.1	4	52.9	4.7	51
58	"	6	61.1	14.9	34	59.7	7.4	16
59	"	25	66.5	12.1	16	60.5	14.7	14
60	Poland	4	69.9	7.6	10	64.6	9.2	5
61	"	5	51.6	20.8	79	61.4	10.6	12
62	"	6	61.7	10.8	33	56.2	7.9	35
63	"	15	56.3	13.2	49	56.2	12.4	34
64	"	9	54.4	16.1	60	54.5	7.1	43
65	"	10	51.6	6.1	80	63.3	11.6	6
66	"	17	52.2	9.6	76	57.0	10.5	31
67	"	8	53.3	13.0	67	57.2	10.6	30
68	"	7	64.3	12.0	24	66.2	21.3	2
69	"	8	68.2	11.4	13	57.8	6.4	27
70	"	7	63.5	10.2	28	57.9	9.6	24
71	Lithuania SSR	9	73.3	7.4	6	61.2	7.8	13
72	Latvia SSR	8	65.6	12.5	20	55.6	7.9	36
73	Estonia SSR	5	77.5	14.9	3	58.1	7.4	23
74	"	8	79.7	9.8	1	60.0	9.1	15
75	White Russia SSR	6	69.5	6.2	11	62.6	9.2	11
76	Russia SSR	5	77.7	8.6	2	66.2	7.6	3
77	"	5	64.4	11.0	23	46.7	8.4	87
78	"	7	66.2	10.2	17	59.1	3.2	21
79	"	4	55.8	27.1	54	46.6	11.1	88
80	"	3	14.9	9.7	96	44.7	13.8	92
81	"	3	53.8	12.0	64	57.2	1.0	29
82	Denmark	5	66.8	8.2	15	63.2	17.7	9
83	Norway	10	68.8	14.6	12	54.3	6.5	45
84	"	5	63.8	20.3	31	49.7	2.5	75
85	"	5	54.0	20.0	62	48.3	12.6	82
86	Sweden	7	62.5	15.5	32	54.2	9.9	46
87	"	9	65.5	11.3	21	48.0	8.1	83
88	"	8	67.5	11.1	14	55.4	11.0	39
89	"	4	59.1	7.4	39	51.3	11.8	65
90	"	18	60.8	17.8	36	51.4	8.1	62
91	"	9	56.1	18.7	52	44.0	9.0	94
92	"	9	56.1	13.9	53	42.0	6.0	96
93	"	6	62.9	13.2	30	43.2	6.4	95
94	Finland	6	63.3	15.9	29	52.3	15.8	54
95	"	4	57.0	21.1	47	45.6	5.9	91
96	Canada	1	64.0		25	62.9		10

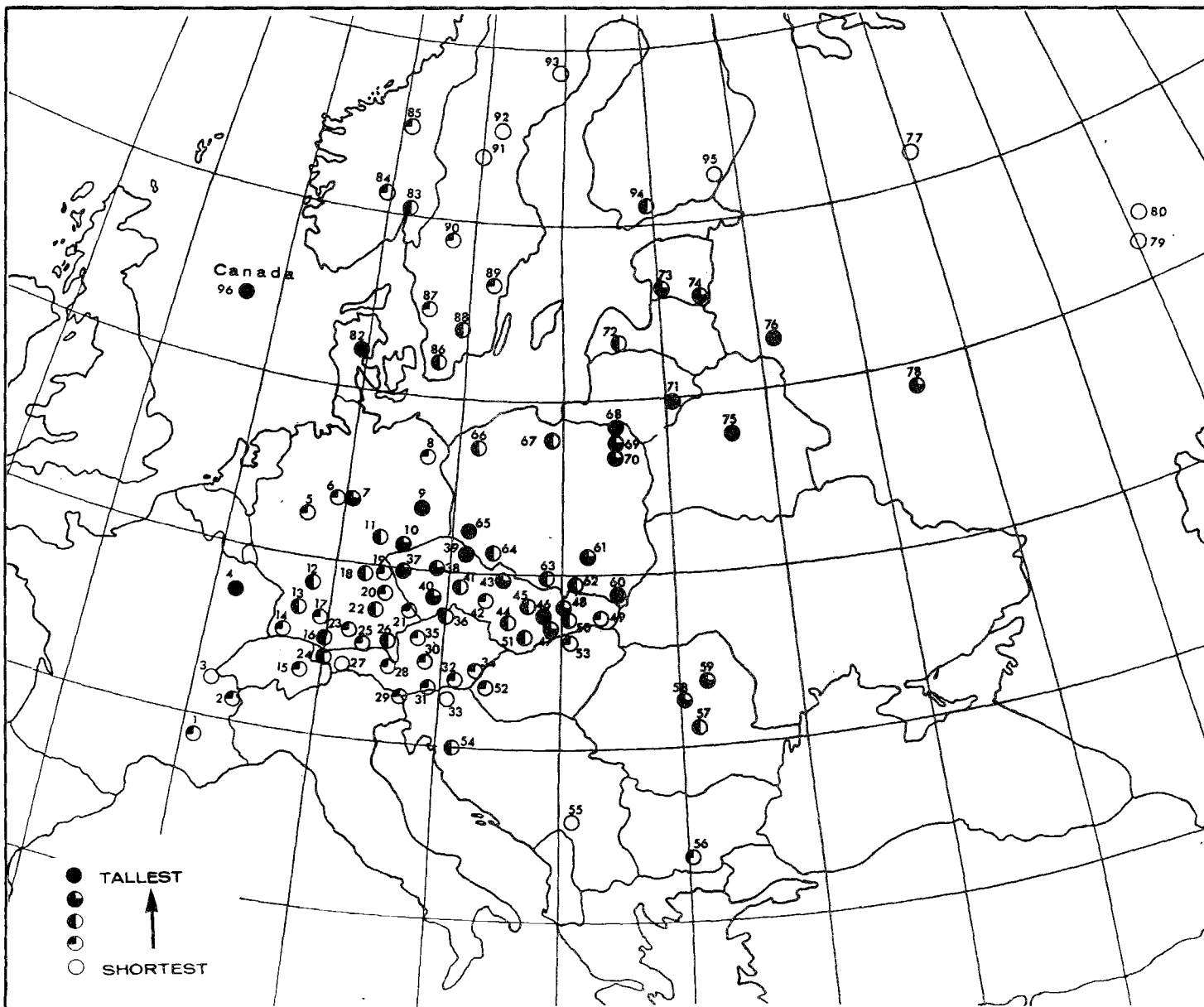


Fig. 9. Experiment 43. Geographic origin and relative height of Norway spruce, grouped by provenance areas, in experiment 43 - Chipman, N.B.

Correlation of height of provenance regions on mean latitude, longitude or elevation, separately, is not significant. However, the multiple correlation of height on latitude and elevation is significant ($R = 0.48$). Seedling height decreases as latitude and elevation of the provenance region increases ($ht = 100.56 - 0.788 \text{ lat} - 0.011 \text{ alt}$).

Differences in mean height among provenance regions vary from 42 to 68 cm and are significant. Provenance mean heights vary from 16 to 109 cm. Three non-native provenance regions (France (4), Denmark (82) and Canada (96) are among the best 10 with respect to height. Omitting these three regions, the best 10 are located in a band of lower elevations extending from northeastern Poland through Lithuania and White Russia to western Russia and in the Sudetan and Carpathian Mountains of Poland, Czechoslovakia, and East Germany. Of these 10, seedlings from the more northern provenance area (northeast Poland to western Russia) have above-average survival, those from southern Poland and Czechoslovakia have average survival and seedlings from the East German provenance region have poor survival. Based on 5-year height and survival, the "best area overall" appears to encompass northeastern Poland, Lithuania, western Latvia, southern Estonia, northern White Russia and western Russia. Seedlings from this area (regions 68, 69, 70, 71, 74, 75, 76) average 16 and 26% greater than the overall mean in height and survival, respectively. Trees of one provenance from region 68 average 108 cm in height exceeding the overall mean by 103%.

Seedlings from north of the Baltic Sea in Finland, Sweden, and Norway and from northern and cen-

tral Russia are the slowest growing and only about average in survival. Materials from the western and southern parts of the species range in Germany, France, Switzerland, Austria, Hungary, Yugoslavia, Bulgaria, and lower elevations in Czechoslovakia are generally slow growing. Survival of seedlings from the western provenance regions is generally below average.

EXPERIMENT 70

Materials and Methods

In this trial, comparisons were made among Norway spruce from 45 progenies from five Bulgarian provenances, one additional Bulgarian provenance, three provenances from Norway, three from Denmark, four from Yugoslavia and three first generation Canadian provenances. Trees of one provenance each of local white, red and black spruce were included as controls. Most of the seed lots used in this trial were acquired by Mark Holst. The Bulgarian materials have also been tested in PFES Exp. 350. Only the provenance aspects of this experiment are presented here. Pertinent data on all provenances and progenies are listed in Table 19.

The seeds were sown in unrepliated nursery beds at AFES, transplanted into a randomized block, 5 replicate design, and raised to 2+2 stock. In April 1970, observations on winter browning were recorded and in August 1971, height was measured for 40 seedlings per plot, i.e. 200 seedlings per provenance.

Two replicated experiments and three observation plantings were field planted in the spring of 1972. Information from the replicated experiments is reported here.

Table 19. Experiment 70 Provenance data

MS	Species	Provenance	Latitude °N	Longitude °E	Elevation m	Type collection
722	SN	Bommerlund, Graasten, Denmark				Plantation
723	SN	Fussingø, Comp. 134, Denmark				Plantation
724	SN	Wedellsborg, Ørsbjerg, Denmark				Plantation
1117	SN	Salmon River, N.B.	45.4	65.5°W	180	Plantation
1118	SN	Fownes Head, N.B.	45.4	65.5°W	80	Plantation
1313	SN	Rakkestad, Norway	59.4	11.3	100	Stand
1314	SN	Trondheim, Malvik, Norway	63.4	10.3	100	Stand
1316	SN	Lunner, Jevnaker, Norway	60.3	10.3-10.6	600	Stand
1380	SN	Sanski Most, Kljuc Co., Yugoslavia	44.8	16.7	1100	Stand
1381	SN	Skrtan, Nisan, Bugojno Co., Yugoslavlia	43.1	17.5	1050	Several Trees
1382	SN	Gornji Janj, Sipovo Joice Co., Yugoslavia	44.1	17.3	900-1200	Several Trees
1383	SN	Kraljevo, Kraljevo Co., Yugoslavia	43.7	20.8	1004	Stand
1384-93	SN	Pouchtinaka, Rila Mts., Bulgaria	42.3	23.6	1000	10 Single Trees
1394-1403	SN	Bistritza, Rila Mts., Bulgaria	42.3	23.6	1400	10 Single Trees
1404-13	SN	Gvardeiska, Poliana, Rila Mts. Bulgaria	42.3	23.6	1600-1650	10 Single Trees
1414-23	SN	Sitniakovska, Skala, Rila Mts. Bulgaria	42.3	23.6	1950	10 Single Trees
1424-33	SN	Lopouha Central, Rhodopes Mts., Bulgaria	41.7	24.7	1000	10 Single Trees
1434-38	SN	Ardachla Central, Rhodopes Mts., Bulgaria	41.6	24.7	1450	5 Single Trees
1447	SN	Hudson's Place, PFES, Ontario	46.0	77.4°W	180	Plantation
1090	Sw	Acadia Forest Exp. Sta., N.B.	46.0	66.4°W	100	Stand
1122	Sr	Acadia Forest Exp. Sta., N.B.	46.0	66.4°W	100	Stand
1327	Sb	Gagetown, N.B.	45.7	66.5°W	100	Stand

Experiment 70A, Acadia Forest Experiment Station

Norway spruce from all 45 families and 17 provenances were tested in this experiment. The experimental design was a randomized block replicated 10 times. The seedlings were planted 6 x 6 ft (1.8 m) spacing in 4-tree square plots. The planting area, a recent clear cut, was cleared of logging debris and hardwood stumps were sprayed with herbicides in August 1971. The site is moderately fertile, moderately fresh (AFES site 24) and would normally support a coniferous succession.

Survival was recorded in June 1973. Total height to the end of the 1976 growing season of all surviving trees was measured in July 1977, and observations on survival and damage were recorded. The results are analyzed by grouping the progeny data as provenances (Table 20).

Experiment 70B, Ten Mile Lake, Queens Co., N.S.

The materials used in this trial were the same as those used for Exp. 70A except that progenies were not kept separate. All progenies from a single provenance were grouped together by mixing approximately equal numbers of each progeny. One of the provenances from Norway (MS 1314) was omitted. A total of 17 Norway spruce provenances and one provenance each of white, red, and black spruce were represented in the test.

The experimental design consisted of randomized blocks replicated six times with 25-tree square plots in which the seedlings were planted at 6 x 6 ft (1.8 m) spac-

ing. The planting area which formerly carried a mature aspen-spruce stand had been clear cut and logging debris had been removed from the site with a bulldozer. The site is a moderately fertile, moderately fresh, sandy loam of the Halifax soil series (Cann and Hilchey 1959) and is gently undulating with some poorly drained patches.

At the time of planting, it was noted that many of the seedlings had damaged leaders caused by winter injury. These were recorded and a survival count was made at the end of the first growing season (1972). In July 1977, survival, total height, and top damage were recorded for 15 trees per plot.

Results

Experiment 70A

The summarized data, results of variance analysis, and ranking are presented in Table 20. Five-year height and geographic locations of the provenances are shown in Fig. 10.

Differences between provenances with respect to nursery height and survival and 5-year height in the field are highly significant. Percentage of trees exhibiting winter browning or weevil damage was generally low and not related to provenance. Trees from Hudson's Place, Ontario (MS 1447) and Fussingø, Denmark (MS 723) provenances have excellent survival and height growth. In fact, Norway spruce from all the plantation provenances (3 Denmark and 3 Canada) have above-average growth and survival. As expected, the three northern provenances from

Table 20. Experiments 70A, Acadia Forest Experiment Station; and 70B, Queens County, N.S.
Summarized data and analysis for 5-year measurements and observations

MS	Species	AFES		AFES - 5 year				Queens Co., N.B. - 5 year			
		4 yr Nursery		1976		Height cm	Rank	1976		Height cm	Rank
		Height cm	Rank	Survival %	Browning %			Survival %	Height cm		
722	SN	30	4	92	15	81	5abc	80	80	11	def
723	SN	33	2	88	3	87	2a	90	106	1a	
724	SN	29	5	78	3	82	4abcc	91	99	4ab	
1117	SN	28	6	75	0	74	8 bcde	86	89	7 bcd	
1118	SN	31	3	83	0	78	6abcd	89	94	5 bc	
1313	SN	14	16	80	0	61	18 ef	87	67	16	g
1314	SN	10	18	68	0	62	17 ef				
1316	SN	11	17	72	0	62	16 ef	90 ²	72 ²		
1380	SN	25	8	78	3	77	7abcd	93	75	14	fg
1381	SN	23	12	61	0	67	12 de	90	78	13	efg
1382	SN	24	10	72	0	66	14 de	89	72	15	fg
1383	SN	25	8	75	3	84	3ab	92	79	12	def
1384-93 ¹	SN	21	13	79	2	67	11 de	87	81	9	def
1394-1403	SN	20	14	77	2	68	10 de	87	81	10	def
1404-13	SN	20	14	76	2	66	13 de	76	86	8	cde
1414-23	SN	9	19	45	6	51	19 f				
1424-33	SN	24	10	76	8	63	15 ef	87	90	6 bcd	
1434-38	SN	26	7	74	3	70	9 cde	93	99	3ab	
1447	SN	35	1	85	6	88	1a	97	99	2ab	
Mean		21.5		75.5	3	71.2		88	92.9		
ANOVA		**		**		**		NS	**		
1090	Sw	16		68	0	59		87	76		
1122	Sr	19		88	9	82		84	85		
1327	Sb	35		83	0	97		81	109		

¹ Data from MS 1384-93, 1394-1403, 1404-13, 1414-23, 1424-33, 1434-38 treated as one source each, by randomly selecting the required number of observations (40) from individual progeny data.

² Seedling planted in only 2 of 6 blocks, hence not included in analysis.

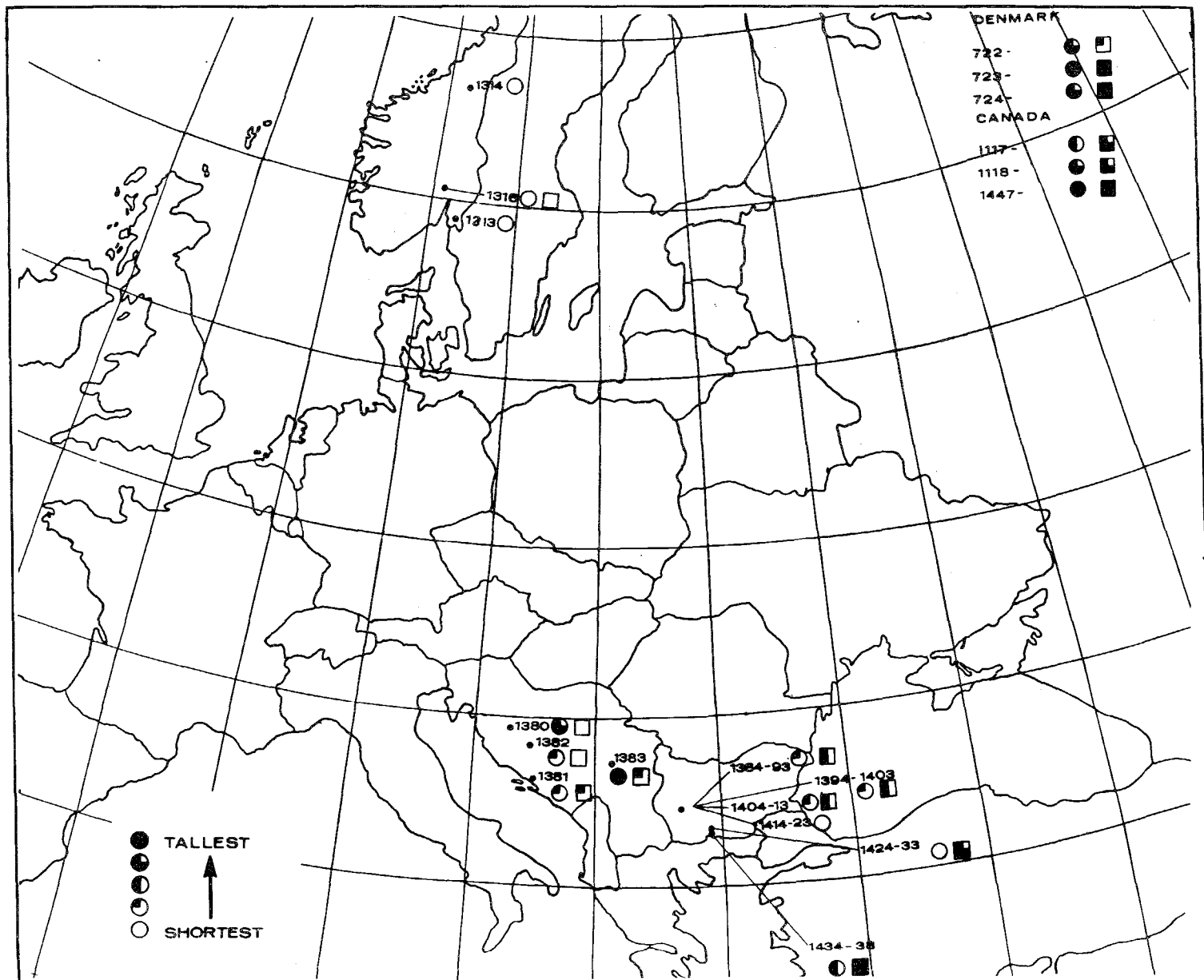


Fig. 10. Experiment 70. Geographic origin and relative height of Norway spruce in experiments 70A - Acadia Forest Experiment Station (○); and 70B - Queens County, N.S. (□).

Norway produce trees that are slow growing and have average to below-average survival. Norway spruce of Bulgarian provenances also perform rather poorly with those from high elevations from the Rila Mountains (MS 1414-23) exhibiting low survival and poor growth. Trees from Yugoslavia are highly variable in growth and survival. Trees from one provenance (MS 1383) grow well and have above-average survival.

The correlation of 4-year nursery height and 5-year height in the field is highly significant ($r = 0.89$). The rankings have changed little since outplanting, four of the tallest five in the nursery retain their position in the top five, after 5 years.

Black spruce performs well. It is as tall as the best Norway spruce in the nursery, 10% taller than the best after 5 years in the field and has above-average survival. The red spruce is slightly above the average for Norway spruce for both height and survival, whereas the local white spruce has below-average survival and rather poor growth.

Experiment 70B

The summarized data, results of analysis of variance, and ranking are presented in Table 20. The geographic location of the provenances and rankings for 5-year height are shown in Figure 10.

The mean height for trees of all provenances is 30% greater and survival is 16% better in this trial than in Exp. 70A. The correlation of 4-year nursery height and 5-year height in the field is significant ($r = 0.69$). Differences in 5-year height and survival are significant and height growth of provenances in Exp. 70A and 70B is significantly

correlated ($r = 0.59$). As in Exp. 70A, trees from Fussingø, Denmark, and Hudson's Place, Ontario, are fast growing and have above-average survival. With the exception of one Danish source (MS 722), all the plantation-source trees are above average in height. Trees from the Norwegian provenances and the four Yugoslavian provenances are slow growing while those from Bulgaria are highly variable. Norway spruce from the two Rhodopes Mountains provenances perform well and are generally superior to those from the Rila Mountains.

Black spruce from Gagetown, N.B. is 3% taller than the best Norway spruce and 15% taller than the average for Norway spruce. Red and white spruce from New Brunswick are slow growing and have below-average survival.

EXPERIMENT 99

Materials and Methods

In this trial, Norway spruce seedlings from six first generation Canadian provenances were compared. Five of these provenances were from plantations established by Pejepscot Paper Co. Ltd. in Saint John and Kings counties, N.B. about 1918 (Hughes and Loucks 1962). Two of the New Brunswick provenances were represented by more than one seed collection, Fownes Head (3) and Salmon River (2). One of these plantations, Salmon River, has been developed as a seed production plantation. The sixth Norway spruce provenance was from Hudson's Place, Ontario. In addition, trees from one provenance each of local white, red, and black spruce were included as controls. The primary objectives of this trial were to determine if

Table 21. Experiment 99, Provenance data

MS	Species	Provenance	Latitude °N	Longitude °W	Elevation m	Type collection
874	SN	Fownes Head, Saint John Co., N.B.	45.4	65.5	80	1965-plantation
875	SN	Salmon River, Saint John Co., N.B.	45.4	65.5	180	1965-plantation
1114	SN	Shepody Rd., Kings Co., N.B.	45.6	65.3	250	1966-plantation
1115	SN	Shepody Rd., Kings Co., N.B.	45.6	65.3	250	1966-plantation
1116	SN	Shepody Rd., Kings Co., N.B.	45.6	65.4	250	1966-plantation
1117	SN	Salmon River, Saint John Co., N.B.	45.4	65.5	100	1966-plantation
1118	SN	Fownes Head, Saint John Co., N.B.	45.4	65.5	50	1966-plantation
1132	SN	Fownes Head, Saint John Co., N.B.	45.4	65.5	50	1966-squirrel cache
1447	SN	Hudson's Place, PFES, Ont.	46.0	77.4	180	several trees
1090	Sw	Acadia Forest Expt. Sta. N.B.	46.0	66.3	100	general
1122	Sr	Acadia Forest Expt. Sta. N.B.	46.0	66.3	100	general
1327	Sb	Gagetown, N.B.	45.7	66.5	100	general

differences exist among the Canadian origin provenances, which presumably were of the same (unknown, possibly German) origin and to determine if type or year of collection influences subsequent growth. With the exception of one Norway spruce provenance (MS 1447), all seeds were acquired locally and are listed with pertinent data in Table 21.

The seeds were sown in unreplicated nursery beds in the fall of 1967 and raised to 2+2 stock. One replicated experiment at AFES and one observation trial near Glassville, N.B. were established in the spring of 1972. Data from the replicated experiment are reported here. The experimental design was a randomized block, replicated 10 times with 4-tree plots planted at 6 x 6 ft (1.8 m) spacing. Replicates 1-5 were

planted on a moderately rich, moderately wet site (AFES site 27) which would normally follow a coniferous succession. Replicates 6-10 were on a moderately rich, fresh site (AFES site 4) which would normally support a mixedwood succession. A single row of surround trees was planted around replications 1-5 and a double row around replications 6-10.

Survival was recorded for replicates 1-5 in July 1973. Total height was measured in all replicates and weevil and other damage were recorded for all surviving seedlings in July 1977.

Results

The summarized results are presented in Table 22. Weevil and winter damage were observed on

Table 22. Experiment 99, Acadia Forest Experiment Station. Summarized data and analysis for 3- and 6-year survival and 6-year height

MS	Species	1973 Survival ¹ %	1977 6-years	
			Survival %	Height cm
874	SN	90	85	68
875	SN	70	60	70
1114	SN	90	90	76
1115	SN	65	68	61
1116	SN	100	90	71
1117	SN	95	85	77
1118	SN	90	88	70
1132	SN	100	75	63
1447	SN	90	85	75
Mean	SN	88	81	70
ANOVA		NS	NS	NS
1090	Sw	90	75	57
1122	Sw	80	83	63
1327	Sb	63	75	88

¹ 1973 survival recorded for replication 1-5 only.

less than 1% of the trees and do not appear to be related to provenance. After 6 years in the field, differences in survival and height due to provenances are not significant. This is not unexpected as all of the Norway spruce except MS 1447 are thought to come from the same unknown source. Trees from Hudson's Place are the third tallest and have above-average survival. Year and type of collection do not have a significant effect on growth.

In this trial, white spruce has below-average survival and is clearly inferior to Norway spruce in height after 6 years. Red spruce has average survival and is only as tall as the shortest Norway spruce. Black spruce is 12% taller than the tallest and 20% taller than the average for Norway spruce, although its survival is slightly below average.

COMPARISON WITH NATIVE SPRUCES

One or more of the native spruces (black, white, and red) are planted as controls, surrounds, and dividers, or in adjacent plots in 9 of the 10 experiments reported here. The species comparisons are summarized for survival (Table 23), height (Table 24) and damaging factors (Table 25).

Survival

Average overall survival of Norway and black spruce is the same (86%) in all 13 plantings in which comparisons are possible. Norway spruce has higher survival in six plantings while black is better in seven. In all cases except Exp. 42, survival of the black spruce controls falls within the survival range of Norway spruce provenances or the ranges for survival overlap (Exp. 41B).

Norway spruce generally survives better than either white or red spruce. It has 87% survival compared to 80% for white spruce and was better in 12 of 15 comparative plantings. The overall difference is, however, primarily the result of poor survival of white spruce in Exp. 31 and 39-40A, both of which are planted at AFES. Survival of Norway spruce (88%) is equal to or better than survival of red spruce (79%) in 9 of 12 comparisons. Survival of red spruce is highly variable and especially poor in Exp. 41C (44%) and 35A (60%).

Height

The black spruce controls are taller than the tallest Norway spruce provenances in all but one (Exp. 41C) of the 13 plantings where comparisons can be made. Mean annual height increment for the 13 plantings is 20.4 cm for black spruce compared to 16.4 cm for Norway spruce. Experiment 41 is essentially a progeny test of 10 families from two Czechoslovakian provenances. Neither of the black spruce provenances in Exp. 41C, Antigonish Co., N.S. can be considered as local, one being from New Brunswick and the other from Newfoundland. In a test of these same provenances (Exp. 41B at AFES), the local provenance of black spruce is superior to the best Norway spruce progeny.

Mean annual height increment for 15 plantings is 16.7 cm for Norway spruce compared to 14.0 cm for white spruce. Average height for Norway spruce is equal to or exceeds that of white spruce in all but one (Exp. 16C) of the 15 plantings where comparisons can be made. The poorest Norway spruce provenance is equal to or better than white spruce in eight plantings. In Exp. 16C, located at Green River in northwestern New

Table 23. Summary of survival of Norway, black, white, and red spruce

Experi- ment no.	Age yr.	Norway			Black			White			Red		
		No. prove- nances	Range %	Mean %	No. prove- nances	Range %	Mean %	No. prove- nances	Range %	Mean %	No. prove- nances	Range %	Mean %
16A	8	11	85-95	90				1		93			
	17	11	77-95	87				1		96			
16C	17	12	66-100	87				3	66-88	80			
31	5	12	81-94	86	1		79	1		55			
	10	12	72-92	84	1		76	1		52			
33	6	6	89-97	92	1		91	2	88	88	3	83-93	88
	10	6	82-94	90	1		87	2	82-84	83	3	73-83	79
35A	8	23	75-100	80	2	81-90	86	1		83	1		60
35B	6	23	65-95	83	2	85-90	88	1		80	1		83
35C	8	23	90-100	98	2	98-100	99	1		100	1		95
39-40A	5	39	65-98	86	1		90	1		65	1		70
39-40B	6	39	65-100	85	1		77	1		80	1		70
41B	6	2 ¹	87-88	88	2	87-92	90	1		75	1		83
41C	7	2 ¹	92-94	93	2	89-92	91	1		80	1		44
42	5	7	73-93	82	1		98	1		75	1		95
70A	5	19 ²	45-92	76	1		83	1		68	1		88
70B	5	17	76-100	95	1		82	1		94			90
99	6	9	60-90	81	1		75	1		75	1		83
³ Mean Survival													
Norway vs black				86					86				
Norway vs white				87						80			
Norway vs red				88							79		

¹ Includes 20 single tree progenies.

² Includes 45 single tree progenies.

³ In experiments where survival is recorded at two ages, only survival to the greater age is included in the mean.

Table 24. Summary of height of Norway, black, white, and red spruce

Experi- ment no.	Age yr.	Norway			Black			White			Red		
		No. prove- nances	Range cm	Mean cm	No. prove- nances	Range cm	Mean cm	No. prove- nances	Range cm	Mean cm	No. prove- nances	Range cm	Mean cm
16A	8	11	111-141	125				1		135			
	17	11	330-440	380				1		320			
16C	17	12	220-350	280				3	250-410	320			
31	5	12	82-120	101	1		100	1		80			
	10	12	193-246	227	1		267	1		175			
33	6	6	91-109	96	1		109		82-91	86	3	79-82	80
	10	6	165-218	184	1		226		156-176	166	3	159-166	163
35A	8	23	91-157	130	2	157-181	169	1		119	1		61
35B	6	23	92-128	111	2	128-160	144	1		96	1		108
35C	8	23	72-109	90	2	106-136	121	1		91	1		88
39-40A	5	39	84-116	99	1		134	1		91	1		74
39-40B	6	39	65-89	77	1		101	1		47	1		36
41B	6	¹ 2	104-107	106	2	113-146	130	1		95	1		86
41C	7	¹ 2	130-134	132	2	96-111	104	1		81	1		39
42	5	7	46-59	53	1		89	1		44	1		54
70A	5	19 ²	51-88	71	1		97	1		59	1		82
70B	(5)	17	67-106	93	1		109	1		76	1		85
99	6	9	61-77	70	1		88	1		57	1		63
³ Mean annual increment (Height cm)													
Norway vs Black				16.4	20.4								
Norway vs White				16.7					14.0				
Norway vs REd				15.8					12.4				

¹ Includes 20 single tree progenies.

² Includes 45 single tree progenies.

³ In experiments where height is recorded at two ages, only height at the greater age is included in mean annual increment.

Brunswick, the poor performance of one Norway spruce provenance (MS 96) from a plantation near Halifax, N.S. and the good performance of a white spruce provenance from AFES accounts for the overall poor showing of Norway spruce. If MS 96 is not included in the comparison, the mean height for the 11 Norway spruce and three white spruce provenances is essentially the same, with Norway spruce being slightly taller than local white spruce.

Norway spruce also outgrows red spruce being as tall or taller than red spruce in 11 of 12 comparisons. Mean annual height increment is 15.8 cm for Norway spruce compared to 12.4 cm for red spruce. In 6 of 12 comparisons the poorest Norway spruce provenance is taller than red spruce and in the other comparisons red spruce height is within the range exhibited by Norway spruce. Red spruce is taller than the mean for Norway spruce only in Exp. 70A planted at AFES.

Damaging factors

Norway spruce is recognized as being susceptible to damage by the white pine weevil whereas the native eastern North American spruces are resistant. Our experiments confirm these observations. Incidence of damage caused by weevils is a serious factor only in the older plantations. Nineteen percent of the Norway spruce in Exp. 16A are damaged compared to only 3% for white spruce. Top damage, which included damage by weevils and breakage caused by hardwood competition, is high in Norway spruce (48%) compared to white spruce (2%) in Exp. 16C. In two other experiments (Exp. 31 and 41B), 6% of the Norway spruce are weeviled while damage is less than 1% on the native spruces. In the

other experiments, damage by weevils is slight but can be expected to become more serious.

Winter damage is relatively easy to assess but difficult to interpret. Most Norway spruce exhibit foliage browning and some needle loss at some time during their early development. This is especially prevalent when the seedlings are planted on exposed sites and during first emergence from winter snow cover. It is, however, unusual for winter damage to be severe enough to kill buds or shoots. Undoubtedly, if winter damage and resulting needle loss occur annually over a period of years, the photosynthetic capability of the trees is reduced and growth potential will not be attained. In all but one planting (Exp. 39-40B) winter damage appears to be temporary and of relatively little importance. Experiment 39-40B is situated in a large clear cut on the Cape Breton Highlands. Exposure is extreme in this location and bud and shoot damage is extensive on all Norway spruce provenances as well as on the native species. In those experiments where comparisons can be made, Norway spruce shows more evidence of winter damage than do the native spruces. The comparison is confounded however, because the species grow at different rates and thus, at different times, pass through the period when damage is most severe. For example, the comparatively low damage to red spruce in Exp. 35 and 39-40B is primarily because the species is slow growing and still protected by snow cover or by adjacent plots of more rapid growing species. Intuitively we would rate both Norway spruce and red spruce as being more susceptible to winter drying than are black or white spruce.

Table 25. Summary of weevil and winter damage of Norway, black, white, and red spruce

Experi- ment no.	Damage	Age yr.	Norway			Black			White			Red		
			No. prove- nances	Range %	Mean %	No. prove- nances	Range %	Mean %	No. prove- nances	Range %	Mean %	No. prove- nances	Range %	Mean %
16A	Weevil	17	11	5-27	19				1		3			
16C	Weevil ¹	17	12	16-69	48				3	0-7	2			
31	Weevil	10	12	3-10	6	1		0	1		0			
41B	Weevil	6	2 ²	6-7	6	2	0-2	1	1		0	1		0
35A	Winter	8	23	38-86	65	2	27-33	30	1		33	1		33
35C	Winter	8	23	47-90	73	2	10-15	13	1		40	1		21
39-40B	Winter	6	39	83-100	93	1		100	1		96	1		67
42	Winter	5	7	3-26	11	1		3	1		3	1		8
70A	Winter	5	19 ³	0-15	3	1		0	1		0	1		9

¹ Includes other types of tip damage.

² Includes 20 single tree progenies.

³ Includes 45 single tree progenies.

Late spring frost damage is not evident in any of the experiments although both Norway spruce and white spruce are reported to be susceptible to damage of this type.

Based on observations in Exp. 33G it is evident that Norway spruce is more susceptible to damage from meadow voles than are any of the three native spruces.

Defoliation by spruce budworm is serious only in Exp. 16C located in northern New Brunswick. White spruce is the only other species planted in this experiment. Differences between white and Norway spruce provenances with respect to budworm damage are not evident.

Damage to Norway and native spruce by porcupines, and various disease organisms could not be compared because of the low incidence of damage in the experiments. Assessment when the plantations are older will probably provide better information on the relative importance of these organisms.

The exceptionally good overall performance of black spruce in comparison with that of Norway spruce in these experiments is surprising and does not support the opinion that better Norway spruce provenances will outproduce native species (Holst 1963; MacArthur 1964; Bailey 1963). It should be emphasized that these trials have been evaluated at a young age (5 to 16 years from planting) and that assessment is based primarily on height growth. It has been established that Norway spruce is capable of maintaining good height and volume growth over rotations of 50 years or more on good sites in eastern North America (Hosley 1936; Hawley and Lutz 1943; Hughes and Loucks 1962). Similar information is not

available for plantation-grown black spruce in the Maritimes. We believe that Norway spruce of good provenances and planted on average to above-average sites will surpass black spruce in volume growth over rotations of 40-50 years or more. Information from periodic measurements of these experiments over the next 10 to 20 years will provide a more meaningful basis for comparing the relative merits of black and Norway spruce in the Maritimes Region.

EFFECT OF SELECTION WITHIN PROVENANCES

The seed was collected for these experiments in several different ways; some was obtained from phenotypically superior individuals of selected provenances, some from selected plus trees, and others from unselected individuals and stands. Thus, a comparison is possible between selected and unselected material.

In Exp. 31, progenies from four plus trees average 10% taller after 10 years than the mean for trees of three comparable, but different, Danish provenances. Two of three progenies from selected New Brunswick trees (Exp. 35), tested in three locations, compare favorably with trees from the same unselected provenance. However, performance of the progeny from the other selected tree was poor.

Norway spruce from 22 trees selected in the Proulx plantations, Quebec, are not superior in height to unselected materials of the same provenance (Exp. 35). On the other hand, the growth performance of Hudson's Place Norway spruce, which represents only four highly selected trees, is exceptional almost everywhere they are planted.

The Danish progenies and the Hudson's Place provenance (Holst and Heimbürger 1969) result from a high level of selections, whereas selection intensity for the New Brunswick progenies and the Proulx provenance is considerably lower. Although the evidence must be considered tenuous, it appears that progenies and provenances from highly selected trees can be expected to be superior to trees from comparable unselected provenances. On the other hand, low levels of selection appear ineffective. It follows that the additional cost of obtaining Norway spruce seeds from provenances represented by selected trees is not warranted on the basis of anticipated improvement in height growth. It should be pointed out that growth rate is only one of the criteria used for selecting superior trees, yet in evaluating performance through these experiments, height has been the prime consideration. It is possible, if not probable, that selection for other characteristics would be more effective, stem form and branching.

SUITABILITY OF NORWAY SPRUCE PROVENANCES FOR EASTERN CANADA

For discussion purposes the range of Norway spruce is subdivided into five geo-climatic areas. Also, Norway spruce provenances from outside the natural range of the species are included. The subdivisions are as follows:

1. Northern Europe (Norway, Sweden, Finland and northern Russia).
2. East of Baltic Sea (northeastern Poland, Lithuanian SSR, Latvian SSR, Estonian SSR, White Russian SSR, and western Russia).

3. Sudeten and Carpathian Mountains (southern Poland, northern Czechoslovakia, northern Hungary, and Romania).
 4. East Germany.
 5. Alps and Jura Mountains (southern Germany, eastern France, Switzerland, Austria, and northern Italy).
 6. Dinaric Alps and Balkan Mountains (Yugoslavia, Albania, and Bulgaria).
 7. Non-native provenances (Europe and North America).
1. Northern Europe - Norway spruce from provenances north of the Baltic Sea and from northern and central Russia are consistently slow-growing and have only average to below-average survival when planted in the Maritimes (Exp. 31, 43, and 70). The poor performance and survival of Norway spruce from northern provenances may be because they are being grown 10 to 20° of latitude south of their origin. This, as expected, results in reduced growth and poor adaption to environmental conditions of the Maritimes. It is doubtful if trees from Northern Europe can be expected to compete successfully even in climatically rigorous parts of the Maritimes, e.g. Cape Breton Highlands and northern New Brunswick.
- These conclusions fully support Holst's (1963) recommendations that Norway spruce of Scandinavian and northern Russian provenances should not be used for reforestation in northeastern North America.
2. East of Baltic Sea - Norway spruce from provenances east of the Baltic Sea are included in three experiments (Exp. 35, 39-40, and 43). Norway spruce from eastern Poland, although more variable

than those from mid-elevations in southern Poland, generally performed well in tests in central New Brunswick. In Exp. 39-40A, 12 of 16 provenances from eastern Poland rank average or above in height, and except for one provenance (MS 955) are average for survival. None of these provenances are considered suitable for use on the Cape Breton Highlands (Exp. 39-40B). Seedlings from all three eastern Polish provenance areas tested in Exp. 43 performed well; provenance area 68 ranked second out of 96.

Norway spruce from further north and directly east of the Baltic Sea generally performs adequately in tests in central New Brunswick, the Lithuanian and Estonian provenances ranking as average or above average in Exp. 35B and 43. Trees from the one Latvian provenance included in Exp. 39-40A are below average in height and survival, whereas a provenance from Latvia ranks well for both traits in Exp. 43. In northern New Brunswick, Norway spruce from Lithuania and Latvia rank exceptionally well for both growth and survival (Exp. 35A). The relative performance of trees of these same provenances is less impressive in Nova Scotia (Exp. 35C) where all rank average or below. Norway spruce from the one Latvian provenance tested on the Cape Breton Highlands (Exp. 39-40B), although one of the best, cannot be considered suited to this area.

Trees from further east, from White Russia and western Russia, are tested in only Exp. 43 where they perform well. In this experiment in central New Brunswick, provenance area 76, western Russia, ranks 2 for survival and 3 for height (out of 96), provenance area 75, White Russia, ranks 11

for both categories, while Russian provenance 78 ranks 17 for survival and 21 for height.

In conclusion, Norway spruce from eastern Polish provenances is among the most promising for planting in the Maritimes. Latvian and Lithuanian materials are promising for northern New Brunswick, but considerably less promising for Nova Scotia. Norway spruce from White Russia and western Russia, although not adequately tested, appear promising for use in central and northern New Brunswick.

3. Sudeten and Carpathian

Mountains - Norway spruce from the Sudeten and Carpathian Mountains have been tested in six of the experiments reported here (Exp. 16, 31, 33, 35, 39-40, and 43). Spruce from mid-elevation in southern Poland are performing well throughout the Maritimes except on the Cape Breton Highlands. Trees from higher elevation provenances (above 700 m) are less reliable. In tests at AFES, Polish sources rank among the best in Exp. 16A and 35B, are among the best 25% in Exp. 31A and 39-40A, and are satisfactory although only average in Exp. 33. The six provenance areas from the Sudeten and Carpathian Mountains of Poland are average to outstanding in Exp. 43 near Chipman, New Brunswick.

In tests in northern New Brunswick, the performance of spruce from southern Poland is more variable. In Exp. 16C in northwestern New Brunswick, one of two Polish provenances ranks among the best (MS 95) while the other (MS 85) is among the poorest. In Exp. 35A, near Edmundston, N.B., trees from Poland although among the best with respect to height, have poorer survival than trees of fast-growing Latvian provenances.

In Nova Scotia, trees of Polish provenances rank among the best in Exp. 16 (PFES) and 35C at Corbett Lake and Caledonia, respectively. Norway spruce from Poland are unsuited for planting on exposed sites on the Cape Breton Highlands (Exp. 39-40B).

Performance of Norway spruce from the Sudeten and Carpathian Mountains of northern Czechoslovakia is poor and more variable than that of the Polish sources. In Exp. 39-40A, in central New Brunswick, trees of the two Czechoslovakian provenances have average survival but are slow-growing. Of the 14 provenance areas from Czechoslovakia tested in Exp. 43, all but three rank as average or above. In Exp. 41, at AFES, which is essentially a progeny test, performance of even the best progenies is not impressive compared to that of black spruce. On the other hand, these same progenies are superior to black spruce in a test at Maryvale, N.S. Norway spruce of Czechoslovakian provenance are not suited for the Cape Breton Highlands (Exp. 39-40B).

Norway spruce from the southern Carpathian Mountains of Romania are included in Exp. 35, 39-40, and 43. The performance of trees from these provenances is highly variable and generally inferior to that of trees from farther north. In trials in New Brunswick, trees of Romanian provenance are slow-growing in Exp. 35B and 39-40A, whereas, in Exp. 43 they are average to above-average, although clearly inferior to trees from more northern provenances such as Poland. Survival of the Romanian materials is average in these experiments. In northern New Brunswick, Exp. 35A, trees from Romania rank as average or above for growth and survival

but are inferior to trees from Latvia or Poland.

The performance of Norway spruce from Romania is variable in the Nova Scotia test (Exp. 35C) where one provenance (MS 896) ranks among the best and others are average or below. Spruce from Romania are unsuited for the Cape Breton Highlands (Exp. 39-40B).

In conclusion, Norway spruce from mid-elevations in the Sudeten and Carpathian Mountains of Poland are among the most promising for all areas except the most northern parts of New Brunswick and the Cape Breton Highlands. Trees from Czechoslovakian provenances, appear to be less reliable. Norway spruce from further south in the Carpathians of Romania are generally unsatisfactory but should be further tested, especially in the milder parts of Nova Scotia.

4. East Germany - Norway spruce from provenances along the western part of the species range in East Germany have been included in six experiments (Exp. 16, 31, 33, 35, 39-40, and 43). The performance of trees from this area has been extremely variable wherever they have been planted in the Maritimes Region. This high variability and the absence of any obvious relationship to environmental factors may relate to the fact that the species has been under intensive management in this area for centuries. It is probable that some of the German provenances are not from native stands. Variability of Norway spruce from German provenances is especially evident in Exp. 31A where trees from two seed lots (MS 701 and 702) from the same location, differ significantly in height, one ranking among the best and the other among the poorest. East German Norway spruce rank among the best and

poorest in Exp. 16(PFES), 31A, 35B, 35C, and 43. In Exp. 16A, 33, 35A and 39-40A, 39-40B the performance of trees of German provenances is average or below.

It is concluded that the variability in performance of Norway spruce from different German provenances complicates their use for reforestation in the Maritimes. To be effective, best provenances would have to be identified at the stand or plantation level.

5. Alps and Jura Mountains -

Information on the performance of Norway spruce from the Alps and Jura Mountains is available from four experiments (Exp. 16, 39-40, 42, and 43). With few exceptions, survival and growth of trees from this area have not been outstanding. Trees from two mid-elevation provenances, one from Germany (MS 89) and the other from Austria (MS 90) rank among the best for height and survival after 17 years in Exp. 16C in northern New Brunswick. In this same experiment, trees from elsewhere in the Alps are below-average in growth and highly variable in survival. Of the almost 30 provenance areas from the Alps and Jura Mountains tested in Exp. 43, none are outstanding and most are classed as average or below. The few above average provenances are from the Bohemian Forest of western Czechoslovakia.

It is concluded that the performance of Norway spruce from Alps or Jura Mountain provenances, although highly variable, is generally unsatisfactory in the Maritimes. There is however, an indication (Exp. 16C) that certain provenances may be useful in the climatically more rigorous parts of the Region.

6. Dinaric Alps and Balkan Mountains - Norway spruce from Yugoslavia and Bulgaria are

included in two trials (Exp. 43 and 70). In general, the performance of trees from these provenances does not compare favorably with that of other Norway spruce and black spruce (Exp. 70). The Bulgarian trees, although only slightly below average in survival, are consistently slow-growing in tests in central New Brunswick. The relative performance of trees of these same provenances is better in southern Nova Scotia (Exp. 70B) where trees from one provenance (MS 1434-38) rank among the best.

Except for trees of one provenance (MS 1383) which have average survival and above-average height growth at AFES, the Yugoslavian provenances are consistently poor. The provenances from Yugoslavia and Bulgaria, tested in Exp. 43, rank average or below-average.

It is evident that trees of Dinaric Alp or Balkan Mountain provenance are generally unsuited for direct use in the Maritimes Region.

7. Non-native provenances - For centuries Norway spruce has been planted outside its native range in many parts of Europe. The true origin of these "provenances" and the extent to which they have been influenced by local selection (natural and man) are generally not known. Despite this lack of information, non-native provenances are potentially valuable sources of seed. Norway spruce representing several of the non-native provenances are included in the IUFRO 1964-68 provenance test (Exp. 43) planted in central New Brunswick. As might be expected, the performance of trees of non-native provenances is highly variable. Provenance region 82 from Denmark (5 provenances) and region 4 in northern France (5 provenances) produce trees that are growing well, ranking 9 and 4

out of 96, respectively. Survival, however, of the trees from the French region 4 is well below average. Other provenance regions from outside the species natural range in Germany and Poland rank as average or below in Exp. 43. Norway spruce from "naturalized" Danish provenances has also been tested in Exp. 31 and 33 where, with one exception (MS 722 in Exp. 33) they fail to distinguish themselves.

Norway spruce has been planted on a limited scale in eastern Canada since the early 1900's. Some of these plantings have done exceptionally well (Hughes and Loucks 1962; Holst 1963; MacArthur 1964) and are of potential value as seed production plantations. However, as the origin of these plantations is unknown, their value with respect to performance of other Norway spruce is also unknown. Non-native provenances from promising first generation North American plantations have been tested in Exp. 16C, 31, 35, 42, 43, 70, and 99. The growth of Norway spruce from New Brunswick provenances is disappointing and generally inferior to that of trees of the better European provenances. It is evident that these "local" non-native provenances do not represent areas of better European provenance and that natural selection has not significantly improved them.

Non-native provenances from more continental parts of North America have performed better in central and northern New Brunswick than have the "local" non-native provenances. An exception is the Manitoba provenance of Finnish origin (Exp. 31) which is very slow growing. Norway spruce from a plantation at Hudson's Place, Chalk River, Ontario (see Holst and Heimbürger 1969) ranks among

the best in Exp. 35A, 35B, 43, 70A and 70B, is above average in Exp. 99, and is poor only in Exp. 35C in Caledonia, N.S. Holst (1963) suggested that the good performance of trees of this provenance results from intensive selection among trees of poor German origin. Trees of non-native Quebec (Exp. 35) and New York (Exp. 33) provenances perform well in central New Brunswick.

PROVENANCE RECOMMENDATIONS

At the present stage of provenance testing of Norway spruce in eastern Canada, identification of best provenance at the stand or local population level has little practical value. Aside from the fact that most tests fail statistically to identify single best provenances, identification of best provenance is usually impractical for one or more of the following reasons:

1. Seed procurement from individual stands is usually difficult to arrange and control.
2. The stands chosen for testing, and subsequently identified as best, may not be suitable for commercial seed collection because of size, ownership, or some other reason.
3. The original stand from which seed was collected no longer exists.
4. Seeds from a single stand planted over wide areas will be of limited value for future breeding work because of the restricted genetic base.

Primarily for the above reasons, we have chosen to recommend areas of best provenance and further to recommend that genetically broad based seed collections, e.g.

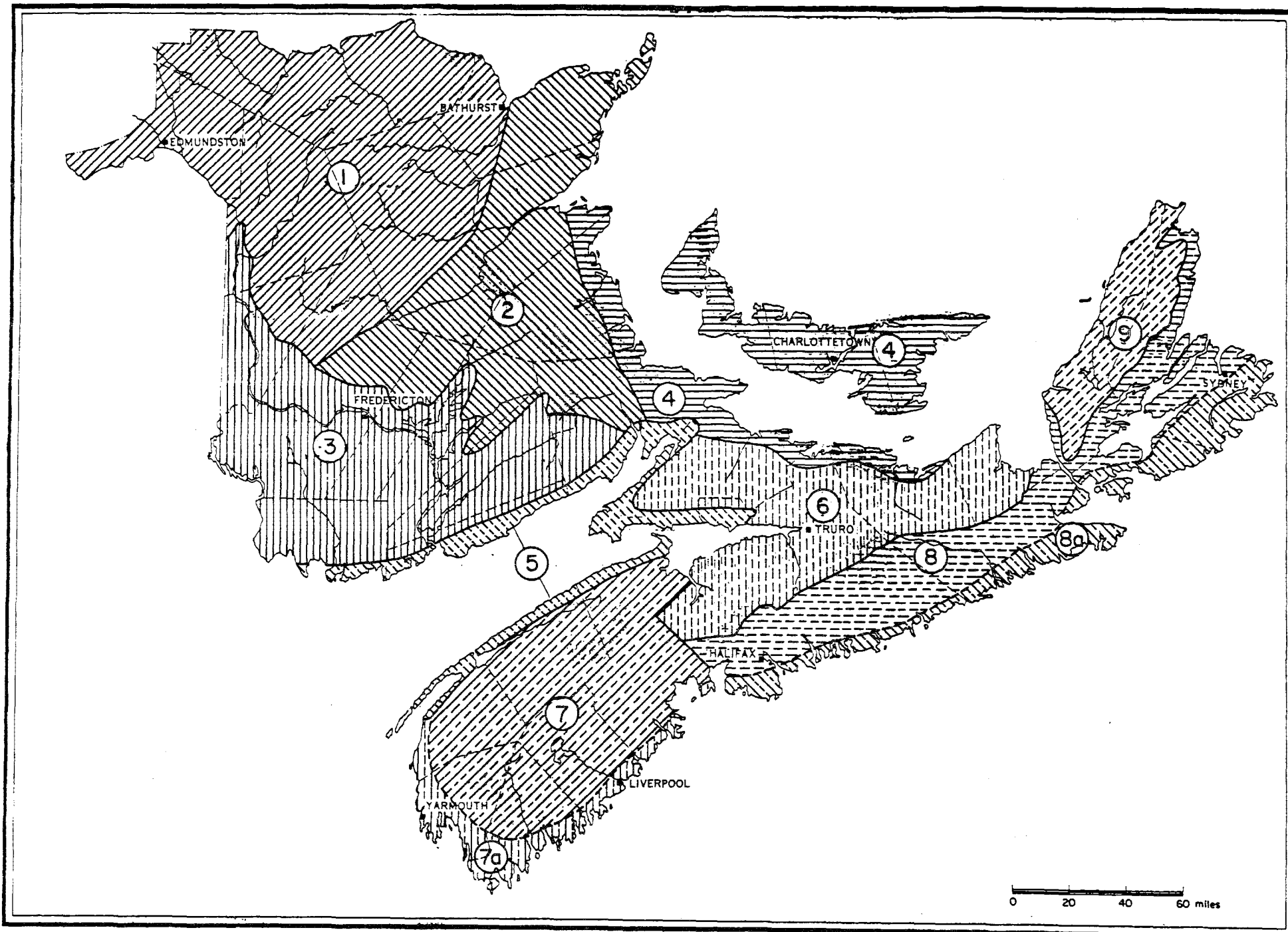


Fig. 11. Seed zones of the Maritime Provinces.

collections from several stands, be favored over single stand collections. Norway spruce seeds purchased for use in general reforestation programs should be certified as to authenticity of origin (if possible under the O.E.C.D. scheme), by some responsible agency.

A seed zone map, based primarily on environmental subdivisions of the Maritime Provinces (Fowler and MacGillivray 1967) is presented in Figure 11. Recommendations as to Norway spruce provenance areas best suited to the various seed zones follows:

Seed Zone 1 - Northern New Brunswick. Norway spruce of provenances east of the Baltic Sea in Lithuanian SSR, Latvian SSR, White Russian SSR and western Russia are best suited for this seed zone.

Seed Zone 2 - Northeastern New Brunswick. Norway spruce from northeastern Poland and from mid-elevation (less than 700 m) provenances from the Sudeten and Carpathian Mountains of Poland can be expected to be best in this seed zone. Seeds from provenances directly east of the Baltic Sea will also perform well especially in climatically more rigorous parts of this zone.

Seed Zones 3, 4, 5, 6, 7, and 8 - Southern New Brunswick, Prince Edward Island, and Nova Scotia (except for Seed Zone 9). Norway spruce from mid-elevations in the Sudeten and Carpathian Mountains of Poland are recommended for this area. Trees from northeastern Poland can also be expected to grow well and may have an advantage when used on exposed sites.

Seed Zone 9 - Cape Breton Highlands and Hills. Norway spruce cannot be recommended for planting in the Cape Breton Highlands. None of the provenances tested

here, including high elevation (1000-1400 m) ones from the Carpathian Mountains are able to cope with the severe exposure characteristic of this area. Norway spruce from east of the Baltic Sea is recommended for planting in climatically less severe parts of Seed Zone 9, e.g. valleys along the northeastern shore and lower hills and valleys along the eastern and southeastern edges of this zone.

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