Forest Research Branch

GROWTH OF NORWAY SPRUCE (*PICEA ABIES* (L) KARST.) PROVENANCES IN EASTERN NORTH AMERICA

by
M. HOLST

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ABSTRACT

In the early 1940's, international provenance tests of Norway spruce were established in Massachusetts, Vermont, New York, Michigan, Wisconsin, New Brunswick and eastern Ontario. In New England and the Maritime provinces of Canada, growth has been excellent for many provenances, exceeding that of native spruces and balsam fir. Any fast-growing, moderately hardy race should find growing conditions suitable if not planted on droughty soils or in frost pockets. In the inland part of the Great Lakes-St. Lawrence Forest Region, the climate of the planting site and provenance must be fairly carefully matched. The most promising material seems to come from stands originating around the south-east corner of the Baltic Sea, Poland and White Russia. White pine weevil is a serious problem everywhere in eastern North America and selection should be made for weevil resistance.

Growth of Norway Spruce (*Picea Abies* (L.) Karst.) Provenances in Eastern North America[1]

by

M. Holst[2]

INTRODUCTION

In the late 1930's, I.U.F.R.O. (International Union of Forest Research Organizations) made available good seed of Norway spruce for establishment of provenance trials in eastern North America. Although World War II prevented best use of this material, several provenance experiments were planted. This paper: (1) reviews briefly the results to date of these experiments, (2) mentions several difficulties in growing Norway spruce, and (3) indicates the potential productivity of Norway spruce in various regions.

PROVENANCE EXPERIMENTS

I.U.F.R.O. International Norway Spruce Provenance Trial of 1939 at the Petawawa Forest Experiment Station, Chalk River, Ontario

Norway spruce seed was sown in spring 1940 and planted in the field in 1943 and 1945, at which time all small plants and plants showing signs of frost damage or early flushing (90 to 95 per cent) were eliminated. The experiment was conducted to select trees of known origin adapted to the local climate.

The trees were planted on a good spruce site at 3- by 6- feet spacing so that early elimination of undesirable types would still leave enough plants to form a stand. Small, poorly formed, and heavily weevilled trees were thinned in 1951 and 1961, reducing the stand from 5,627 to 2,295 trees, see Table 1 for 1961 remeasurement.

The best seed lot was from a local source (Hudson's Place, Petawawa Forest Experiment Station), the second generation of a German (?) provenance; it had the following history. The original plantation of Norway spruce, set out at Hudson's Place in 1924, consisted of some 1,500 2-2 stock. After the severe winter of 1933–34, hardy trees were selected and released from competition. The superior seed lot referred to above (S. 284-42) came from one tree pollinated from hardy trees. It is interesting that seed from hardy trees fertilized with pollen from non-hardy trees (lot S.210-40) was poorer, the difference in height of trees from the two seed lots being about $1\frac{1}{2}$ metres.

The next best two provenances were from the Latvian S.S.R. Another Latvian provenance ranked tenth in southern Sweden (Dönjelt) and first in central Sweden (Bjornsjön). Although it is not known from where the next lot (the Poland Number 10) came, its performance suggests northeastern Poland: Norway spruce from the southeastern Baltic region is particularly suitable for the Chalk River area. It may also come from the Hercynian-Carpathian region

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[1]Department of Forestry, Canada, Forest Research Branch Contribution No. 513.

[2]Research Officer, Department of Forestry, Canada, Petawawa Forest Experiment Station, Chalk River, Ontario.

in central and southern Poland where both fast-growing and hardy provenances occur. In any event, it was about a metre taller than the other Polish provenance from Pförten, Brandenburg.

Valea Bistrei (Mt. Bihor, Romania)[1] belongs to Langlet's (1960) southern fast-growing and fairly-late-flushing provenances. It ranked fourth in southern (Dönjelt) and seventh in central Sweden (Bjornsjön). It is surprising that such a northern provenance as Ivanovsk, U.S.S.R. (an area 200 miles east of Archangel on the White Sea) should do so well here. It is about half a metre taller than the provenance from Vilppula, Finland, which has a somewhat similar climate. It is a typical northern spruce with short needles, slender open crowns, and small diameters.

In the remaining provenances, which grow more poorly, the slow growth of the lots from northern (Rovaniemi) and central Finland (Vilppula) is not surprising. But provenances from Sweden (Småland), and Norway (Gjerpen, Aust Agder, and Follafoss) also grew relatively poorly as did alpine types from Switzerland (Frienisberg). Although the exact origins of the Småland and Poland #10 spruces are not known, it is interesting to note that the Polish lot was 14 per cent taller (its 1951–61 height growth was 19 per cent greater) than the Småland spruce. A similar height difference between "svensk gran" (Swedish spruce) and "tysk gran" (German spruce) resulted in the volume of the latter being 24 per cent greater at 55 years and 32 per cent greater at 77 years of age (Langlet 1960, and Carbonnier 1954).

When the plants were 4 years old, the three best provenances after grading were:

Provenance	Height in cm.	Per cent hardy
Valea Mare, Romania	28.5	62
Wildberg, Schwartzwald, Germany	28.0	77
Hudson's Place, Petawawa	26.0	89

Why did the Schwartzwald provenance drop from being the most promising in the nursery to the poorest in the field, and the Valea Mare lot from the top to the middle third? Climate may be the answer. The Schwartzwald region of Germany has an oceanic climate with a warm fall and mild overcast winter, whereas Chalk River has a continental climate with severe cold starting in November and a bright sunny winter. In another experiment at Chalk River, ungraded plants of Schwartzwald (Nagold) provenance have grown very poorly with many dead and frozen seedlings; alongside them, a provenance from Istebna, Poland, is healthy and hardy. This is important, because Schwartzwald stock has been planted widely in Canada.

Norway Spruce Provenance Trials in the Lake States of the U.S.A.

Twelve I.U.F.R.O. provenances (see Table 2) were planted in the Manistee National Forest near Wellston, Michigan. Lake Michigan only 25 miles away moderates the severity of the winters. July, however, is often dry and the sandy soil is poor and dry for spruce.

The experiment was rated and measured after a sharp spring frost and summer drought in 1955 (Slabaugh and Rudolf, 1956). Spring frost-damage was severe in provenances that usually flush early (e.g. Åsnes and Valea Bistrei), but oddly enough not in the Czechoslovakian provenance from Svinosice, which also flushes early.

[1]For sake of convenience, the name of the locality is often used here for the provenance.

Summer drought-damage occurred in the Dolina and Valea Bistrei lots, suggesting that provenances from the Carpathian Mountains may be generally susceptible to summer drought. Golubetz (1960) noted this in his investigation of growth and survival of Norway spruce in the Ukrainian lowlands. Fröhlich (1960) rated the Balticum spruce (East Prussia and East Silesia) as drought resistant, the Hercynian-Carpathian types as intermediate, and the Alpine spruce as drought susceptible. It has long been known that alpine types are very susceptible to drought when planted in the lowlands. This experiment, however, suggests that the Carpathian spruces are more susceptible to drought than spruce from high elevations in the Alps. Moreover, Slabaugh and Rudolph (1956) reported winter injury on the provenances from Svinosice, Radom, Valea Bistrei, Muntele, and Vilno; and severe weevil damage on that from Pokljuka. They rated the Dolina provenance as having outstanding growth, but moderate amounts of injury. If relative freedom from injury be considered, the Pförten, Svinosice, and Bialowieza provenances rated high.

Farther west in the Eagle River district of the Nicolet National Forest Wisconsin, is another test area for various spruces; Table 3 lists the Norway and white (*Picea glauca* (Moench) Voss) spruce provenances. The Bryansk, Mozyr and Gomel provenances from Russia were better than the northern European provenance. As in other experiments in both continental and maritime climates, the Yugoslavian provenance was poorest.

The three Russian provenances were also growing better than the local white spruce, but were poorer than white spruce introduced from Ontario. This is because both the Russian Norway spruce and local Wisconsin white spruce are variable in growth, and the Ontario white spruces are much more uniform, which gives them a better average height.

The I.U.F.R.O. Norway Spruce Provenance Trials in the New England States and New Brunswick

Two experiments have been planted in New England—one in the Harvard Forest at Petersham, Massachusetts, and the other in the Fox and Vincent State Forests at Dering, New Hampshire. Both planting sites are within 100 miles of the Atlantic Ocean, which strongly influences their climates. The spring is cool and late; but the fall is also late and warm, giving a long growing season. The winter is mild, overcast, and rainy.

Thirteen provenances were planted in the Harvard Forest. The results of the last remeasurement (see Table 4) were provided by Dr. W. F. Murison.[1]

As expected from their poor performance elsewhere, the provenances from Follafoss, Romanija Mountains, Pförten, Vilppula and Tyldal were slow growing. The Stolpce, Crucea, Valdu Rau, and Istebna provenances were fast growing, and the Drängsered, Vecmokas, and Winterthur provenances were intermediate.

The dominant trees in the Harvard Forest trials were $1\frac{1}{2}$ to 2 metres taller than those of the same provenance at the same age in the trial at the Petawawa Forest Experiment Station—a good indication of the favourable climate of New England for Norway spruce.

Twenty-four I.U.F.R.O. and eighteen other provenances were planted at the Fox and Vincent State Forests in the most complete and best replicated trial of Norway spruce provenances in North America. Dr. H. I. Baldwin[2] has provided preliminary data for heights after 11 growing seasons from seed and will be writing a separate report on the results of the 25-year remeasurement.

The preliminary figures do not lend themselves to tabulation similar to that given for other experiments, but the trends may be quickly summarized. The best provenances were from Crucea and Valea Bistrei in Romania, Svinosice in

[1]Personal communication, 1962.
[2]Personal communication, 1962.

Czechoslovakia, Griva in Latvia, and Dolina in the Ukraine; the White Russian Stolpce, Polish Istebna, and the south coastal Swedish Drägsered provenances were intermediate in growth in that order. The St. Blasien lot from high in the Schwartzwald was poor in growth as expected from its growth in other experiments.

The State of New York Conservation Department has planted the following experiments of the 1938 series:

Location	Number of Provenances	
	I.U.F.R.O.	Others
Ontario County	21	2
Schoharie County	5	—
Otsego County	24	10

According to E. J. Eliason[1] these experiments were remeasured in 1962 but data are not yet available.

Farther north in New Brunswick, nine provenances were planted in the early 1940's at the Acadia Forest Experiment Station near Fredericton. The best provenance was a second generation stock in Canada from the Proulx Plantations in Quebec, and the next best were from the Carpathian Mountains and Riga. The remaining provenance (mainly Norwegian) grew poorly. Dominant heights, but not mean heights, of the Norway spruce were better than those of adjacent comparable white spruce, indicating the greater variability of the Norway spruce.

DAMAGE IN NORWAY SPRUCE PLANTATIONS

The white pine weevil (*Pissodes strobi* Peck.) is the most serious pathogen of Norway spruce in North America. Eggs are laid in the leader and the larvae feed on the cambium, girdling the leader one or two years back. Damage to single trees varies greatly. Some are repeatedly weevilled; others may have two whorls killed, giving rise to a pronounced kink in the stem; in still others only the tip of the leader is killed and the stem straightens satisfactorily.

Weevil-free trees in the provenance trial at Chalk River averaged about 4 per cent and seemed to lack any pattern (Table 1). However, the average number of weevil-killed leaders during the last seven growing seasons was 2.6 for provenances with weevil-free trees and 3.3 for those with no unweevilled trees. There should have been some slight selection for weevil resistances in the provenances from Proulx and Hudson's Place. Table 1 gives some suggestion of this, but there are too few trees for any thorough investigation. Selection of adapted hardy and weevil-tolerant Norway spruce types may be possible and such selection work is in progress.

A branch and stem canker (*Valsa kunzei* Fr. var. *picea* Waterman) has been found on Norway spruce (and white spruce). The predisposing factor is believed to be drought, which weakens trees with poor root systems. On sandy soils in warm southern Ontario, 20 per cent of the trees in plantations and 65 per cent of trees in shelterbelts were diseased (Jörgensen and Cafley 1961). In the Proulx plantations in Quebec, which are growing on poor sand, the attack was 8 per cent (Ouellette and Bard 1962). We found a 0.05 per cent infection on a good spruce site at the Petawawa Forest Experiment Station. This canker may then be important on droughty sites and may show up in Norway spruce provenances particularly susceptible to drought.

[1]Personal communication, 1963.

YIELD

By 1936, some 120,000 acres of Norway spruce had been planted in New England alone and Norway spruce is still widely planted. Hosley's (1936) study of these plantations indicated an average yield of about 84.5 cunits[1] per acre (*ca.* 591 cubic metres per hectare) at 55 years of age. Highest yield found was 130 cunits per acre (*ca.* 911 cubic metres per hectare) at 55 years.

In New Brunswick near the Bay of Fundy in a region with coastal fogs and 49 inches (*ca.* 1,250 mm.) of precipitation a year, Hughes and Loucks (1962) reported a plantation containing 85 cunits per acre (595 cubic metres per hectare) at 55 years. This is 34 cunits (238 cubic metres) greater than the yield of local stands of native red spruce (*Picea rubens* Sarg.) and balsam fir (*Abies balsamea* (L.) Mill.).

On good spruce sites at the Petawawa Forest Experiment Station, we expect roughly 48 cunits per acre (*ca.* 327 cubic metres per hectare) at 55 years. The height of unweevilled Norway spruce at 20 years is about 3 per cent greater than that of native white spruce. In frost pockets the relationship is reversed (Ahlgren 1954).

CONCLUSION

In New England and adjacent parts of Canada where annual precipitation ranges from 39 to 51 inches (1,000 to 1,300 mm.) and the summers are rainy, growing conditions for Norway spruce are probably better than in most of Europe. Norway spruce will produce more wood here than the native red, white and black (*Picea mariana* (Mill.) BSP) spruces. Any fast-growing, moderately hardy race should find the growing conditions suitable as long as it is not planted on sandy or gravelly soils or in frost pockets. Slow-growing provenances and provenances with poor form must be avoided if the potential of the species is to be realized. Spring frost damage is not a major problem in this region.

In the inland part of the Great Lakes–St. Lawrence Forest Region, Norway spruce should only be planted on fresh acid sites within the natural range of white spruce. Winters are cold and bright, and the growing season relatively short. The climates of the planting site and provenance must therefore be fairly carefully matched. The most promising material seems to come from stands originating in the area around the southeast corner of the Baltic Sea, Poland, and White Russia.

White pine weevil is a serious problem for Norway spruce plantations in all parts of eastern North America and selections should be made for weevil resistance.

[1]100 cubic feet of solid wood.

TABLE 1.—THE I.U.F.R.O. INTERNATIONAL NORWAY SPRUCE PROVENANCE TRIAL OF 1939 AT THE PETAWAWA FOREST EXPERIMENT STATION, CHALK RIVER, ONTARIO, CANADA

(46°00′ N. lat., 72°12′ W. long.)

I.U.F.R.O. serial number	P.F.E.S. seed lot number	Origin	Height growth 1951 to 61[1] (metres)	Height at 22 years from seed (after thinning) (metres)	Per cent weevil free
	S.284-42	Hudson's Place, Petawawa Forest Exp. Station, Chalk River, Ont.	6.81	—	(16.0)[2]
	S.13-37	Riga, Latvian S.S.R.	6.47	—	(4.5)
	S.86-39	Burtnicki District, Latvian S.S.R.	6.43	—	5.7
10	S.196-40	Poland	6.27	7.64	2.9
	S.84-39	Proulx Plantations, Quebec	6.03	—	4.8
11	S.194-40	Valea Bistrei, Romania	6.02	7.41	4.3
15	S.207-40	Ivanovsk District, U.S.S.R.	5.81	7.23	3.9
13	S.206-40	Valea Marc, Romania	5.69	7.31	2.3
1	S.195-40	Murat, France	5.67	6.97	4.1
	S.35-38	Gjerpen, Norway	5.61	—	(1.6)
	S.16-37	Aust Agder, Norway	5.59	—	0
	S.17-37	Aust Agder, Norway	5.58	—	2.1
4	S.203-40	Pförten, Poland	5.31	6.62	5.3
	S.210-40	Hudson's Place, P.F.E.S., Ont.	5.26	6.94	6.2
7	S.199-40	Småland, Sweden	5.26	6.72	2.6
14	S.193-40	Pokjuka, Yugoslavia	5.18	6.25	6.4
8	S.192-40	Vilppula, Finland	5.15	6.75	(0)
12	S.205-40	Tarcau-Fata Strajei, Romania	4.70	6.04	3.8
2	S.198-40	Frienisberg, Switzerland	4.65	5.90	0.4
5	S.204-40	Follafoss, Norway	4.61	5.60	10.3
3	S.200-40	Wildberg, Schwarzwald, Germany	4.46	5.80	0
9	S.197-40	Rovaniemi, Finland	—	3.38	—

[1]Differences between mean height of unweevilled trees in 1951 and the mean height of all trees after thinning in 1961.

[2]Figures in brackets based on less than 100 plants.

TABLE 2.—THE I.U.F.R.O. INTERNATIONAL NORWAY SPRUCE PROVENANCE TRIAL OF 1938 PLANTED IN 1941 IN THE MANISTEE NATIONAL FOREST NEAR WELLSTON, MICHIGAN, U.S.A.

(44°16′ N. lat., 85°57′ W. long.)

I.U.F.R.O. serial number	Origin	Average height 17 years from seed (metres)	Cause of injury in per cent			
			White pine weevil	Summer drought	Spring frost	Winter frost
36	Dolina, Ukrainian S.S.R.	2.23	13	11	0	4
34	Bialowieza, Poland	1.83	9	2	3	3
27	Svinosice, Czechoslovakia	1.80	1	1	3	12
8	Pförten, Poland	1.77	7	1	2	0
35	Radom, Poland	1.77	6	2	6	10
—	Alps, Switzerland, (Elev. 1,300-1,500 metres)	1.74	11	4	0	4
30	Valea Bistrei, Romania	1.74	14	16	18	15
33	Vilno, Lithuanian S.S.R.	1.71	14	3	4	10
—	Alps, Switzerland (Elev. 1,500-1,700 metres)	1.56	7	5	9	7
29	Muntele, Romania	1.46	18	1	0	12
24	Asnes, Norway	1.22	6	4	10	4
28	Pokljuka, Yugoslavia	1.16	27	2	5	6

TABLE 3.—NORWAY AND WHITE SPRUCE PROVENANCE TRIAL PLANTED 1936 IN THE EAGLE RIVER DISTRICT (45° N. lat., 89°10′ W. long.) OF THE NICOLET NATIONAL FOREST, WISCONSIN, U.S.A.

Seed lot number	Origin	Average height 20 years from seed (metres)
	Norway Spruce	
135	Bryansk Forest Experiment Station, U.S.S.R.	2.62
134	Mozyr District, White Russian, S.S.R.	2.32
137	Gomel District, White Russian S.S.R.	2.23
131	var. *borealis*, Northern Europe	2.04
140	Kilbourn, Wisconsin	1.89
138	Forest Research Station, University of Belgrade, Yugoslavia	1.53
	White Spruce	
257	Douglas, Ontario	2.87
256	Angus, Ontario	2.75
32–33	Port Arthur, Ontario	2.29
273	Florence, Wisconsin (local control)	2.17
255	Chippewa National Forest, Minnesota	2.14
39	Superior National Forest, Minnesota	2.04

TABLE 4.—THE I.U.F.R.O. INTERNATIONAL NORWAY SPRUCE PROVENANCE TRIAL OF 1938 PLANTED IN 1944 ON THE HARVARD FOREST, PETERSHAM, MASS.

I.U.F.R.O. serial number	Origin	Dominant heights 22 years from seed (metres)	Average heights 22 years from seed (metres)	Langlet's Rating	
				Growth rate	Flushing
9	Stolpce, White Russian S.S.R.	9.4	7.12	fast	late
10	Istebna, Poland	9.2	5.86	fast	interm.-late
13	Winterthur, Switzerland	8.4	5.32	interm.	interm.
21	Waldu Rau, Romania	7.8	6.06	interm.	interm.
6	Drängsered, Sweden	7.6	5.82	interm.	early
20	Crucea, Romania	7.4	6.48	fast	interm.-late
7	Vecmokas, Latvia S.S.R.	7.4	5.78	fast	interm.
5	Follafoss, Norway	7.2	5.22	slow	interm.
14	Val de Fiemme, Italy	7.0	5.32	slow	interm.
19	Romanija Mts., Yugoslavia	6.6	5.10	slow	late
8	Pförten, Poland	6.4	5.06	interm.	interm.-late
2	Vilppula, Finland	6.4	5.06	interm.-slow	early
3	Tyldal, Norway	5.6	3.82	slow	early

SUMMARY

Preliminary results are reported of the Norway spruce provenance experiments planted at the Petawawa Forest Experiment Station, Chalk River, Ontario; the Manistee National Forest, Wellston, Michigan; the Eagle River district Nicolet National Forest, Wisconsin; the Harvard Forest, Petersham, Massachusetts; the Fox and Vincent State Forests, New Hampshire, Ontario, Schoharie and Otsego Counties, New York; and the Acadia Forest Experiment Station, Fredericton, New Brunswick. In the western half of the Great Lakes–St. Lawrence Forest Region with its somewhat continental climate, provenances from countries around the southeast corner of the Baltic Sea and from Poland, and White Russia have been best. One Canadian plantation—heavily selected for winter-hardy trees—has shown much promise, while other unselected plantations of unknown origin have been intermediate or poor in growth. In the moister and milder climate along the Atlantic Ocean (New England States, and New Brunswick) generally fast-growing provenance, such as Crucea, Valdu Rau, Stolpce, Svinosice, Dolina and Istebna, have been growing very well. In all areas, white pine weevil causes considerable damage. In coastal U.S.A. and Canada Norway spruce will outproduce any of the native spruces. In the Great Lakes–St. Lawrence Forest Region, Norway spruce may grow slightly faster than white spruce on good fresh spruce sites, but white spruce is better on poorer sites and in frost pockets.

SOMMAIRE

L'auteur expose les résultats préliminaires d'expériences concernant la provenance de l'épinette de Norvège à la station forestière expérimentale de Petawawa, à Chalk River, dans la forêt domaniale de Manistee, Wellston (Michigan), dans la forêt domaniale de la rivière Eagle, district de Nicolet (Wisconsin), dans la forêt de Harvard, Petersham (Massachusetts), dans les forêts domaniales de Fox et de Vincent (New Hampshire), dans les comtés d'Ontario, Schoharie et Otsego, New York, et à la station forestière expérimentale d'Acadia, à Fredericton (Nouveau-Brunswick). Dans la partie occidentale de la région forestière des Grands lacs et du Saint-Laurent, où le climat est à peu près continental, les sujets provenant de pays situés près de l'extrémité sud-est de la Baltique, de la Pologne et de la Russie Blanche ont été les meilleurs. Un peuplement canadien composé d'arbres particulièrement vigoureux a donné des résultats fort prometteurs, tandis que d'autres peuplements de sujets non choisis et d'origine inconnue ont eu une croissance moyenne ou médiocre. Dans le climat plus humide et plus doux du littoral de l'Atlantique (États de la Nouvelle-Angleterre et Nouveau-Brunswick), les sujets de croissance rapide et provenant d'endroits tels que Crucea, Valdu Rau, Stolpce, Svinosice, Dolina et Istebna, ont très bien poussé. Sur le littoral des É.-U. et du Canada, l'épinette de Norvège surpassera toutes les espèces d'épinettes indigènes. Dans la région forestière des Grands lacs et du Saint-Laurent, l'épinette de Norvège croîtra peut-être un peu plus rapidement que l'épinette blanche dans les stations humides d'épinettes, mais l'épinette blanche est plus propice dans les stations médiocres et dans les dépressions ou «trous de gel».

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