
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 "Norwegian 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

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testing to the field of tree breeding, the testing of off-
spring and seed orchard problems. Since the 1970s, in-
terest is also focused on the "clonal option" and multiclona-
lar varieties.

Key words: IUFRO, provenance, Picea abies.

Zusammenfassung

Drei gemeinsame Großversuche sind die Basis interna-
tionaler Zusammenarbeit im Arbeitskreis für Fichtenher-
künfte (S2.02.11) und Züchtung der Fichte (S2.03.11) des
Internationalen Verbandes forstlicher Versuchsanstalten,
IUFRO. Der erste Herkunftsversuch von 1938 und 1939 wur-
den in den USA und im 1960er und 1970er USA angelegt. Der zweite
Versuch, angeregt durch die Ergebnisse des vorherge-
henden, umfaßt 1100 Herkünfte. An diesem inventier-
enden Versuch, IUFRO 1964/1968 nehmen 13 Länder mit 20
Versuchsflächen teil, ein Versuch steht in Ost-Canada. Die
dritte Versuchsreihe begann 1972. In 10 Ländern (43 Ver-
suchsorte) werden 20 polnische Herkünfte zusammen
mit lokalen Herkünften geprüft. Auch an diesem Versuch
nimmt Ost-Canada mit 6 Versuchsflächen teil. Die inter-
nationale Zusammenarbeit umfaßt nunmehr neben der
Provenienzforschung auch züchterische Fragen, Nach-
kommenschafsprüfung, Züchtungsstrategien, Samenplan-
tagefragen und seit den 70er Jahren auch Klonaus-
wahl und -prüfung sowie Anbau von multiklonalen Va-
rietäten.

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 afforested 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 artificial regeneration until the effects of pol-
olution 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-Voigt'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-Voigt's magnificent work refers to more than
1300 publications.

History

After the last glaciation, Norway spruce re-immigrated
into its natural distribution from four refugia: Cen-
tral Russia, the Carpathians, the Dinaric 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 19th 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 in-
igenous 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.

Geneological studies

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

The first test on a forest species was carried out by
Dubois du Monceau, Inspector General of the French
Navy. Between 1745 and 1755 he planted pine from dif-
ferent provenances in comparative trials. Dubois du
Monceau was followed by others, especially Philippe 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 la-
ter 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 "Veren 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.
Cieslars 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 develop by means of mutations
(Hugo de Vries) or by selection (Darwin) or even by direct
adaption in Lamarcks sense or else: Certain is that climate
is the cause for the absolute prevalence 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 transfer 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. GONNAR 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 BonneBüsch (1935), and GöHN (1966).

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

The oldest seed source trials with Norway spruce were performed in Germany by KIrNITZ at Gahrenberg in 1878 and by NOBBE at Tharandt in 1880 (cit. SCHMIDT-VoGT, 1987). In 1925 new experiments were established by MüNNICH at Tharandt and by ÖEKLERS and GERV von SCHWEFFENBERG at Hann. Münden. These trials again were followed by 2 major series of experiments by RunNER. His first series was planted in the Herzyan 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.

<table>
<thead>
<tr>
<th>Trial no</th>
<th>Country</th>
<th>Number of IUFRO-sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Austria</td>
<td>21</td>
</tr>
<tr>
<td>3-4</td>
<td>Belgium</td>
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<tr>
<td>5</td>
<td>Finland</td>
<td>21</td>
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<tr>
<td>6</td>
<td>France</td>
<td>12</td>
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<tr>
<td>8</td>
<td>U.K.</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Norway</td>
<td>11</td>
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<tr>
<td>10</td>
<td>Poland (this trial was lost during WWII)</td>
<td></td>
</tr>
<tr>
<td>11-12-13</td>
<td>Sweden</td>
<td>36/39/36</td>
</tr>
<tr>
<td>14-15-16</td>
<td>Switzerland</td>
<td>21/13/16</td>
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<tr>
<td>17-21</td>
<td>USA</td>
<td>28/13</td>
</tr>
<tr>
<td>23-24-25</td>
<td>USA</td>
<td>10/23/19</td>
</tr>
<tr>
<td>18-19-20</td>
<td>Czechoslovakia</td>
<td>20/18/18</td>
</tr>
<tr>
<td>22</td>
<td>Romania</td>
<td>13</td>
</tr>
<tr>
<td>1</td>
<td>Canada</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>Denmark</td>
<td>12</td>
</tr>
</tbody>
</table>

The 1939-series had only two participants:

| 1 | Canada |
| 2 | Denmark |

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, Olle HEINKHEIMO from Finland, Stanislaw Barrows from Poland, Gustav Vincent from the CSSR and Aldo Pavari from Italy were the initial members; later on, Olaf 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 GERTYCH (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 Petrin) 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".

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

<table>
<thead>
<tr>
<th>Exp block</th>
<th>Name</th>
<th>Lat</th>
<th>Long</th>
<th>Alt</th>
</tr>
</thead>
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<tr>
<td>01 all</td>
<td>Bronnoy</td>
<td>66</td>
<td>47</td>
<td>70</td>
</tr>
<tr>
<td>02 all</td>
<td>Castlemorris</td>
<td>52</td>
<td>17</td>
<td>70</td>
</tr>
<tr>
<td>03 all</td>
<td>Salisbury</td>
<td>50</td>
<td>52</td>
<td>170</td>
</tr>
<tr>
<td>04 1-2-3-7-8-9-10</td>
<td>Lillebog</td>
<td>57</td>
<td>49</td>
<td>150</td>
</tr>
<tr>
<td>05 4-6-11</td>
<td>Vata</td>
<td>59</td>
<td>45</td>
<td>150</td>
</tr>
<tr>
<td>06 3-4-5-6-8-9</td>
<td>Bjerkøy</td>
<td>59</td>
<td>12</td>
<td>5-10</td>
</tr>
<tr>
<td>07 1-2-4-10-11</td>
<td>Overud, Kubberud</td>
<td>60</td>
<td>11</td>
<td>200</td>
</tr>
<tr>
<td>08 all</td>
<td>Hjuleberg-Abild</td>
<td>56</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>09 all</td>
<td>Liseøen</td>
<td>59</td>
<td>16</td>
<td>65</td>
</tr>
<tr>
<td>10 all</td>
<td>Løppohøgberget</td>
<td>63</td>
<td>25</td>
<td>150-200</td>
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<tr>
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<td>49</td>
<td>15</td>
<td>410</td>
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<tr>
<td>12 03</td>
<td>Gambier de Brene</td>
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<td>27</td>
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<tr>
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<td>Rocherst</td>
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<td>26</td>
<td>600</td>
</tr>
<tr>
<td>14 01</td>
<td>Kinroo</td>
<td>51</td>
<td>45</td>
<td>20-50</td>
</tr>
<tr>
<td>15 03</td>
<td>Gendron-Caille</td>
<td>50</td>
<td>50</td>
<td>200-300</td>
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<tr>
<td>16 05</td>
<td>Baraque Frature</td>
<td>50</td>
<td>16</td>
<td>600</td>
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<tr>
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<td>Deutselbach</td>
<td>49</td>
<td>07</td>
<td>640</td>
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<tr>
<td>18 3-6-10</td>
<td>Kall-Hord</td>
<td>49</td>
<td>06</td>
<td>620</td>
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<tr>
<td>19 1-2</td>
<td>Brandcheid</td>
<td>50</td>
<td>06</td>
<td>620</td>
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<tr>
<td>20 01</td>
<td>Ruppertweiler</td>
<td>49</td>
<td>07</td>
<td>305</td>
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<tr>
<td>21 01</td>
<td>Kind備ch</td>
<td>49</td>
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<td>260</td>
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<tr>
<td>22 01</td>
<td>Winter</td>
<td>50</td>
<td>07</td>
<td>380</td>
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<tr>
<td>23 01</td>
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<td>07</td>
<td>350</td>
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<tr>
<td>24 01</td>
<td>Holzendorf</td>
<td>51</td>
<td>07</td>
<td>250</td>
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<td>Rödershausen</td>
<td>51</td>
<td>10</td>
<td>235</td>
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<tr>
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<td>09</td>
<td>305</td>
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<td>27 4</td>
<td>Dellebeisen</td>
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<td>09</td>
<td>305</td>
</tr>
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<td>28 5-6</td>
<td>Horden</td>
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<tr>
<td>29 01</td>
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<td>07</td>
<td>400</td>
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<td>30 02</td>
<td>Brüggen</td>
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<tr>
<td>31 03</td>
<td>Letakhebe</td>
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<td>250</td>
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<td>Linn</td>
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<td>07</td>
<td>350</td>
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<tr>
<td>34 06</td>
<td>Sassenhauenan</td>
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<td>400</td>
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<tr>
<td>35 09</td>
<td>Herrnstein</td>
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<td>07</td>
<td>245</td>
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<tr>
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<td>Schleiden</td>
<td>50</td>
<td>06</td>
<td>264</td>
</tr>
<tr>
<td>37 11</td>
<td>Raggendorf</td>
<td>50</td>
<td>07</td>
<td>280-300</td>
</tr>
<tr>
<td>38 8-9</td>
<td>Minard Forest</td>
<td>56</td>
<td>10</td>
<td>170</td>
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<tr>
<td>39 10-11</td>
<td>Drummond Hill (plots of 3-2 plantas)</td>
<td>56</td>
<td>04</td>
<td>137-183</td>
</tr>
</tbody>
</table>

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 1956, Olof Langeland 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 Timijrahs (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 Bir/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-

and 1939 for Norway spruce, Scots pine and Larch.

In September 1979, the Working Party 82.02.11 on Norway spruce convened in Bucharest. The trials of 1938 and 1939 were chosen for the meeting. After the indoor sessions at Bucharest, Dr. Valente 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 Brasov. At the working session, the party assigned Dr. Măcșe Gîrțăca from Kornik with the task of compiling all known information from the 1938 and 1939 IUFRO series with Norway spruce.
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 prove-
nances.

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 interac-
tions; 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 pre-
conditioning 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 mem-
er of a special group within IUFRO that gave a guar-
antee 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. Knaak planted about
100 seed sources in field experiments in the heavily pol-
luted Ruhr industrial area. Prof. Schmidt-Vogt had some
of the material under physiological observation in his
Günterstal experimental station close to Freiburg, Cze-
choslovakia 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 Diet-
richson from Norway collected material for microscopic
studies of cell formation, lignification and, indirectly, of
cessation of growth and hardness (Dietrichson, 1989).

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”. Lävi Kärki from the Foundation of
Forest Tree Breeding in Finland informed me in Novem-
ber 1988 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 (1980) carried out electrophore-
tic 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 1966 at age
20 from seed. A total of 2,886 trees were examined. Data
on seed characters and field data from the IUFRO experi-
ments (Dietrichson et al., 1976) from the trials at Lapp-
kojberget (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 re-

fects relatively recent historical events related to the
last glaciation and that Norway spruce is still in a pro-

cess of adaption and differentiation. There is a clear geo-

graphic pattern in the variation of allele frequencies. A
major part of the allele-frequency variation can be ac-

counted for by a few synthetic variables (principal com-
ponents), 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 simi-
lar to that observed for seven morphological traits
examined. This similarity suggests that the same evolu-
tionary forces have acted upon both sets of characters.”

Giertych (pers. comm.) informed me of a very in-

teresting follow-up to IUFRO 1964/1968. The provenance
of Koloznowskie/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 re-
established 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 (Passon and Passon, 1982). A sum-
mary report on this series will be released by the Work-

ing Party 52.02.11. 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 Po-
land 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 con-
sequence of 1 to 2 generations of artificial cultivation. A
certain temperature, 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 Swed-
ish and Finnish as well as those from North Russia. In
this region cessation exhibits a strictly cinal 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

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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 southwestern 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 Stanisław Tyszkiewicz, 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 succeeded 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 Tyszkiewicz retired, he was replaced by Stefan Kociecki, who had been working with Tyszkiewicz 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'/22° 03'/170 m) the most north-eastern source and Zwiercyniec Lubelski (50° 34'/22° 58'/260 m) in the south eastern lowlands of Poland. Next fastest growing were two sources from Białowieża.

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.

<table>
<thead>
<tr>
<th>No.</th>
<th>Country</th>
<th>Polish sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-6</td>
<td>Canada</td>
<td>20</td>
</tr>
<tr>
<td>7-14</td>
<td>Austria</td>
<td>3-10</td>
</tr>
<tr>
<td>15</td>
<td>Belgium</td>
<td>15</td>
</tr>
<tr>
<td>16-22</td>
<td>CSSR</td>
<td>12-20</td>
</tr>
<tr>
<td>23-25</td>
<td>Finland</td>
<td>14</td>
</tr>
<tr>
<td>26</td>
<td>France</td>
<td>20</td>
</tr>
<tr>
<td>27-36</td>
<td>Germany (FRG)</td>
<td>10-20</td>
</tr>
<tr>
<td>37</td>
<td>Norway</td>
<td>20</td>
</tr>
<tr>
<td>38</td>
<td>OSS (USSR)</td>
<td>10</td>
</tr>
<tr>
<td>39-42</td>
<td>Poland</td>
<td>20</td>
</tr>
</tbody>
</table>

*) 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 Tjörnarps/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 genetic 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 — man-made 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.

Acknowledgements

I am indebted to Dr. Howard Keiffer and Dr. Eric Thiemer du Clos for kindly reviewing this paper.

Literature


IUFRO's Role in Coniferous Tree Improvement

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

By H. Weiserber1 and J. Sindelár2

(Received 30th February 1983)

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. Beside the 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 and the 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 conditions 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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