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IUFRO's Role in Coniferous Tree Improvement: Norway Spruce (Picea abies (L.) Karst.)

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Abstract

Three large scale field trials have been the basis of international cooperation in IUFRO Working Party S2.02.11 "Norway spruce provenances and breeding" and its predecessors S2.02.11 "Norway spruce provenances" and S2.03.11 "Breeding Norway spruce". The first Norway spruce provenance trial was initiated within IUFRO. Started in 1938 and 1939, it comprises 36 seed sources and is planted out in 26 field tests in Europe and the north-eastern USA. The second trial, inspired by the results of the first one, contains 1100 seed sources. In this 1964/68 test with 20 field trials, 13 countries are participating, including eastern Canada. The third series, started in 1972, has 43 plantation locations in 10 countries, again includiig Canada; 20 Polish provenances and single-tree progenies are under test along with local seed sources. The international cooperation extends from provenance

testing to the field of tree breeding, the testing of offspring and seed orchard problems. Since the 1970s, interest is also focused on the "clonal option" and multiclonal varieties.

Key words: IUFRO, provenance, *Picea abies*.

Zusammenfassung

Drei gemeinsame Großversuche sind die Basis internationaler Zusammenarbeit im Arbeitskreis für Fichtenherkünfte (S2.02.11) und Züchtung der Fichte (S2.03.11) des Internationalen Verbandes forstlicher Versuchsanstalten, IUFRO. Der erste Herkunftsversuch von 1938 und 1939 wurde innerhalb der IUFRO konzipiert. Er umfaßt 36 Herkünfte und ist an 26 Versuchsorten in 14 Ländern Europas und den nordöstlichen USA angebaut. Der zweite Versuch, angeregt durch die Ergebnisse des vorhergehenden, umfaßt 1100 Herkünfte. An diesem inventierenden Versuch, IUFRO 1964/1968 nehmen 13 Länder mit 20 Versuchsflächen teil, ein Versuch steht in Ost-Kanada. Die dritte Versuchsreihe begann 1972. In 10 Ländern (43 Versuchsorte) werden 20 polnische Herkünfte zusammen mit lokalen Herkünften geprüft. Auch an diesem Versuch nimmt Ost-Kanada mit 6 Versuchsflächen teil. Die internationale Zusammenarbeit umfaßt nunmehr neben der Provenienzforschung auch züchterische Fragen, Nachkommenschaftsprüfung, Züchtungsstrategien, Samenplantagefragen und seit den 70er Jahren auch Klonauswahl und -prüfung sowie Anbau von multiclonalen Varietäten.

Introduction

Norway spruce is the economically most important species of Northern Europe. It has been seeded and planted very intensely ever since the middle of the 19th century in steadily increasing proportions. It has been cultivated far outside its natural range: In some countries it has been introduced as a newcomer and in other countries its acreage has doubled or even tripled over the last 100 to 200 years. It has replaced large areas of broad leaved species and mixed stands, it has been used to afforest abandoned agricultural land and to reforest depauperate forests. It now covers 40% to 60% of the forest area in many European countries. Norway spruce was the number one species in artifical regeneration until the effects of pollution and climatic change became obvious.

Today its reputation is not the best one. Norway spruce is held responsible for acidification of the soil, and for reducing both floral and faunal diversity in its artificial habitat. It is sometimes called an "ugly" species, since it has been planted extensively in "monocultures".

However, its economic superiority continues. It is still the most valuable pulping species. As a Christmas tree, Norway spruce is still our most common indoors coniferous ornamental.

A 4 volume bibliography, "Die Fichte", by Helmut Schmidt-Vogt's covers thoroughly all aspects of the species. In this paper, only a fraction of our to day knowledge on Norway spruce can be mentioned. So, readers are highly recommended to study "Die Fichte"; Schmidt-Vogts magnificent work refers to more than 1300 publications.

History

After the last glaciation, Norway spruce re-immigrated into its natural distribution from four refugia: Central Russia, the Carpathians, the Dinarian alps and the Apeninnes. In all the western parts of Central Europe, Norway spruce has been cultivated in a large scale both within and outside its natural range since the middle of the 18th century. Seed transfer has been more or less random, with the result that today's stands are mostly of unknown origin and only a few areas still contain indigenous forests of Norway spruce. In the eastern parts of Central Europe, forest cultivating activities came much later — here native stands are still found.

Scandinavian countries have imported forest tree seed in very large quantities in the past. Denmark never had any native Norway spruce of its own. In Sweden, large reforestation and restoration of devastated forest started in the 1860s and went on, with some interruptions, into the 1920s. The larger part of the imported seed was of Norway spruce; since Scots pine often failed it was banned from importation already before the turn of the century.

Genecological studies

Provenance research, the study of geographic variability in plant material and trees has ben carried out for one or two forest rotation periods. Olof Langlet (1971) in "200 years of Genecology" gives a very thorough report on activities and research in that field.

The first test on a forest species was carried out by Duhamel du monceau, Inspector General of the French Navy. Between 1745 and 1755 he planted pine from different provenances in comparative trials. Duhamel du Monceau was followed by others, especially Phillipe André de Vilmorin, who established in 1821 the famous comparative trial with different provenances of Scots pine on his estate Les Barres. The time for Norway spruce came later. In the 1880s and 90s, a hundred years ago, shortly before IUFRO was established, the first reports on comparative trials with Norway spruce appeared. The later attention to Norway spruce was due to the fact that Scots pine, especially during the time of sailing ships, was much more valuable than Norway spruce. Scots pine is also a considerably more difficult species to grow in plantations. For its survival and its timber quality the question of provenance is much more important than it is for Norway spruce.

John Booth, at the Congress of the "Verein deutscher forstlicher Versuchsanstalten" (the predecessor of IUFRO) held at Baden-Baden from September 6th to 12th, 1880 said: "Es ist dort" (in Scotland, with regard to imported seed of Scots pine from Germany "ein beständig auf der Tagesordnung stehender Artikel: Die Verschlechterung der Kiefer."

Kienitz at Hann. Münden (1879), Cieslar in Vienna (1887), and Engler in Zürich (1905) are usually cited as the pioneers in the field of provenance research in forest trees. Cieslar's work is of special interest since he claimed (1895) that the differences found between provenances are due to inherited adaption to the length of the vegetation period at their place of origin. Engler confirms this in his work on Norway spruce from different altitudes (1908): Climatic varieties may develope by means of mutations (Hugo de Vries) or by selection (Darwin) or even by direct adaption in Lamarck's sense or else: Certain is that climate is the cause for the absolute prevailence of a climatic variety in its habitat (translated from Engler, 1908, o. c. pg 313).

In 1907, when the first international trial on a forest species, *Pinus sylvestris*, was started, Scots pine was in the center of attention. Norway spruce was regarded as an

easy species to work with. Tolerant to tranfer and adaptable even to suboptimal climatic conditions. At that time, in 1907, much of the variability of Norway spruce was known from the pioneer work mentioned above. There was certainly a warning against altitudinal transfer. Scandinavian sources had a bad reputation in Central Europe and correspondingly the use of Central European spruce was restricted to southern Scandinavia. These may be the reasons why international cooperation did not begin until 1936.

Before that time not many and only institutionally performed seed source trials with Norway spruce were initiated.

In Sweden provenance research with Norway spruce began early: MAAS established comparative seeding trials in 1905. GUNNAR SCHOTTE, also in Sweden, planted a series of field trials with 5 sources from Central Europe and one local source (cit LANGLET, 1960).

Results from Danish experiments, started in 1914, with 10 sources on three locations are reported by BORNEBUSCH (1935), and GÖHRN (1966).

Finnish field experiments were established in 1926 with 10 Finnish and 11 Central European sources on 5 locations from Solböle in southern Finland up to Rovaniemi at 66° 25' (KALELA, 1937; and HEIKINHEIMO, 1949).

The oldest seed source trials with Norway spruce were performed in Germany by KIENITZ at Gahrenberg in 1878 and by NOBBE at Tharandt in 1880 (cit. SCHMIDT-VOGT, 1987). In 1925 new experiments were established by MÜNCH at Tharandt and by OELKERS and GEYR VON SCHWEPPENBERG at Hann. Münden. These trials again were followed by 2 major series of experiments by RUBNER. His first series was planted in the Herzynian mountains in 1930. The second, a very extensive trial of 41 seed sources, was planted in 1937 in the Saxonian mountains, in the Thuringia Forest, in Bavaria and in Württemberg.

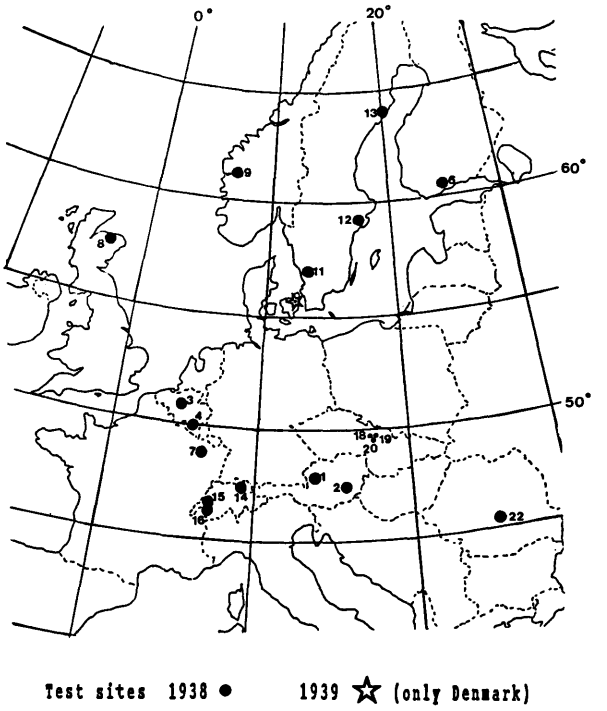


Figure 1. — International Provenance Test with Norway spruce IUFRO 1938 and 1939.

Table 1. — In all, 26 field trials were established.

Trial no	Country	Number of IUFRO-sources
1-2	Austria	21
3-4	Belgium	21/20
6	Finland	21
7	France	12
8	U.K.	17
9	Norway	11
10	Poland (this trial was lost during WW II)	
11-12-13	Sweden	36/34/36
14-15-16	Switzerland	21/13/16
17-21	USA	24/13
23-24-25	USA	10/23/19
18-19-20	Czechoslovakia	20/18/18
22	Romania	13
The 1939-series had only two participants:		
1	Canada	13
2	Denmark	12

IUFRO

It was not until 1936 that IUFRO, at its 9th congress in Hungary, embarked on a coordinated international program of provenance testing. A subcommittee was formed on September 8th in Lillafüred for "The Study of Seeds and Races". As chairman, WERNER SCHMIDT from Germany (Eberswalde) was elected, HENRY I. BALDWIN from the USA, OLLI HEIKINHEIMO from Finland, STANISLAV TYSKIEWICZ from Poland, GUSTAV VINCENT from the CSSR and ALDO PAVARI from Italy were the initial members; later on, OLOF LANGLET from Sweden and OSCAR HAGEM from Norway joined the committee in 1937.

This group agreed on new international seed source trials with Scots pine, Norway spruce and Larch. For the trials with Norway spruce the seed was collected and distributed to the participants by W. SCHMIDT in 1937 (36 seed sources) and 1938 (15 seed sources).

The IUFRO Trials of 1938 and 1939 with Norway Spruce

Remarkably enough Germany, which took a very active part in the planning of these experiments, did not participate in the field work.

The provenances in the first series were grouped into 22 obligatory and 14 optional provenances. Unfortunately, very little attention was paid to orthogonality in the series making the comparison of results from different localities difficult. For comments see GIERTYCH (1984), pg 165 ff.

World War II seriously hampered cooperation on this series. However, according to "H.I.B. and S.P" (HENRY I. BALDWIN and SVEN PETRINI in Chronica Botanica 1941), "The meeting originally planned for Sept 16, 1939 in Warsaw was cancelled for obvious reasons, but a meeting was held in Copenhagen in Jan. 1940, attended by representatives of Norway, Sweden, Denmark and Germany. Mimeographed reports of this meeting were distributed to all members, and replies received from those who had been prevented to attend the meeting. From Oct. 15 to 19, 1940 a meeting was held at Vienna attended by 19 delegates from the forest experiment stations of Finland, Sweden, Holland, Italy, Poland, Czechoslovakia, Hungary, Austria, and Germany. Round robin letters of greeting were mailed to all absent members of the commission".

M. V. EDWARDS and R. LINES (1970) and later R. LINES (1976) listed publications on the IUFRO trials of 1938

Table 2. — The planting sites of the IUFRO 1964/1968 series.

Exp	block	Name	Lat	Long	Alt
01	all	Bronson	46 11	65 47 w	70
02	all	Castlemorris	52 28	07 17 w	70
03	all	Salisbury	50 58	01 52 w	170
04	1-2-3-5-7-8-9-10	Ilsvåg	59 31	05 49 e	150
	4-6-11	Vats	59 29	05 45	150
05	3-4-5-6-8-9	Bjerköy	59 12	10 28	5-10
	1-2-4-10-11	Overud, Kabberud	60 10	11 05	200
06	all	Hjuleberg-Abild	56 56	12 44	60
07	all	Lisjö	59 43	16 05	65
08	all	Lappkojberget	63 25	18 37	180-200
09	non experimental	Salon Karlano	60 45	24 10	120
	non experimental	Haapastensyrja	60 36	24 25	130
10	all	Amance	48 47	06 18	240
11	02	Herbeumont	49 48	05 15	410
	04	Fagne del Berne	50 02	05 27	560
	06	Rocherath	50 28	06 20	600
12	01	Kinrooi	51 07	05 40	20-50
	03	Gendron-Celle	50 15	05 00	200-300
	05	Baraque Fraiture	50 15	05 45	600
13	1-2	Deuselbach	49 45	07 06	640
	5	Kell-Nord	49 38	06 50	620
	2-3-6-10	Brandscheid	50 30	06 40	620
	7	Ruppertsweiler	49 11	07 41	305
	8	Kindsbach	49 04	07 07	240
	9	Nister	50 40	07 51	380
	11	Bellerhof	50 40	07 51	440
14	1-6-7-8	Holzerode	51 40	10 07	250
	2-10-11	Rüdershausen	51 34	10 16	235
	3-9	Schoningen	51 38	09 42	305
	4	Delliehausen	51 40	09 42	305
	5	Hörden	51 37	10 16	235
15	01	Heltorf	51 57	07 34	400
	02	Brüggen	51 14	06 06	37
	03	Letmathe	51 28	07 40	250
	04	Gedern	50 25	09 08	340
	5-6	Linz	50 36	07 20	340
	7-8	Sassmannshausen	51 00	08 30	400
	09	Herrnstein	50 49	07 30	220
	10	Schleiden	50 28	06 21	624
	11	Reggsdorf	50 34	07 29	280-300
16	8-9	Minard Forest	56 10	05 15	170
	10-11	Drummond Hill (plots of 3*2 plants)	56 35	04 05	137-183
17	1-2-3-4-5-6	Zahradka	49 37	15 15	370-390
	7-8-9	Dolni Karlovice	49 40	15 00	370-380
		Borovsko	49 42	15 07	360-380
18	1-2	Klein-Mariazell	48 03	15 58	460
	3-4	Stollberg	48 05	15 51	520
	5-6	Ottenstein	48 37	15 17	550
	7-8	Landsee	47 34	16 19	600
	9	Klaus/Phyrnbahn	47 51	14 07	550
	10	Eberstein	46 50	14 37	1550
	11	Kelchsau	47 22	12 08	1020
19	1-3-4-5-7-8-9-11	Krynica	49 28	21 01	705-795
	2-6-10	Krynica	49 21	20 58	729-785
20	all	Gyöngyössolymos	47 56	19 58	540-630

and 1939 for Norway spruce, Scots pine and Larch.

In September 1979, the Working Party S2.02.11 on Norway spruce convened in Bucharest. The trials of 1938 and 1939 where the focus of the meeting. After the indoor sessions at Bucharest, Dr. VALERIU ENESCU and his staff took the party on a memorable field trip into the Carpathian mountains to many of the now well known provenances of both the 1938 and 1964 series. The final meeting was held at "high altitude" in the Transylvanian Alps south of Brasóv. At the working session, the party assigned Dr. MACIEJ GIERTYCH from Kornik with the task of compiling all known information from the 1938 and 1939 IUFRO series with Norway spruce. His report was published in 1984. It is a very thorough study of background, performance and results of both series.

The IUFRO Trial of 1964/1968 with Norway Spruce

The 1964/1968 IUFRO trial was originally an independent investigation of Norway spruce conducted by the Royal College of Forestry at Stockholm. In 1959, OLOF LANGLET and his assistant PETER KRUTZSCH, encouraged by the first results from the 1938 IUFRO trials in Sweden, started a new investigation on Norway spruce.

The aim of the new collection was to compare as many sources as possible in an inventory test. A first test was sown in 1962 in a nursery nearby Stockholm. Studies on flushing and growth in the first 5 years were performed on the transplanted seedlings (KRUTZSCH, 1975).

A detailed report on the background and early history of this international experiment, now known as the "IUFRO 1964/1968" was presented by KRUTZSCH in Silvae Genetica 1974 in memory of KLAUS STERN.

The series contains 1,100 provenances, from the Arctic circle to the Rhodope mountains in Bulgaria and from Le Pertius (longitude 4° 00' E.G.) to Timirjas (longitude 84° 59' E.G.). Even Canada was represented by a second generation seed lot provided by MARK HOLST from a stand of Norway spruce at Petawawa.

These 1,100 sources were grouped into 11 groups of 100 provenances each. Each block of 100 sources is a complete trial. Due to the stratified sampling, the groups are estimated to be equal in mean and variance, thus easily comparable. Each provenance is represented by 25 plants. For the plantations single tree plots with a 2 meter by 2 meter spacing were recommended.

In September 1973 at a meeting of the Working Party on Provenances of Norway spruce at Biri/Norway, the name of the trial was changed from the original "IPTNS" (Inventory Provenance Test on Norway Spruce) to "IUFRO 1964/1968".

The design of this project with about 300,000 seedlings in field experiments had certain advantages. Eight-

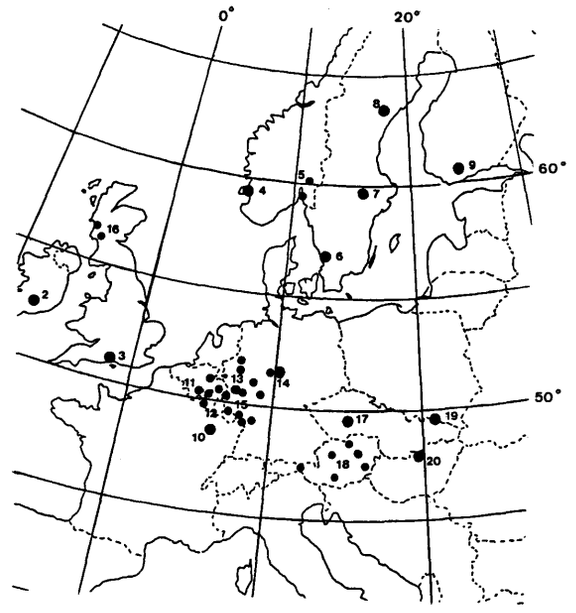


Figure 2. — International Provenance Test with Norway spruce IUFRO 1964/1968, Test sites.

een of the experiments are absolutely orthogonal, only two experiments, no. 16 (Scotland) and no. 19 (Finland) have a somewhat altered layout. Some of the participants included an extra local source as a standard, however, with the exception of a few missing plantlots in the shipment, all the 11 blocks in each trial contain the same provenances.

Another advantage was the uniform pretreatment, i. e. the raising of plants in the same nursery under exactly the same conditions. There were, of course, some interactions; the Canadian plants had to be root washed before they could be air lifted across the Atlantic. On the other hand, all the material was treated under Halstenbek nursery conditions, regardless of its final destination. Had different local nurseries been in charge, the preconditioning would have been different.

Fortunately for all participants, economic conditions were favorable for the establishment of the trials. The possibility of buying this extensive material, along with all documentation and the prospect of becoming a member of a special group within IUFRO that gave a guarantee for future cooperation, was certainly most welcome.

The spinoff effect of this trial is quite impressive. Many of the surplus plants from the Pein and Pein nursery were used for other experiments. Dr. W. KNABE planted about 100 seed sources in field experiments in the heavily polluted Ruhr industrial area. Prof. SCHMIDT-VOGT had some of the material ander physiological observation in his Günterstal experimental station close to Freiburg. Czechoslovakia also acquired some of the surplus material from Pein and Pein, although to my knowledge, nothing has been reported from any trial with that material.

During the nursery stage in Halstenbek, Dr. JON DIETRICHSON from Norway collected material for microscopic studies of cell formation, lignification and, indirectly, of cessation of growth and hardiness (DIETRICHSON, 1969).

At an early stage of the seed collection period, we shared sources with Dr. ACHIM FRÖHLICH at Hann. Münden. These 420 provenances became part of a German seed source trial widely spread throughout Western Germany. Also this series is one of the IUFRO items, reviewed whenever the Working party convenes (see further in SCHMIDT-VOGT, 1986, Band II/1, pg 224, "Internationaler Fichtenversuch 1962".)

Finland participated with one complete set: Dr. RISTO SARVAS' objective was, in his words, mainly the "purchase of genetic diversity". LAURI KÄRKI from the Foundation of Forest Tree Breeding in Finland informed me in November 1968 that the material had been planted in rows of 25 plants, one field with mostly northern sources and another with the rest of the provenances.

LAGERCRANTZ and RYMAN (1990) carried out electrophoretic studies on 70 widely distributed provenances of the 1964/1968 series. Dormant buds were collected in the field experiments in South and Central Sweden in 1984 at age 20 from seed. A total of 2,868 trees were examined. Data on seed characters and field data from the IUFRO experiments (DIETRICHSON et al., 1976) from the trials at Lappkojberget (no. 08, the northernmost) and Amance (no. 10, the French trial of the 64/68 series) were used.

I cite from their abstract:

"We suggest that the population structure largely reflects relatively recent historical events related to the last glaciation and that Norway spruce is still in a process of adaption and differentiation. There is a clear geographic pattern in the variation of allele frequencies. A major part of the allele-frequency variation can be accounted for by a few synthetic variables (principal components), and 80% of the variation of the first principal component is "explained" by latitude and longitude. The Central European populations are consistently depauperate of genetic variability, most likely as an effect of severe restrictions of population size during the last glaciation. The pattern of differentiation at protein loci is very similar to that observed for seven morphological traits examined. This similarity suggests that the same evolutionary forces have acted upon both sets of characters."

GIERTYCH (pers. comm.) informed me of a very interesting follow-up to IUFRO 1964/1968: The provenance of Kolonowskie/Poland has shown very good results in many of the IUFRO trials. The original stand has been cut and is lost forever. GIERTYCH contacted his colleagues with a request for scions. Now the population seems to be reestablished at Kornik by grafts from 109 clones collected in 11 field trials of the series.

Many results from this IUFRO experiment have been published. In the proceedings of every IUFRO World Congress at least some contributions deal with results from one or other of the experiments. For a complete list of publications to 1984, see SCHMIDT-VOGT "Die Fichte", Band II/1, pg 224.

A report from the three experiments in Sweden has just been published (PERSSON and PERSSON, 1992). A summary report on this series will be released by the Working Party S2.02.11. A. KÖNIG and T. SKRÖPPA are in charge of the effort.

Some results so far

Our knowledge of the variability of Norway spruce is very good in comparison with that of other species. The early results and conclusions from the first IUFRO series of 1938 and 1939 have been confirmed and extended in the second IUFRO trial of 1964/1968. The characters most important for forestry are generally studied. Some results follow.

1. Time of flushing

Extremely early flushing provenances are found at high latitudes (northern Scandinavia and Finland) and at high altitudes in the Central European Alps. Late flushing is common in eastern material, with the exception of Finnish sources and those from northern Russia. The latest flushing sources come from White Russia, Northeast Poland and the interior of the Baltic Republics. In western Europe, with the exception of the Alpine region, early flushing is normal. Differences between stands are here as big as differences between regions, which may be a consequence of 1 to 2 generations of artificial cultivation. A certain temperaturesum, perhaps above source-specific thresholds, seems to be the stimulus for the beginning of bud burst and growth in Norway spruce.

2. Time of growth cessation

Extreme early cessation of growth occurs again at high latitudes and at high altitudes. Early sources are Swedish and Finnish as well as those from North Russia. In this region cessation exhibits a strictly clinal variation with latitude. The adjacent, more southern sources in the east are intermediate: White Russia, Northern Poland, Southern Poland and the East Carpathian mountains. All are in named order of successively later cessation. Western

sources in general grow late into autumn, with the exception of alpine sources, where cessation becomes earlier with increasing altitude. Night-length is the external factor which initiates the cessation of growth. High latitude sources will respond to 2 to 3 hours of darkness (a day length of 21 to 22 hours) with a growth period of only 40 to 50 days at their place of origin. Sources from south-western Europe, the other extreme, require 8 to 9 hours of darkness before they start the process of hardening off (Dormling et al., 1974).

3. Growth capacity

Growth per se depends on the climatic and photoperiodic conditions of the planting site. Thus Nordic sources planted in the south will grow very little, driven into dormancy by the darkness of southern latitudes. Southern sources, planted in the North, will prolong growth due to short nights for a too long time and suffer from early frosts. In spite of these strong interactions of photoperiod and growth performance, differences in growth capacity have been studied. Southeastern sources from the eastern Carpathians and the Bihor mountains in Romania seem to have the greatest growth capacity.

These findings are carefully used in recommendations for the choice and transfer of sources for the cultivation of Norway spruce. In many regions it seems to be fairly safe to obtain a gain of 10% in volume production by choosing a non-local source.

The Polish IUFRO Trial of 1972

A letter of invitation signed by Stanislaw Tyskiewicz, was sent in February 1972 to potential participants in the 1972 Norway spruce experiment.
He wrote:

"With reference to studies on pine and spruce undertaken by the commission of Seed Science called into being in 1936 in Budapest (Xth Forestry Congress and IUFRO meeting) I would like to announce a proposal of the continuation of comparative studies on spruce.

Owing to a very good crop of spruce in 1971 as well as having seed collected during previous years we suceeded in the collection of sowing material from 20 localities both in Polish lowlands and in mountain areas (Carpathians, Sudetic mts). Cones have been collected on permanent study areas from numbered, measured and described standing trees. Each area is represented by seeds collected from at least 20 trees. Compilation of data concerning parent stands is enclosed. More detailed information on the study areas is contained in the book entitled "Population studies of Norway spruce in Poland".

When professor Tyskiewicz retired, he was replaced by Stefan Kociecki, who had been working with Tyskiewicz for many years. In Kociecki's last circular letter, dated October 6th 1987 the following 42 field trials were mentioned:

The IUFRO Trial of 1972 with Norway Spruce

No summary report has been compiled so far, and obviously Kociecki had some difficulties obtaining information from all the collaborators who had received seed in 1972. In the circular letter mentioned above, plant heights relative to test mean from 26 experiments were reported. The two tallest sources (9 to 12 years from seed) were Wigry (54° 03'/23° 03'/170 m) the most north-eastern source and Zwiercyniecz Lubelski (50° 34'/22° 58'/ 260 m) in the

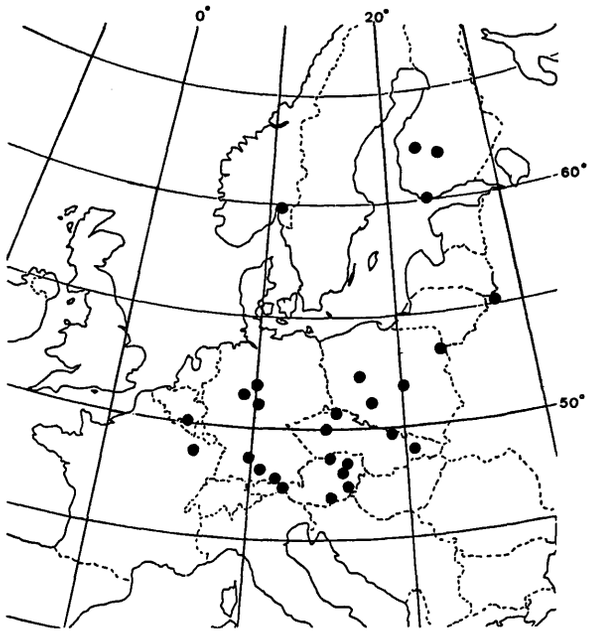
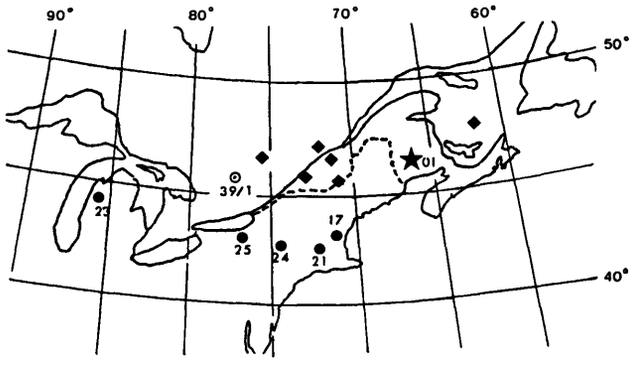


Figure 3. — International Provenance Test with Norway spruce IUFRO 1972, Test sites.



● 17-25 the IUFRO series of 1938 (5 sites)
⊙ 39/1 the IUFRO series of 1939 (Petawawa)
★ 01 site of exp. 01 in IUFRO 1964/68
◆ 6 sites from the Polish IUFRO series 1972

Figure 4. — IUFRO trials with Norway spruce in Canada and USA.

south eastern lowlands of Poland. Next fastest growing were two sources from Bialowieza.

Indeed, as the invitation said, the sources are very well studied in Poland. According to the "Population studies" mentioned, some of the mother stands of this IUFRO trial have been planted in or before 1963 at Jegel (NE of Warsaw), for Gene conservation and observation. Certainly there are good prospects for a second generation study in the near future. I think that these stands could be included in the series.

An amazing number of publications, not less than 34 during the first 15 years, are listed in Kociecki's circular letter of October, 1987.

IUFRO's Importance for the Research on Norway Spruce

Although the international seed source trials with Norway spruce are of paramount importance, they are just the beginning, as far as IUFRO's role is concerned.

Table 3. — Participation in the 1972 IUFRO series.

No.	Country	Polish sources *
1-6	Canada	20
7-14	Austria	3-10
15	Belgium	17
16-22	CSSR	12-20
23-25	Finland	14
26	France	20
27-36	Germany (FRG)	10-20
37	Norway	20
38	OSS (USSR)	10
39-42	Poland	20

*) According to the circular letter. In most of the trials, extra sources both local and others are included for comparison

These trials — they must be assumed to be milestones — had, in their turn, great influence on national research on provenances and on international research related to the genetics of Norway spruce. They certainly created a great number of activities, initially perhaps isolated, but sooner or later returning to IUFRO.

Thus assessing the role of IUFRO in research work with Norway spruce should be much more than just dealing with provenances.

The breeders of Norway spruce formed a working party (S2.03.11) of their own. This working party became a forum for discussion and evaluation of breeding theory and practical breeding plans. Studies of heritability as well as "seed orchard genetics" or "problems" were given attention. Since the early 1970s, the "clonal option" also provided ideas and exchange of experience between scientists. The two working parties on Norway spruce are now united again. The last meeting was held at Tjörnarp/Sweden under the chairmanship of MARTIN WERNER in September 1988 (STENER and WERNER, 1989).

Summary

Norway spruce attracted rather late official international attention. Scots Pine, on the contrary, was recognized as an object of international cooperation 30 years earlier. One can wonder why. Was it that the cultivation of Scots Pine, with the random use of seed sources, more often went wrong, whereas Norway spruce was considered an "easy species"? Was it that Scots Pine was a more valuable and thus a more important species? Perhaps research for the most part has shown that it is not worth replacing local ones with other sources. For Norway spruce the situation seems to be reversed. The local sources are often not the best ones; new sources outgrow the local ones because of a better fitness to local climatic conditions.

It was not until 1936 that IUFRO created a subcommittee for Seed and Race Problems in Forestry. In this subcommittee the plan for the 1938 and 1939 international experiments with Norway spruce were developed. Ever since the end of World War II at all the meetings dealing with forest genetics, at least one paper or contribution has dealt with results from the IUFRO 1938 trial which is still of great interest, in spite of its remarkable age of 50 years in the field.

It is difficult to judge how many of the activities in genetic research on Norway spruce that followed World War II can be attributed to IUFRO's trials. Certainly they had an important impact and led to the IUFRO trial of 1964/1968 and the Polish IUFRO series of 1972.

The IUFRO Norway spruce trials appear to follow exactly the approach to species trials that was outlined at the IUFRO meeting at Pont à Mousson in 1965:

A first trial with a few sources covering the range of the species, with the objective to find out whether there are differences within the species and possibilities for introduction of non-local sources.

A second medium term experiment to investigate thoroughly the patterns of variation and to identify valuable populations or regions.

Finally, a third step, long term experiments for thorough investigation of valuable sources and perhaps for the exchange of gene resources for breeding purposes. The Polish IUFRO trial of 1972 is a promising beginning of stage 3 activities. It might be worth while also considering other sources in joint actions.

The future

The field experiments established within the IUFRO family cover a large part of the Northern hemisphere with very different climatic conditions. This is a gigantic test laboratory wherein the same material is tested under realistic conditions including specific local stress, the impact of man made pollution and current or predicted climatic changes.

This network should be used in many ways:

1. Of course, our normal "provenance studies" in IUFRO series and other trials should go on. We still need more insight into this kind of genecology to get better advice for practical forestry.
2. Selection of locally superior and thus specialized individual genotypes, in order to provide tree breeders with basic material, should go on, with consideration of possible environmental changes.
3. Open pollinated progeny from these multi-source plantations will offer increased genetic diversity and heterogeneity. Who is going to use this gene resource?
4. The change in our environmental conditions — manmade and probably irreversible — could well be studied in these fields with thousands of individuals under different conditions. Studies on fitness and on changes in fitness, against the background of earlier studies, might tell us what is happening in our biosphere.
5. We are all concerned about the question what seed sources to use in the future. Perhaps we could carefully interpret the field trials of our colleagues initiated and conducted under conditions that might occur to us in the future.
6. Further provenance trials of type III as the IUFRO series of 1972 with Polish sources should be initiated as international undertakings for the conservation and long term utilization of valuable gene resources.

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IUFRO's Role in Coniferous Tree Improvement

History, Results, and Future Trends of Research and International Cooperation with European Larch (Larix decidua Mill.)

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Summary

European larch has many favourable traits and was therefore, at an early stage, of great interest to forest tree breeders and forest geneticists. The first systematic provenance trials go back to the time when IUFRO came into being. The big trial series of 1944 and 1957/1958 are impressive evidence of the value of international cooperation. The most important results of those investigations are reported. On their base research has been going on particularly in the last 3 or 4 decades in the field of intra- and interspecific hybridization. Comprehensive information from progeny tests is on hand, above all for "growth", "stem shape" and "susceptibility to canker". These already allow the use of "tested reproductive material" as stipulated in the EC and OECD legal regulations. Besides seed production in seed orchards vegetative methods will also be able to utilize the gain of hybridization when these methods will be applicable. The report contains information on the present state of knowledge on this subject, covering conventional propagation by cuttings and also in vitro techniques.

It is suggested that future larch research should be intensified particularly in the field of hybridization. Selective measures should not lead to an irretrievable loss of a wide genetic variation. The utilization of the diverse possibilities for international cooperation that IUFRO offers is seen as a guarantee for the success of this line of research.

Key words: Larix decidua, provenance research, intra- and interspecific hybridization, vegetative propagation.

1. Natural distribution and distinguishing characteristics of European larch

European larch, which is one of ten species of the genus *Larix*, ranks among the most important managed forest trees of the northern hemisphere. Its natural range, with four completely separate sub-areas in the Alps, the Sudetic mountains, the Carpathian mountains and in Poland represents the remains of a former larger and probably continuous source in the early post-glacial period (roughly 6000 B. C.). Larch was excluded from those regions initially by oak and later by beech, fir and spruce.

The natural distribution of larch demonstrates its preference for continental climatic influences and for transitional forms in the direction of a temperate low mountain climate. Its altitude distribution ranges from 150 m above sea level in the north of the Polish sub-area to around the timberline in the Alps (2400 m). Mountain and low mountain situations are obviously colonized more successfully than colline areas.

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