been explained by BÜSGEN. The ideas generated by research on seedlings were later applied to trees.

The dynamic analysis of the growth pattern took into consideration the relationship between weather and growth, as well as the time of transplantation and influence of physiological age on growth. OTTO SCHRÖCK was aware of the limits of these early tests and made the following suggestions:

— With this method a pre-selection can be carried out, hereditary growth properties can be recognized at an early stage, and majority of low-scoring progenies and provenances can be excluded.
— A systematic breeding program is possible within a reasonable time, also for long-lived objects, and the wide area needed for performance tests could be reduced.

Research on the genus *Populus* focussed on two fields: 1.) fundamentals of performance testing, for which he set up a reliable "Registration of cultivars" and 2.) the indigenous grey poplar (*Populus canescens* SM.) still growing on very small areas.

Clonal selection in natural forests and feasible propagation methods were worked out successfully for this poplar, which is difficult to propagate. By means of bark and rind patterns he demonstrated the possibility to recognize valuable wood structures for timber processing. This enlarged further the scope and importance of grey poplar in forestry.

Since OTTO SCHRÖCK could take over WOLFGANG WETTSTEIN's poplar collections established already before the Second World War, the hybrids of STOUT and SCHREINER, so called *P. androscoggin* and *P. rochester* could be used soon for clonal comparison. His happiest and most successful research activities took place at the beginning of the 1950's at the time of a close professional and amicable cooperation with his colleague KLAUS STERN, until STERN left Waldsieversdorf to work with WOLFGANG LANGNER in Schmalenbeck.

At a time when a scientist active over a decade can start compiling his lifework and draw conclusions from his research, OTTO SCHRÖCK was relieved of his duties. This injustice caused him a great deal of depression.

In summary, I would like to mention that OTTO SCHRÖCK and HANS SCHÖNBACH enriched forest genetics and forest tree breeding through their research and thinking. Their work within the framework of the world-open IUFRO family would be of mutual benefit to all.

Studies on Genetic Variation in Scots Pine (Pinus sylvestris L.) coordinated by IUFRO

By M. GIERTYCH and J. OLEKSYN

Polish Academy of Sciences
Institute of Dendrology
PL-62-035 Kórnik
Poland

(Received 14th February 1992)

Summary

Information is given about the organization of the Scots pine IUFRO provenance trials of 1907, 1938, 1939 and 1982. In spite of differences in opinions, wars and financial problems, international cooperation proved possible in the establishment stage of these trials. Sustaining interest was more difficult. IUFRO agencies were generally unsuccessful in achieving regular joint evaluations of results. Need for them constantly reappears in IUFRO resolutions but they prove unattainable. It is demonstrated on a few examples how mutually enriching such joint evaluations are. It is recommended that an internationally sponsored team should periodically visit, measure and report on the trials for the benefit of all.

Twice on the initiative of IUFRO monographs were produced on the genetics of Scots pine.

Key words: Pinus sylvestris, provenance, genetics, history

Historical Survey

The IUFRO trial of 1907

The importance of seed origin in silviculture was discussed as early as the first IUFRO Congress in Vienna in 1893) (SPEER, 1972). At the 5th IUFRO Congress in Stuttgart in 1906, ADAM SCHWAPPACH, the famous author of volume tables for Central Europe, proposed that an international experiment be established to test the influence of origin of pine seed on the growth of stands (WIEDEMANN, 1930). As usually happens with IUFRO initiatives, the author of an approved idea is asked to implement it, thus SCHWAPPACH was asked to coordinate the proposed trial, which he did from his station in Eberswalde.

Following this initiative, 13 seed lots (Table 1) were obtained and distributed among cooperating institutions. Not all participants received all the seed sources, but most had the first 8 in Table 1. Usually some local material was also included. Initially, experimental areas included 5 in Germany (1 in Prussia in Chorin close to Eberswalde, 1 in Saxony in Tharandt, 2 in Hessen and 1 in Bavaria), 2 in Austria, 2 in Hungary (actually in Slovakia, which was then part of Hungary), 1 in Russia (near St. Petersburg), 2 in Sweden and 6 in Belgium. A year later 2 areas were established in the Netherlands (WIEDEMANN, 1930).

Some of these trials were lost or forgotten. For example, the Raunheim (Hessen) experiment was destroyed by fire in 1921 and thus only the small demonstration plot at Gießen remained from the Hessen effort (ECKSTEIN, 1973). The Russian plot, now within the city limits of St. Petersburg, still exists. We saw it in 1985; however, its documentation was lost, no data are known to have been

Table 1. — Data on Scots pine provenances from the IUFRO 1907 experiment.

IUFRO No.	Provenance	Lat. (N)	Long. (E)	Alt. (m)
1	Scotland, Invernesshire Seafield For. Estate	57°14′	3°42′W	200
2	Langeac, Haute Loire France	44°58′	3°07′E	1140
3	Guzianka, Olsztyn Poland	53°40′	21°30′	130
4	Hasselt, Campine Belgium	50°54′	5°40′	104
5	Kaiserslautern, Rhein Pfalz, Germany	49°25′	7°45′	300
6	Kliewenhof, Latvia	56°45′	25°45′	10
6A	Kliewenhof, Latvia	56°45′	25°45′	10
7	Chorin and Biesental Germany	52°50′	14°10′	40
8	Perm, Stroganov Estate Russia	57°00′	64°00′	300
9	Creweno, Phillipopolis Bulgaria	42°10′	23°50′	1550
10	Jokkmokk, Sweden	66°36′	20°00′	260
11	Spiš, Smolnik Czechoslovakia	48°45′	20°45′	550
12	Bratislava, V. Levāre Czechoslovakia	48°30′	17°00′	210
13	Hoenderlo, Utrecht Netherlands	52°10′	5°20′	5

Table 2. — Location of planting sites for the IUFRO 1907, 1938, 1939 and 1982 Scots pine provenance experiments.

Exp. No.	Locality	Lat. (N)	Long. (E)	Alt. (m)
1907				
1	Chorin, Germany	52°50′	13°50′	100
2	Tharandt, Germany	50°58′	13°33′	412
3	Gießen, Schiffenberg, Germany	50°30′	8°40′	200
4	Belle Etoile, Belgium	50°50′	4°25′	125
5	Belle Etoile, Belgium	50°50′	4°25′	125
6	Knickövel, Belgium	50°36′	6°02	350
7	Hässleby, Jönköping, Sweden	57°38′	15°37′	180
8	Likavka, Rozumberk, Czechoslovakia	49°08′	19°17′	560
9	Kootwijk, Netherlands	52°10′	5°50′	30
1938				
1	Wienerwald, Austria	48°51′	16°13′	380
2	Gutenstein, Austria	47°53′	15°53′	780
3	Marchfeld, Austria	48°22′	16°45′	220
4	Herbeumont, Belgium	49°47′	5°13′	415
5	Rovaniemi, Finland	66°35′	25°35′	80
6	Ruotsinkylä, Finland	60°22′	25°00′	60
7	Arboretum de Joueou, France	42°43′	0°38′	1000
8	Arboretum Les Barres, France	47°50′	2°45′	673
9	Arboretum Royat, France	45°46′	3°02′	850
10	Como, Brenna, Italy	45°40′	9°25′	350
11	Como, Alzato, Italy	45°40′	9°25	350
12	Matrand, Eidskog, Norway	60°02′	12°15′	110
13-16	Sweden			
17	Vincent State Forest, N.H., USA	43°06′	71°47′W	360
18	Fox State Forest, N.H., USA	43°09′	71°55′W	260
19	Wellston, Manistee, Mich., USA	44°16′	85°57′W	790
20	Herkimer State Forest. N.Y., USA	43°18′	75°07′W	415
21	Lubień, Poland	51°16′	19°47′	200
22	Bugac, Kecskemét, Hungary	46°52′	19°40′	150
23	Hůrky, Czechoslovakia	49°01′	14°38′	500
24a	Finowtal (0.3 x 0.3)*, Germany	52°48′	13°56′	100
24b	Finowtal (1.0 x 1.0)*, Germany	52°48′	13°56′	100
1939				
1	Petawawa For. Exp. Sta., Canada	45°55′	77°30′W	
2	Bahçeköy, Turkey	41°10′	28°58′	110
1982				
1	Wyszków, Poland	52°41′	21°28′	112
2	Kórnik, Poland	52°15′	17°04′	70
3	Supraśl, Poland	53°12′	23°22′	160
4	Rogów, Poland	51°47′	19°56′	190
5	Niepołomice, Poland	50°02′	20°22′	195
6	Bensheim, Germany	49°39′	8°31′	94
7	Waldsieversdorf, Germany	52°33′	14°05′	50
8	Escherode, Germany			
9	Drenovac, Croatia	45°33′	15°22′	210
10	Acsad, Hungary	47°22′	16°42′	200
11	Lasek, Czechoslovakia	48°35′	17°08′	250

* Planting distance in m.

ever published, and thus it is useless. From Wales (Bangor), Bavaria (Grafrath) and Austria (Mariabrunn) no information appeared beyond the nursery stage (ages 1—3) summarized by KALELA (1937/1938). There are regular reports for 3 of the 6 Belgian tests (2 in Belle Etoile and 1 in Knickövel). The others (Raevels and Pijnven I and II) were reported on until 1922 (WIEDEMANN, 1930) but the authors have not found anything more recent. In the 1910 Proceedings of the 6th IUFRO Congress in Brussels, detailed plans are presented of the two Pijnven experiments (actually replicate blocks next to each other) in connection with a visit to them by the Congress participants (Anonym, 1910). Perhaps they could be reactivated. The Swedish trial at Hässleby is still functional; the one at Bispgården yielded results at age 8 (KALELA, 1937/38) but we know of no report from it since. Thus the number of functional tests has declined with time. Those still existing are listed in Table 2.

Although some of the trials are no longer operative, one can complement the experiment with some other related ones. Switzerland did not officially participate in the experiment because at about the same time a similar, much larger experiment with many more provenances was established there at 7 locations by A. ENGLER. The trials established in 1908 and 1909, at the same time as the IUFRO experiments, included 7 provenances which represent the same or almost the same seed sources as the IUFRO trial (Nos. 1—5, 8, 10, of Table 1); thus results can be compared. One of the experimental areas, at Eglisau, was visited in 1948 during the 10th IUFRO Congress in Zürich. The handout on the experiment (Anonym, 1948) contained conclusions identical with those of most of the IUFRO trials, namely that northern provenances have good form but poor growth and that southern ones have better growth but poor form. The best one on the average, was provenance Olsztyn from northern Poland. Thus the trial can be considered as a valuable supplement to the IUFRO experiment.

Provenance 8 from Perm in Russia, was included with 40 other seed lots in a major Russian experiment established in the years 1910—1916 throughout the empire. It is everywhere a poor performer in volume production (Fig. 2). It can serve as one of the links between the IUFRO and the Russian trials.

These early trials were neither randomized nor replicated and are often not considered too seriously. Their main advantage is their age and the large size of the plots, which permits evaluation of volume production per unit area; current experiments are not designed for this. When experiments lied out today reach felling age, there will probably also be complaints about inadequacy of the experimental design. Improvements in design are consequence of persistent IUFRO efforts to introduce them in coordinated trials.

The first IUFRO Scots pine provenance experiments established in 1907, generated considerable interest at the 6th IUFRO Congress in 1910 in Brussels. During an excursion, the areas at Pijnven and Belle Etoile were visited and the early results were made available (Anonym, 1910). MAYR (1910) reported on nursery results in Eberswalde, primarily concerning needle cast damage. The French provenance (No. 2) was most affected. The importance of hereditary differences in trees and the consequence of indiscriminate seed transfers were generally recognized and it was proposed that origin of seed in trade be placed under state control (CRAHAY, 1910).

This topic was to become one of considerable controversy for some time. It was brought up at the International Congress of Silviculture in Rome in 1926, where it was recommended that "Forest Administrations and Research Stations should study means of creating favourable conditions for making available to foresters supply of data on race and provenance of certain seed and for international cooperation and exchange arrangements, so that results obtained in one country would serve all others". Following this recommendation, P. H. GUINIER proposed in 1929 at the Stockholm 7th IUFRO Congress that IUFRO should control the seed market through "verification of provenance, its identification and assurance in international trade" (GUINIER, 1929).

There were several papers on the topic at the Congress. OLOF LANGLET explained how 19th century pine seed introductions, primarily from Darmstadt, Germany, proved inadequate in Sweden, where they were attacked by fungi and were branchy with twisted stems and persistent dead branches. Study of transfers within Sweden itself also indicated racial variation. LANGLET recommended that local seed or from a similar climate be used (LANGLET, 1929). GUSTAV VINCENT proposed the creation of seed zones and the identification of provenance in seed and plant trade. He considered this not only a right but also a duty for the buyer to demand (VINCENT, 1929). WERNER SCHMIDT voiced similar opinions. All of this discussion led to a resolution approved on July 26th 1929 at the session of Section II reading:

"The International Union of Forest Research Organizations should request the various associated stations to arrange the cropping of forest seeds from various good stands in the most suitable way in each case; latitude and longitude, height above sea level, and other ecological conditions being carefully given with reference to each cropping place.

The experimental stations should send annual reports to the Secretary General as to the possible unused surpluses of cropped seeds with a view to making distribution possible" (Resolution 8, Proc. 7th IUFRO Congress, Stockholm, 1929).

Soon afterward, the first overall review of results from the IUFRO 1907 and other Scots pine provenance experiments was published by EILHARD WIEDEMANN from Eberswalde. This paper continues to be the most detailed source of information about the first IUFRO trial of 1907 (WIEDEMANN, 1930). It indicated that racial differences are substantial and that provenances from extreme climates (northern, southern, high altitude) are unsuitable for Central Europe. Two "elite" provenances, the Belgian land-race (No. 4) and Olsztyn, N. Poland (No. 3) were recommended as being of value for wider usage.

At the 8th IUFRO Congress in Nancy in 1932, the subject of tree seed provenance was again given much attention. The organization of provenance control in seed trade as it functioned in various countries was described by H. BALDWIN for the USA, M.E.D. VAN DISSEL for Holland and G. VINCENT for Czechoslovakia. VINCENT proposed that: 1) the guaranteeing of seed origin should be in the hands of forest research institutes; 2) the guarantee should be optional; 3) the local chief officer of the Forest Service should give a certificate of origin; 4) research institutions should verify the certificates, register them and give guarantee labels (VINCENT, 1932). The proposal was strongly opposed, particularly by J. HAUSBRANDT from Poland, who insisted that control of seed trade is the responsibility of forest administration and not of research institutions. After much discussion, extensively reported upon in the Congress proceedings, it was formally recommended:

"That Research Stations continue to exchange seeds for scientific purposes, through the Secretary General of the Union.

That Governments, while retaining entire liberty in the matter of organizing control in their respective countries be requested to adopt international standards for guaranteeing the control and origin of seeds" (Proc. 8th IUFRO Congress, Nancy, 1932 p. 836).

These recommendations remained on paper only.

The IUFRO trials of 1938 and 1939.

At the 9th IUFRO Congress in Budapest in 1936, the subject of seed provenance was again much discussed. D. DELEVOY (Groenendaal, Belgium) proposed that now, after 25 years, the results of the first IUFRO Scots pine provenance experiment be jointly evaluated and reported upon at the next Congress in 1940 in Helsinki. Needless to say, World War II prevented all this from happening. At

Table 3. — Data on Scots pine provenances from the IUFRO 1938 experiment.

IUFRO No.	Provenance	Lat. (N)	Long. (E)	Alt. (m)
1	Inari, Finland	68°40′	27°37′	140
2	Rovaniemi, Finland	66°25′	26°36′	250
3	Sääminki, Finland	61°40′	28°55′	85
4	Tonset, Norway	62°22′	10°48′	550
5	Mälselv, Tromso, Norway	69°06′	18°50′	75
6	Åsnes, Hamar, Norway	60°32′	12°11′	230
7	Svanøy, Norway	61°30′	5°07′	50
8	Voxna, Sweden	61°20′	15°31′	200
9	Tönnersjöheden, Sweden	56°40′	13°08′	100
10	Böda, Sweden	57°18′	17°01′	5
11	Vecmokas, Latvia	57°03′	23°10′	80
12	Susk, Ukraine	50°50′	26°00′	185
13	Presov, Czechoslovakia	49°00′	21°15′	500
14	Talmacel, Romania	45°40′	24°08′	600
16	Kandersteg, Switzerland	46°29′	7°41′	1300
17	Glen Garry, Scotland	57°04′	4°55′W	150
18	Herselt, Belgium	51°03′	4°56′	20*
19	Diever, Netherlands	52°51′	6°21′	10*
20	Brody (Pförten), Poland	51°47′	14°46′	85
21	Göddenstedt, Germany	52°59′	10°50′	75
22	Ruciane, Poland	53°41′	21°26′	120
23	Elmstein, Germany	49°20′	7°57′	325
24	Zellhausen, Germany	50°01′	9°00′	140
25	Lenti, Hungary	46°38′	16°33′	250
26	Ambert, France	45°33′	3°45′	700
27	Millau, France	44°10′	3°22′	825
28	Les Angles, France	42°36′	2°07′	1570
29	Bromarv, Finland	60°03′	23°06′	15
30	Modum, Norway	60°04′	10°00′	300
31	Val di Fiemme, Italy	46°18′	11°20′	1100
32	Griva, Russia	55°58′	26°15′	160
33	Breda, Netherlands	51°34′	4°46′	10*
34	Tinoava, Romania	47°24′	25°22′	910
35	Langensteinbach, Germany	48°55′	8°30′	260
36	Langenbrand, Germany	48°47′	8°40′	525
37	Supraśl IA, Poland	53°13′	23°22′	160
38	Supraśl IB, Poland	53°13′	23°22′	160
39	Bolewice IIA, Poland	52°24′	16°10′	90
40	Bolewice IIB, Poland	52°24′	16°10′	90
41	Susk IIIa, Ukraine	50°50′	26°00′	185
42	Kuřivody, Czechoslovakia	50°36′	14°43′	300
43	Tišnov, Czechoslovakia	49°21′	16°24′	375
44	Třebon-Wittingau, Czechslo.	49°00′	14°45′	450
45	Vysoké Tatry, Czechoslo.	49°09′	20°13′	650
46	Vindeln, Sweden	64°11′	19°35′	270
47	Brännberg, Sweden	65°48′	21°16′	100
48	Vitsand, Sweden	60°23′	12°55′	175
49	Axamo, Sweden	57°46′	14°03′	225
50	Strömsund, Sweden	63°50′	13°33′	300
51	Svenskądalen, Sweden	64°02′	13°04′	500
53	Mustejki, Lithuania	54°08′	24°25′	130
54	Rychtal, Poland	51°12′	17°55′	190
55	Luboml, Ukraine	51°15′	24°05′	196

* In this place Scots pine is an introduced species

Table 4. — Data on Scots pine provenances from the IUFRO 1939 experiment.

IUFRO No.	Provenance	Lat. (N)	Long. (E)	Alt. (m)
1	Svanøy, Norway	61°29′	5°07′	50
2	Åsnes, Norway	60°30′	12°10′	180
3	Troms (coast), Norway	69°10′	18°00′	200
4	Troms (interior), Norway	69°10′	19°30′	150
5	Småland, Sweden	57°	14°	
6	Vindeln, Sweden	64°12′	19°50′	200
7	Inari, Finland	68°55′	27°00′	140
8	Rovaniemi, Finland	66°30′	25°45′	150
9	Orton Estate, Scotland	57°33′	3°09′W	115
10	Balnagowan Wood, Scotland	57°16′	3°39′W	240
11	Murat, France	45°06′	2°52′	625
12	Luchon, France	42°46′	0°35′	>1000
13	Bebenhausen, Germany	49°58′	8°57′	135
14	Pisz, Poland	53°38′	21°48′	130
15	Rychtal, Poland	51°10′	17°52′	125
16	Vladimir, Russia	56°	40°	100
17	Poltava, Russia	49°30′	34°30′	100
18	Talmacel, Romania	45°40′	24°15′	600
19	Griva, Russia	55°50′	26°25′	150
20	Vecmokas, Latvia	57°00′	23°07′	80
21	Çatacik, Turkey	39°33′	30°30′	1350
22	Hungary	46°40′	16°40′	150
23	Norfolk County, Ont. cult.	43°40′	80°30′W	200

the same Congress, on Sept. 8th 1936 in Lillafured, Hungary, on the initiative WERNER SCHMIDT (Eberswalde) and STANISLAW TYSZKIEWICZ (Warsaw), a subcommittee was established for the Study of Seeds and Races. The subcommittee included W. SCHMIDT Chairman, H. BALDWIN, O. HEIKINHEIMO, S. TYSZKIEWICZ, G. VINCENT and A. PAVARI (ROTH, 1936, p. 61—62). O. LANGLET and O. HAGEM joined the subcommittee in 1937 (BALDWIN and PETRINI, 1941). It was decided that a series of international provenance experiments should be organized and SCHMIDT was given the responsibility. Cones gathered by cooperating institutions were extracted in Eberswalde and the seed was sent out to various parts of Europe and North America for the establishment of comparative plantations.

This has been done twice for Scots pine, in 1937 and 1938, for sowing the following spring. The experiments have since been known as the Scots pine IUFRO 1938 and IUFRO 1939 series, respectively. The provenances used in the 1938 trial are listed in Table 3 and those used in 1939 are in Table 4.

In the late 1930s a compilation of results from all previous provenance experiments, including those of Scots pine, was made by AARNO KALELA (1937/38). KALELA's thesis is organized in the form of a consecutive presentation of the latest results from each experimental area. However, for the IUFRO 1907 trial he made an exception by presenting and discussing the combined data. Thus the 1938 and 1939 Scots pine experiments started when all up-to-date information on provenance variation was readily available (in German). KALELA produced his study under OLLI HEIKINHEIMO, a member of the IUFRO Subcommittee for the "Study of Seeds and Races".

It was HEIKINHEIMO (1954) who first produced a summary of the earliest (nursery) results from the new study. In an informative table, he compiled data on seedling weight obtained for 11 provenances in 5 different nurseries, from northern Finland to Belgium.

Seeds were sown in the spring of 1938 or 1939, but World War II disrupted much of the outplanting work. Originally there were 24 planting sites for the 1938 series and 2 for the 1939 series (Table 2). Other than seedling data (LANGLET, 1959), nothing was published from the four Swedish planting sites (Nos. 13—16). Evaluation of the Norwegian experiment (No. 12) included mortality, frost and insect damage, but growth measurements were restricted to selected sample trees felled in 1959 (DIETRICHSON, 1964; 1969). Little information came from the three Austrian plantations (Nos. 1—3), although they were visited by VEEN (1953a). SCHREIBER (1966) compared some nursery data with later height measurements. Of the two Finnish plantings, the northern one (No. 5) at Oulu only provided nursery data (HEIKINHEIMO, 1954) but nothing more. Of the three French plantings in Arboreta, the one at 1000 m elevation (No. 7) yielded no published data. Of the two Italian plantings, the one at Alzato (No. 4) was last measured at age 10 and abandoned later for various reasons (TOCCI, 1976). The Czechoslovak trial (No. 23) has not been reported on since age 19. The USA trials (Nos. 17—20) were reported on at age 17 or 18. Trial No. 18, when visited in 1990, was found to be substantially destroyed by herbicides. When HENRY BALDWIN retired, the experiments were left without scientific supervision and local foresters decided to kill chemically all crooked trees, leaving only some trees of the best provenances. Trial No. 20 (Herkimer, N. Y.) is in good condition and could be scientifically reactivated, but interest in the species as a forest tree in the US is currently nil.

Thus only 9 of the original 24 are active experiments.

Of the two 1939 trials, the one in Turkey is reported on regularly, but nothing has been published on the Canadian test since age 10. Our visit in 1990 indicated that while the area in Petawawa, Canada, has been damaged, being within an artillery training area, it could perhaps be revitalized.

Thus again we see a gradual decline in interest and in the number of functioning trials. In fact, the 1907 experiment fared better than the 1938—39 experiment, since a higher proportion of the original planting sites remained active for a longer time.

The declining interest is usually attributed to defects in the experimental design. However those establishing the trials did their best according to the knowledge available to them. World War II prevented full use of available experience. For example, in Poland (Lubień, Exp. No. 21) the material was in the nursery when war broke out. The responsible forest officer was drafted. The local ranger established the area as best he could from the available instructions but was subsequently arrested. Later, as a result of failures, supplemental planting was employed in the simultaneously and similarly established Norway spruce IUFRO 1938 trial, destroying it in the process. There are no records about such supplemental plantings in the pine plantation but this cannot be excluded. In such conditions even the best instructions would have not helped much.

In a mimeographed circular we have not seen, W. SCHMIDT (1940 ex BALDWIN et al., 1973) recommended that the lay-out of the experiments should include a standard provenance replicated several times in various parts of the area. Most cooperators adopted this design, though some tried to replicate more than one or even all of the provenances. Apparently at the sub-committee meeting in Vienna in October 1940 the question of design was discussed and the participants "agreed upon a scheme for planting out the seedlings at a distance of 1.3 x 1.3 m, using 1000 seedlings from every provenance, so that there shall be 5 parts with each 200 plants" (BALDWIN and PETRINI, 1941). However the need for replicates, randomizations and block designs was a new thing at the time since the idea of using variance analysis (FISHER, 1937) was only beginning to enter agricultural and forestry science. Inadequacy of the experimental design is now obvious. We now know that a single unreplicated, non-randomized, plot does not produce much information. Single-plot data are only meaningful in conjunction with data from other similar plots. For this reason, international evaluation of all plots has always been the aim of IUFRO, although such efforts have not usually been successful.

At the first post World War II IUFRO Congress, the 10th in 1948 in Zurich, the Committee for Seeds and Races then headed by G. Piccarolo, submitted to the Permanent Committee the following proposals:

"1/As soon as possible a Committee for genetics of forest trees should be created

. . . .

4/Former results collected by the Committee, including Institutes for testing of seeds, should be published in common" (Piccarolo, 1949).

As a result of this recommendation in 1949, at a meeting of the Permanent Committee in Helsinki, section 22, the "Study of Forest Plants" was established and C. Syrach Larsen from Denmark was asked to lead it.

In 1951, at a meeting in Wageningen of the Permanent Committee and Section Leaders Syrach Larsen proposed that the Union should find a skilled collaborator who would spend 4—6 months visiting the international provenance tests with Pinus, Picea and Larix. There was a need for exact information on the state of these experiments. FAO was approached and it provided $ 1000 for the purpose; G. Houtzagers from the Agricultural University in Wageningen agreed that his assistant, B. Veen, should make the trip (Syrach Larsen, 1953a).

Veen made his trip in 1952 and reported on it at the 11th IUFRO Congress in Rome. Unfortunately, the full report (Veen, 1953a) is only available in mimeo form, the Congress proceedings having only the text but not the all important tables (Veen, 1953b). It is from these tables that the basic information about provenances and planting sites for these experiments have been made available to scientists. Tables 3 and 4 are based on Veen's report, but since it contained numerous errors in place names and geographic coordinates, these were corrected, using as far as possible information published in papers on these experiments in the respective countries. Planting sites in Table 2 are numbered as given by Veen but new numbers are assigned to those not mentioned by him. This follows the latest summary report made for height growth (Giertych, 1979).

At the 11th IUFRO Congress in Rome (1953), Veen's report was discussed in detail, particularly on the subject of thinning methods in provenance experiments which might lead to completely different results. However there was considerable opposition to centralized enforcement of specific procedures. A resolution concerning provenances was adopted, as follows:

"We stress the need for the formation of a Working Group which would in no way interfere with the activities of individual institutes but would enable the establishment of closer contacts between those specially interested in provenance tests. This working group might later develop into a committee to prepare an exact report on recommended methods. The section repeats the thanks which the President of the Union has already expressed to FAO, the University of Wageningen and Dr. Veen for the work already conducted" (Proc. 11th IUFRO Congress in 1953, Rome; 119—121).

The Chairman of section 22 "Study of Forest Plants", C. Syrach Larsen, called for assistance from M. V. Edwards, U. K., in the future work of the group (Syrach Larsen, 1953 b).

At the 12th IUFRO Congress in Oxford, Edwards (1956) gave a report on the 1938—1944 International Provenance Experiments. In the light of this report the meeting decided that IUFRO Section 22:

"a/Considers that the completion of the collection of data regarding the origins of the seed lots employed is of the highest priority and all the countries concerned are required to facilitate this work so that it can be completed within three months after which the data should be printed and published;

b/ Agrees that the draft code which has been circulated should form the basis for the assessment of the experiments. The minimum assessment required consists of height, basal area, volume (when old enough) and at least one of the simpler expressions of habit of growth;

c/ . . .

d/ Considers that an assessment for as many characteristics as possible should be made in all experiments after the 20th year of growth from seed, and all countries concerned are requested to cooperate to this end".

The 20th year assessments of the IUFRO 1938 Scots pine series should have been made about 1957 or 1958, and for the IUFRO 1939 series one year later. However, we can only find evidence that 2 of the original 24 tests were measured (No. 4 Herbeumont, Belgium and No. 10 Brenna, Italy). Height was measured in both of these tests and DBH only in Brenna. In the 1939 trials, height was measured in Turkey in 1959. Thus recommendation c was only fragmentarily implemented and recommendations a and b not at all.

At the 13th IUFRO Congress in Vienna, Syrach Larsen (1961) reported for Section 22 that a Committee on Provenance Research had been established in 1959 in Prague unter the chairmanship of M. Vyskot. This was reorganized into a Working Group on Provenance Research and Testing with Vyskot remaining chairman. J. D. Matthews assumed the leadership of section 22.

At the same Congress, Langlet of Sweden, proposed that simultaneous measurements should be made in the 25th year of growth of the tests, i. e. in the 1962—63 dormant period for the IUFRO 1938 series. This time the heights and diameters were measured at 3 locations (No. 10 Brenna, Italy, No. 22 Bugac, Hungary and No. 24 Finowtal, E. Germany) and diameter only (including basal area) at No. 8 Les Barres, France. A year later height was measured on the 1939 Turkish site.

Thus attempts at joint evaluations failed. No such recommendations were made with regard to the 1907, 1938 and 1939 Scots pine trials again. In retrospect it seems obvious that the recommendations required designated financial support, as was the case in 1952 when Veen received FAO funds to review the experiments.

In 1963 the First FAO World Consultation on Forest Genetics and Tree Improvement was held in Stockholm. In its recommendation No. 8 (Unasylva 18 (2—3); p. 3, 1964) the Consultation asked section 22 of IUFRO:

"a/ to prepare and distribute summaries of the results obtained from past international provenance tests;

b/ . . .

c/ to prepare instructions concerning the collection of seeds, the design of field experiments and evaluation of results to aid in the development of local studies of provenance".

The Working Group on Provenance Research and Testing presented its "Standardization of methods of provenance research and testing" at the 14th IUFRO Congress in 1967 in Munich (LINES, 1967). This was produced in the three IUFRO languages and officially adopted. This effort was in compliance with recommendation 8c of the Stockholm Consultation, but no progress was made on recommendation 8a.

The "Standardization . ." is a document useful only in the establishment of new provenance trials, having no suggestions for the treatment of old ones with deficient experimental designs. When the new provenance trials reach maturity new ideas about experimental designs are likely to make the "Standardization . ." obsolete and the same type of problems will arise. The accomplishments of the Working Group on Provenance Research and Testing did not meet the main objective of the recommendations from the Oxford IUFRO Congress in 1956, which were concerned with the standardization of evaluation procedures for old provenance experiments. Thus at the Munich IUFRO Congress in 1967 the decision was made to set up a Working Group on Provenance Research to be concerned with organization and assessment of international provenance tests (MATTHEWS and CALLAHAM, 1967).

At the 2nd FAO World Consultation on Forest Genetics and Tree Improvement in Washington D. C. in 1970, it was reported that in compliance with recommendation No. 8 of the previous Consultation the following progress was made:

8a "A new working group has recently been formed under the leadership of P. BOUVAREL (France) for this purpose. Individual members of the group are appointed as coordinators for particular species or groups of species. A preliminary register of existing international provenance trials has been compiled.

8b . . .

8c Report on "Standardization of methods for provenance research and testing" was published in the proceedings of the IUFRO Congress held in Munich (1967). A revised version will appear in volume 19 of Silvae Genetica" (Unasylva, 1970, 24 (2—3); 125—129.).

No revised version appeared in Silvae Genetica. Of perhaps more importance, the Washington Consultation had no new recommendations concerning old provenance experiments. In 1970, only a bibliography on these experiments was published (EDWARDS and LINES, 1970), later supplemented to 1975 (LINES, 1975).

At the 15th IUFRO Congress in Gainesville in 1971, R.Z. CALLAHAM and M. HAGMAN reported (mimeo) that in the Working Group on International Provenance Trials led by BOUVAREL "A summary of international provenance trials is now underway . . .". A meeting was held at the Congress on "Status and future activities in international provenance tests". However all effort was devoted to new provenance trials planned or currently being organized, which did not include Scots pine. No "register" or "summary" of international provenance trials was produced. Interest in old experiments was clearly declining.

The reorganization of IUFRO made in Gainesville led to the creation of Subject Group S2.02.00 "Species, provenance and gene resources" with a working party for each species with international interest in provenance experiments. This did not include Scots pine. However another Subject Group S2.03.00 "Breeding" included a Working Party S2.03.05 "Breeding Scots pine" under STEFAN BIALOBOK from Poland, which decided to include provenance studies among its interests.

Renewed interest came from FAO. The Third FAO World Consultation on Forest Tree Breeding held in Canberra in 1977 brought up the problem of evaluation of provenance experiments in its general recommendations 6 and 11 and in the technical recommendation 2 (Unasylva 30 (119—120, 1978 p. 55—57). Specifically, the suggestion was to standardize evaluation procedures, employ computer-based systems for the purpose, and include data on phenological, physiological, morphological and biochemical traits. The Consultation also "noted the value of periodic visits to all trial sites of experienced international, or regional, assessment officers to facilitate overall appraisal and to assist in the local evaluation of individual trials, and urged concerned organizations to provide the requisite staff and finance for such assessments".

In 1979 a review was published of the latest data on variation in heights for the IUFRO 1907, 1938 and 1939 experiments (GIERTYCH, 1979).

The IUFRO 1982 Scots pine provenance experiment

At the International Symposium on "Genetics of Scots pine" organized in 1973 by IUFRO Working Party S2.03.05 in Kórnik, Poland, the idea of establishing a new provenance experiment was proposed by S. KOCIECKI, A. KORCZYK, T. PRZYBYLSKI and Z. RZEŹNIK (RZEŹNIK, 1991). There was little interest in the idea at the time. However, in a meeting of the Working Party during the Oslo 16th IUFRO Congress, STEFAN BIALOBOK and CSABA MÁTYÁS returned to the proposal for a new international provenance experiment on European Scots pine. The suggestion was to collect seed lots along two transects, from north to south (basically along longitude 20° E) and from east to west (basically along latitude 52° N). The proposal was accepted and STEFAN KOCIECKI from the Forest Research Institute in Warsaw, Poland, was asked to prepare instructions for seed collection and the mode of establishment of experimental areas.

The goals, objectives and methods of experimental design were defined in an instruction which was sent out to all participants (for full text of the instruction see OLEKSYN, 1988). The experimental design was to be a random complete block with 8 replicates.

Table 5. — Data on Scots pine provenances from the IUFRO 1982 experiment.

IUFRO No.		Lat. (N)	Long. (E)	Alt. (m)
1	Roshchinskaya Dacha, Russia	60°15′	29°54′	80
2	Kondezhskoe, Russia	59°58′	33°30′	70
3	Serebryanskoe, Russia	58°50′	29°07′	80
4	Silene, Latvia	55°45′	26°40′	165
5	Miłomłyn, Poland	53°34′	20°00′	110
6	Supraśl, Poland	53°12′	23°22′	160
7	Spała, Poland	51°37′	20°12′	160
8	Rychtal, Poland	51°08′	17°55′	190
9	Bolewice, Poland	52°24′	16°03	90
10	Neuhaus, Germany	53°02′	13°54′	40
11	Betzhorn, Germany	52°30′	10°30′	650
12	Lampertheim, Germany	50°00′	10°00′	95-100
13	Ardennes, Belgium	50°46′	4°26′	110
14	Haguenau, France	48°49′	7°46′	130-180
15	Sumpberget, Sweden	60°11′	15°52′	185
16	Zahorie, Czechoslovakia	48°46′	17°03′	160
17	Pornóapźti, Hungary	47°20′	16°28′	300
18	Maočnica, Montenegro	43°10′	19°30′	1200
19	Prušacka Rijeka, Bosnia	44°05′	17°21′	800-970
20	Çatacik, Turkey	40°00′	31°10′	1380-1420

BIALOBOK following on the proposed outline of the study, began in 1978 to gather seeds from the selected locations. By 1981, seeds were collected from 20 provenances (Table 5). Unfortunately, it proved to be impossible to obtain seeds from all the originally-planned populations. Seeds were lacking from Finland, where two provenances were initially planned, and from Spain and Byelorussia. On the other hand a larger number of Russian and Yugoslav provenances were included in the experiment.

The recommendations were not been fully followed. The suggested time for seed collection (1978—1979) happened to be a period with a poor cone crop; thus only seeds from Belgian provenance No. 13 could be collected, while the rest were collected the following year. The seeds of provenances from Russia (Nos. 1, 2 and 3) came from a commercial seed extraction plant and thus were not specifically collected to meet the needs of the experiment.

The seeds were to be distributed during the winter of 1981—82. Due the martial law imposed in Poland in December 1981 samples of the seeds, were not sent out to individual participants and institutions until early March 1982, and thus in some cases the seeds were sown too late.

General interest in the establishment of a new large-scale international Scots pine provenance experiment was not large. Even organizations and scientists that submitted seeds for the experiment in many cases refused to take part in the establishment of the field tests. As a result there are no experimental areas further north than in Poland, thus limiting possible future geographic, e. g. photoperiodic, responses.

As to the end of 1991, the organizers have obtained information on 11 permanent experimental plots established for the IUFRO 1982 Scots pine experiment (Table 2).

Other IUFRO efforts relating to Scots pine genetics

As of the end of 1991, the organizers have obtained init was decided that an effort should be made to compile data on the prerevolutionary Russian provenance trials of 1910—16 with Scots pine. HAGMAN offered to attempt this. He withdrew that offer during the 16th IUFRO Congress in Oslo in 1976, on the basis of unavailability of data. At the Congress, BIALOBOK reported that he found in Leningrad a 1940 paper by F. I. FOMIN with some data on the 1910—16 trials. This encouraged us to attempt a review of the Russian experiments.

The Russian provenance experiments of 1910—16 were organized by V. D. OGIEVSKIJ with about 40 provenances covering the European part of the Russian empire and a few Siberian populations. They were outplanted at 20 locations. We compiled all published information on the experiment in the form of a review paper, first presented as a poster during the IUFRO "Scots Pine Forestry of the Future" meeting held in Poland in August 1980, and later printed in Silvae Genetica (GIERTYCH and OLEKSYN, 1981). Data were presented from 7 locations, some with the latest reports from the 1940s. Later two additional test locations were found, one of them in Pulawy, Poland, in an area that was part of Russia when the test was established in 1912. The records for the trial were found in Tbilisi, Georgia, where S. Z. KURDIANI, who established the trial, settled after the Russian revolution. We deciphered the plots and took the first measurements ever made on the pines when they were 69 years old (OLEKSYN and GIERTYCH, 1984). The other plantation newly discovered by us is in the experimental park of the Moscow Agricultural Academy, a location now inside the city limits; a

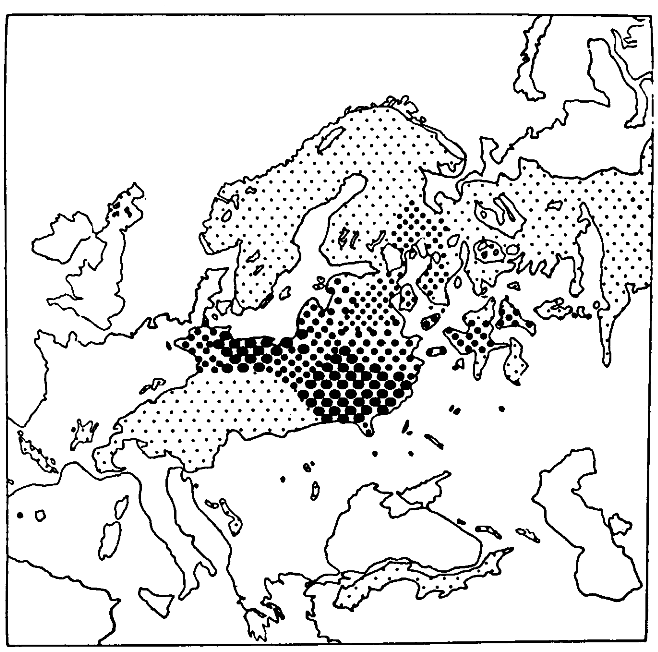

Figure 1. — Location of the most adaptable races of Scots pine recommended for introduction to other regions when local races are inadequate. The larger the spots, the better are the provenances for transfer (OLEKSYN et al., 1936). Based of IUFRO and old Russian trials.

report is pending. These efforts stimulated renewed interest in these old experiments within the USSR. As mentioned above, the Perm provenance and possibly also the Latvian one (Riga pine) used in this series were the same as those used in the IUFRO 1907 trial.

The Russian experiments extend to western Siberia the information about provenance variation in Scots pine and allow us to recognize the geography of its plasticity, thereby determining seed transfer possibilities (*Fig. 1*).

Following the recommendations of the FAO First and Second World Consultations on Forest Tree Breeding in 1963 and 1969, IUFRO Working Party S2.02.03 "Species Monographs" was set up under MIRKO VIDAKOVIĆ with the objective of publishing separate volumes on the genetics of various forest species. The Scots pine volume was written by TADEUSZ PRZYBYLSKI, STEFAN BIALOBOK and MACIEJ GIERTYCH from Poland (PRZYBYLSKI et al., 1976).

At the 17th IUFRO Congress in Kyoto in 1981 the Scots Pine Breeding Working Party did not meet but it was decided, following its recommendations, that CSABA MÁTYÁS should become chairman and JACEK OLEKSYN co-chairman. The new leadership took over responsibility for the IUFRO 1982 experiment and also recommended that all information on the genetics of Scots pine be again compiled into one volume by a team of international experts. In 1985, GIERTYCH was asked to search for possible authors for the monograph. The details of the monograph were decided during the 18th IUFRO Congress in Ljubliana in 1986 at a business meeting of the Working Party, and work began. At that time the name of the Working Party was changed to "Scots pine provenances and breeding" S2.02—18 under Subject Group S2.02—00 "Provenances, breeding and gene resources" to conform with the reorganization within Division II. The leadership of the Working Party remained unchanged.

The Working Party met again in Voronezh, Russia in 1989, where the state of preparations for the monograph

"Genetics of Scots pine" was presented. It has 20 chapters with 24 authors from 9 countries and is truly a IUFRO effort. It was printed in 1991 (GIERTYCH and MÁTYÁS, 1991).

To complete the historical survey, it needs to be added that following the 19th IUFRO Congress in Montreal MÁTYÁS became S2.02-00 Subject Group leader, OLEKSYN (Poland) became chairman of the S2.02—18 Working Party with D. PIRAGS (Latvia) and E. G. STÅHL (Sweden) as co-chairmen, all four of them co-authors of the "Genetics of Scots Pine" monograph.

Value of Joint Evaluations

The whole purpose of IUFRO experiments was to provide the possibility for mutual presentation of results from various geographic conditions. Now we wish to present a few examples of the value of joint evaluations when they were performed. It is sad that so much effort went establishing joint experiments and so little following them up with joint reports.

Evaluation of provenances

The main purpose of joint provenance experiments was to compare their performance under various site condi-

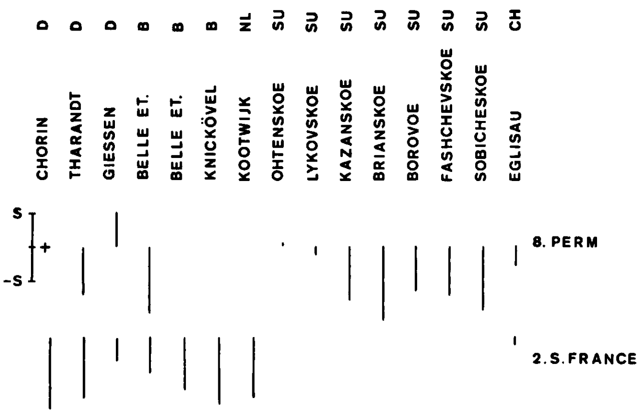

Figure 2. — Latest volume per hectare for provenances 8. Perm and 2. S. France from the IUFRO 1907 and related trials at various locations in units of standard deviation from location means. The data was derived from DITTMAR, 1991 (loc. 1), KOMMERT et al., 1989 (loc. 2), ECKSTEIN, 1973 (loc. 3), NANSON, 1967 (loc. 4—6), SOEST, 1952 (loc. 9), GIERTYCH and OLEKSYN, 1981 (Russian trials), KALELA, 1937/38 (Eglisau).

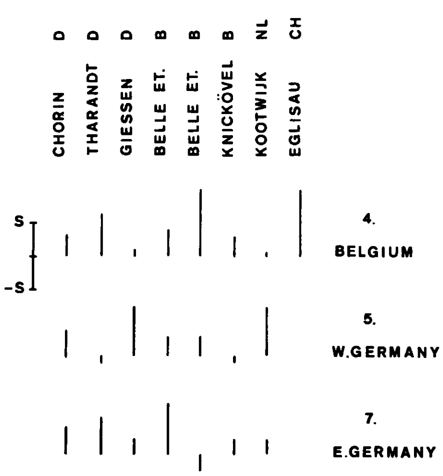

Figure 3. — Latest volume per hectare for provenances 4. Belgium, 5. W. Germany and 7. E. Germany from the IUFRO 1907 trial at various locations in units of standard deviation from the location mean. The origin of data as in fig. 2.

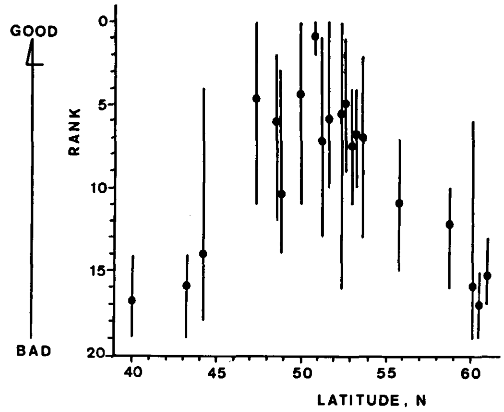

Figure 4. — Relation between latitude and rank of tree height of 1—9 years old Scots pine provenances of the IUFRO 1982 series averaged for 7 locations and with range of scatter from maximum to minimum.

tions. We need productive and adaptable populations performing well on most sites. How can we identify them? Lacking simultaneous measurements, one way of presenting results is to normalize them, presenting only deviations from the plantation averages in units of standard deviation. In this manner, regardless of the age of the last measurement, it is possible to show that some provenances are universally useless, as can be demonstrated by volume per hectare production by provenance No. 8 Perm or No. 2 S. France from the 1907 trials (Fig. 2), while others (No. 4 Belgium, No. 5 W. Germany and No. 7 E. Germany) are mostly high volume producers (Fig. 3). Volume per unit area depends not only on tree size but even more on mortality, which depends on how alien the population is in a given environment. In Fig. 3, it is possible to see that local provenances have an advantage. The conclusions are easy when there is agreement between locations. For growth, however, this is rarely the case.

The latest tree height measurements from the IUFRO 1982 trial averaged over 8 locations are presented in Fig. 4. It can be seen that populations from the central part of the European range of Scots pine are superior to both northern and southern populations.

One should particularly mention the fast growth on all plots of plants of provenance No. 13 (Ardennes, Belgium). Scots pine in Belgium is an introduced species, probably a 19th century introduction from Germany. This provenance exhibited good growth in many other European and North American provenance experiments and plantations (GIERTYCH, 1979).

Both provenances from Yugoslavia and Turkey show slow growth, even on areas located near the place of origin. Similar results were obtained in the IUFRO 1939 experiment in Turkey (SAATÇIOGLU, 1967). Height growth and volume production of provenance material moved northward from Turkey and Yugoslavia was also inferior to populations from central locations of the continuous European range of Scots pine (GIERTYCH, 1979; OLEKSYN and GIERTYCH, 1984).

With quality traits this is easier. For example, a review of the available data on stem crookedness for the provenances of the IUFRO 1938 trial has shown very good agreement among 8 locations (GIERTYCH, 1991b). Clearly we are dealing with an inherited trait that is expressed in a population sample regardless of site conditions.

A technological trait such as tracheid length is much more dependent on the environment. It has been measured at three locations of the IUFRO 1938 series, in the USA (Echols, 1958), Poland (Miler et al., 1979) and Germany (Schultze-Dewitz and Götze, 1987). The latter two neighbouring experiments have six provenances in common and the correlation between them is obvious ($r = 0.78$, signif. at $\alpha = 0.1$), whereas there is no correlation between them and the US data.

Thus evaluating traits over several experiments in different climatic conditions allows separation of genetic from environmental effects.

Relations to climate of origin

The existence of a latitudinal trend in time of growth cessation and tree growth is often related to temperature, precipitation, and day length. Wright (1976) concluded that because most of the above-mentioned environmental factors vary with latitude, even with complex statistical analysis one may not be able to prove that any one factor is most important.

An analysis of growth of Scots pine populations under test conditions usually showed poor performance of southern and northern ecotypes as can be seen by the example of height growth of plants in the IUFRO 1982 Scots Pine experiment (Fig. 4). Without a specially designed experiment it is impossible to judge whether growth differences across different locations and sites are due to photoperiod or other factors. In order to demonstrate photoperiodic ecotypes of Scots pine a special experiment using 24 provenances was established including 18 from the IUFRO 1982 Scots Pine series. The experiment simulated natural changes in day and night lengths over the course of a growing season for latitudes 50^0 and 60^0 N with compensation for quantum flux due to differences in day lengths (Oleksyn et al., 1992). A cluster analysis identified three distinct groups (Fig. 5A). In one, only northern populations from $60^0$15' to $55^0$45' appeared. Another grouped those from central and southern regions. A single population from $40^0$00'N latitude formed the third group. The geographical distribution of these cluster groups is shown in Fig. 5B. A southwestern border between the central and southern groups is also the border of the continuous natural range of Scots pine in Europe.

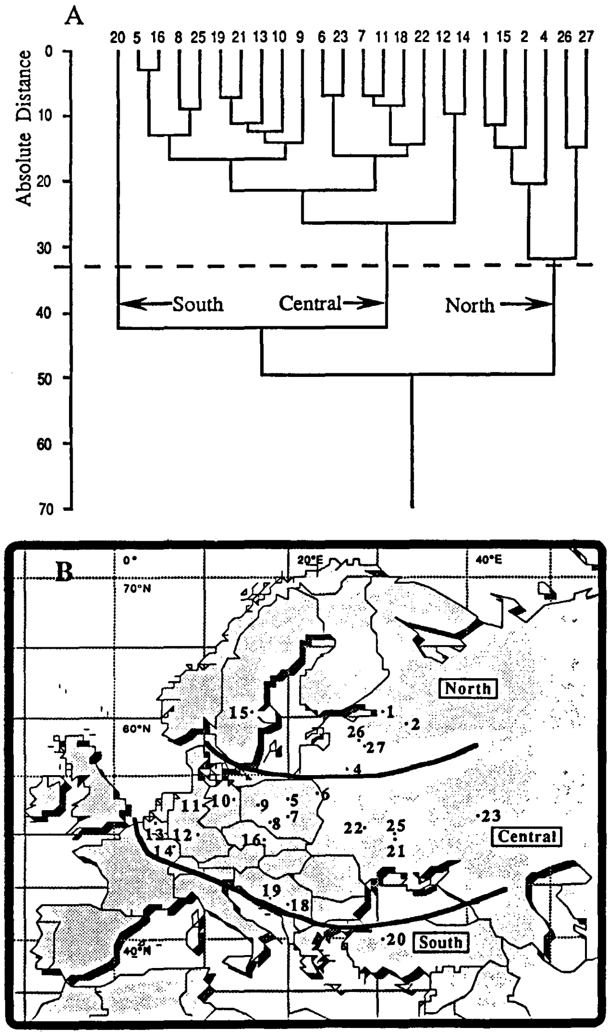

Figure 5. — A. — Dendrogram of Scots pine provenance clustering from the IUFRO 1982 series based on the similarity of first-year growth responses to simulated 50° and 60°N photoperiods.
B. — Geographic origin of seed with the northern, central and southern clusters indicated. Numbers 1—20 correspond to those in Table 5.

The presence of such cluster groups is in agreement with the existing phenotype-based taxonomic divisions of Scots pine (Pravdin, 1969; Wright, 1976; Giertych and Mátyás, 1991). In general, trees from the central provenances had less allocation of biomass to roots and more to shoots than those of northern provenances and grew larger under both photoperiods (Oleksyn et al., 1992). These findings agree with the field results in many localities (Fig. 4) and with the older IUFRO and Russian provenance experiments (Giertych, 1979; Giertych and Oleksyn, 1981).

Correlations with geographic coordinates

Heikinheimo (1954) demonstrated a negative correlation of latitude with 1000-seed weight and seedling weight from the Scots pine 1938 IUFRO collection. The correlation coefficient was —0.750 for the seed weight and between —0.818 and —0.941 for seedling fresh weight at 4 nurseries (S.Finland, Germany, Poland and Belgium). Only at the most northern nursery in Rovaniemi, Finland, was the seedling weight correlation with latitude not significant ($r = -0.367$).

For the IUFRO 1938 trial Langlet (1959) was able to demonstrate from the data of Wright and Baldwin (1957) that height of trees at age 17 in the USA is correlated with a climatic parameter of seed origin (day-length of the first day when the average mean temperature is over 6^0 C). This is effectively a negative correlation with latitude and thus the same correlation as demonstrated for seedling fresh weight.

If we look at the average tree height of the latest IUFRO 1982 trials at 8 locations in Central and Southern Europe, we can see that the correlation with latitude of seed origin is not simple (Fig. 4.). If we ignored the three southernmost provenances, we would get a regression with latitude similar to that of Langlet, who based his conclusions on the US IUFRO 1938 trial, which did not contain southern provenances. Clearly such correlations can be very misleading.

The persistence of seed weight effects can dramatically confuse practical conclusions. These effects were shown to influence seedling and tree size up to age 16 in the 1914 experiment of Busse (1931) where the effect of the age of mothers on progenies was compared. The results were reversed when genetic differences between progenies began to mask the seed weight effect, at an age of about 30 (WILUSZ and GIERTYCH, 1974).

Importance of the time factor

Eventually, the seed weight effect disappears and genetic differences determine our opinions about the value of provenances. Considering tree height alone, the only trait that can be measured throughout the life of the stand, the ranking of provenances will change with time (Fig. 6), each remeasurement leading to different conclusions. This is all the more true when one considers that practical recommendations about the utility of different provenances are based on different traits at different stages in the life of the experiment. Initially, height is the primary consideration. Later DBH or basal area are considered and finally the key factor is volume, or better still total volume produced including thinnings. Usually not all of this information is available from provenance experiments, but when it is the influence of the time factor on practical conclusions becomes obvious. The IUFRO 1907 trial at Chorin is a good example of this (Fig. 7). The split into productive and non-productive provenances was obvious early, but the top producers, even when 80 years old, are not stably ranked.

Height is often confounded by original seed weight. DBH reflects stocking and therefore mortality rather than productivity. It is only volume production per unit area per unit time that makes possible the evaluation of the true productivity of a population.

*

IUFRO Scots pine experiments serve far beyond the initial purpose of SCHWAPPACH "to test the influence of origin of pine seeds on the growth of stands". They serve forest science for years as valuable tools to address such questions as genotype-environment interactions (GIERTYCH, 1991a), resistance to frost or diseases (MAYR, 1910; DIETRICHSON, 1961; 1969) variations in anatomical structures (GEORGI, 1967), wood quality (ECHOLS, 1958; MILER et al., 1979; SCHULTZE-DEWITZ and GÖTZE, 1987), photoperiodic reactions (OLEKSYN et al., 1992), and resistance to environmental pollution (OLEKSYN, 1988; OLEKSYN et al., 1988).

It is, therefore, essential to continue caring for old experiments and exploiting them. There are many problems that can only be studied on old trees including dendroclimatology, wood properties, form factors, verification of early tests and definition of the limits of seed transfer. There are also other means of utilizing these experiments if internationally-coordinated joint evaluations can be made. The financial and intellectual investment in these experiments by far exceedes the resources needed now to maintain and utilize experiments. We recommend that an internationally sponsored team should periodically visit, measure and report on the trials for the benefit of all.

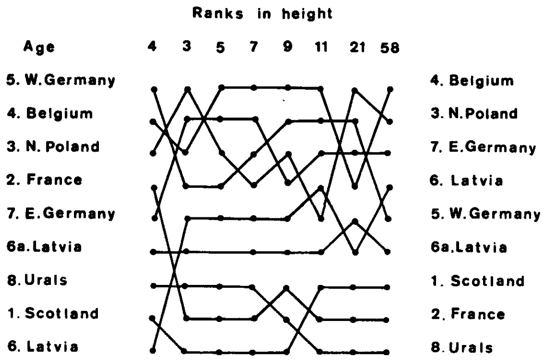

Figure 6. — Rank changes for height of pine provenances in the IUFRO 1907 trial at Belle Etoile, Belgium. Data from NANSON, 1967.

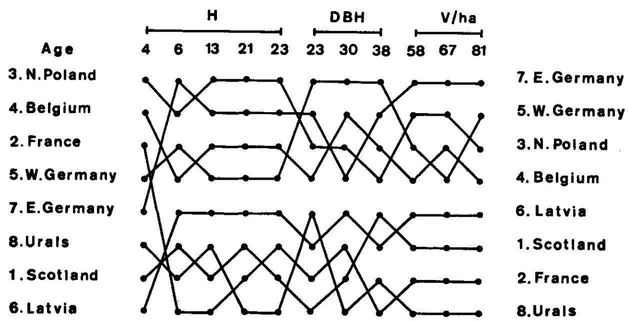

Figure 7. — Rank changes in the growth trait most important for decision-making at a given age for the IUFRO 1907 trial at Chorin, Germany. Data from MAYR, 1910; WIEDEMANN, 1930; KALELA, 1937/38; DENGLER, 1944; ERTELD, 1950; DITTMAR, 1966; 1977; 1991.

Literature

Anonym: Excursion details. Proc. 6th IUFRO Congress 1910, Brussels, Programme Détaillé pp. 44, 50—51, 114—115, 118—119 (1910). —— Anonym: Excursion details. Proc. 10th IUFRO Congress in Zürich 1948: 242—246 (1948). —— BALDWIN, H. I., ELIASON, E. J., CARLSON, D. E.: IUFRO Norway spruce provenance tests in New Hampshire and New York. Silvae Genetica 22(4): 93—114 (1973). —— BALDWIN, H. I. and PETRINI, S. H. I. B. and S. P.: The commission on Forest Seeds and Tree Race Problems of the International Union of Forest Research Organizations. Chronica Botanica 6/9: 207 (1941). —— BUSSE, J.: Einfluß des Alters der Mutterkiefer auf ihre Nachkommenschaft. Mitt. Deutsch. Dendrol. Ges. 43: 63—74 (1931). —— CRAHAY, M. N. I.: La question des semences en sylviculture. Proc. 6th IUFRO Congress, Brussels, Submitted Paper: 1—14 (1910). —— DENGLER, A.: Waldbau auf ökologischer Grundlage. Springer, Berlin, 3rd. Ed. pp. 596 (see p. 196) (1944). —— DIETRICHSON, J.: Breeding for frost resistance. Silvae Genetica 10: 172—179 (1961). —— DIETRICHSON, J.: Provenienzproblemet belyst ved studier av vekstrytme og klima. Medd. Norske Skogforsøksv. No. 71, 19 (5): 499—656 (1964). —— DIETRICHSON, J.: Provenance and resistance to Scleroderris lagerbergii Gremmen (Crumenula abietina Lagerb.). The international Scots pine experiment of 1938 at Matrand. Medd. Norske Skogsforsøksvesen 27: (6): 395—410 (1969). —— DITTMAR, O.: Zuwachsleistung und Ertrag von Durchforstung und Provenienzversuchen in Kiefernjungbeständen. Archiv f. Forstw. 15: 243—253 (1966). —— DITTMAR, O.: The results of the international pine provenance tests Chorin 85 and Finowtal 145 after a 66 resp. 36 years observation. Beiträge für die Forstwirtschaft 11(3): 116—119 + microfilm (1977). —— DITTMAR, O.: Comments on two classical long-term experimental series in the region of Eberswalde, Germany. IUFRO News 20(2): 4—5 (1991). —— ECHOLS, R. M.: Variation in tracheid length and wood density in geographic races of Scotch pine. Bull. Yale. School For. 64 (1958). —— ECKSTEIN, E.: Der internationale Kiefern-Herkunftsversuch im Forstamt Gießen. Allg. Forst. und Jagdzeitung 144 (9/10): 191—197 (1973). —— EDWARDS, M. V.: The 1938—1944 International Provenance Experiments: Report. Proc. 12th IUFRO Congress, Oxford. 1:25 (1956). —— EDWARDS, M. W. and LINES, R.: Bibliography on International provenance experiments begun in 1938. Revised to February 1970. For Comm. Res. and Dev. Pap. No. 76: 1—16 (1970). —— ERTELD, W.: Die Entwicklung einiger Kiefernprovenienzversuche im Land Brandenburg. Der Züchter 20 (3/4): 91—99 (1950). —— FISHER, R. A.: The design of experiments. Ed. 2. Oliver and Boyd Edinburgh (1937). —— GEORGI, E.: Rindenstärke als ein Herkunftsmerkmal der Kiefer (*Pinus silvestris* L.). Arch. Forstw. 16 (6—9): 673—677 (1967). —— GIERTYCH, M.: Summary of results on Scots pine (*Pinus sylvestris L.*) height growth in IUFRO provenance experiments. Silvae Genetica 28(4): 136—152 (1979). —— GIERTYCH, M.: Provenance variation in growth and phenology. In: Genetics of Scots pine. M. Giertych and C. Mátyás (eds.). Elsevier: 87—101 (1991a). —— GIERTYCH, M.: Inheritance of tree form. In: Genetics of Scots pine. M. Giertych and C. Mátyás (eds.). Elsevier: 243—254 (1991b) —— GIERTYCH, M., MÁTYÁS, C.: Genetics of Scots

Pine (Eds), Series Developments in Plant Genetics and Breeding No. 3, Elsevier, pp. 280 (1991). —— GIERTYCH, M., OLEKSYN, J.: Summary of results on Scots pine (*Pinus sylvestris* L.) volume production in Ogievskij's prerevolutionary Russian provenance experiments. Silvae Genetica 30: 56—74 (1981). —— GUINIER, P. H.: L'Organisation internationale de la récolte des semences avec garantie d'origine. Proc. 7th IUFRO Congress, Stockholm: 37—39, Summaries: 39—40 (1929). —— HEIKINHEIMO, O.: Taimitarhan maantieteellinen sijainti siemenen alkuperä ja istutuskandet. Acta For. Fenn 61(9): 1—28 (1954). —— KALELA, A.: Zur Synthese der experimentellen Untersuchungen über Klimarassen der Holzarten. Comm. Inst. For. Fenn. 26: 1—435 (1937/38). —— KOMMERT, R., LÜPKE, R., METTE, H. J.: Leistung und Qualität der Herkünfte des Tharandter Kiefernanbauversuchs 1908. Beiträge für die Forstwirtschaft 23(2): 76—78 (1989). —— LANGLET, O.: Die Entwicklung der Provenienzfrage in Schweden. Proc. 7th IUFRO Congress, Stockholm, 333—342, Summaries: 67—68 (1929). —— LANGLET, O.: A cline or not a cline — a question of Scots pine. Silvae Genet. 8: 1—36 (1959). —— LINES, R.: Standardization of methods for provenance research and testing (Report of WG meeting at Pont-à-Mousson. 1965) Proc. 14th (IUFRO Congress, München, 3: 672—718 (1967.) —— LINES, R.: Bibliography on international provenance experiments begun in 1938. For Comm. Res. and Develop. Pap. 76: 1—16 (1975). —— MATTHEWS, J. D. and CALLAHAM, R. Z.: Study of Forest Plants Sect. 22 report. Proc. 14th IUFRO Congress, Munich 10: 185—190 (1967). —— MAYR, H.: Schüttenkrankheit und Provenienz der Föhre (Kiefer). Proc. 6th IUFRO Congress, Brussels, Submitted Paper: 1—11 (1910). —— MILER, Z., MILER, A., PASTERNAK, P.: Długość włókien drewnych drewna proweniencji sosny zwyczajnej. Prace Komisji Nauk Rolniczych i Komisji Nauk Leśnych 48: 95—101 (1979). —— NANSON, A.: Contribution à l'etude de la valeur des tests précoces. II. Expérience internationale sur l orgine des graines de pin sylvestre (1906). Station de Recherches des Eaux et Forêts Groenendaal/Hoeilaart, Travaux Série E, No. 2: 1—43 (1967). —— OLEKSYN, J.: Report on the IUFRO-1982 provenance experiment on Scots pine (Pinus sylvestris L.). Arboretum Kórn. 33: 211—229 (1988). —— OLEKSYN, J., GIERTYCH, M.: Results of a 70-years-old provenance experiment with Scots pine (Pinus sylvestris L.) in Puławy, Poland. Silvae Genetica 33: 22—27 (1984). —— OLEKSYN, J., GIERTYCH, M. and RED'KO, G. I.: A new look at the Scots pine provenance experiments of V. D. Ogievskij. Lesnoi Zh. 6: 20—24 (in Russian) (1986). —— OLEKSYN, J., KAROLEWSKI, P.: RACHWAL, L.: Susceptibility of European Pinus silvestris L. populations to SO_2, NO_2, SO_2 + NO_2 and HF under laboratory and field conditions. Acta. Soc. Bot. Pol. 57(1): 107—115 (1988). —— OLEKSYN, J., TJOELKER, M. G., REICH, B. B.: Growth and biomass partitioning of populations of European Pinus sylvestris L. under simulated 50 and 60°N daylengths: evidence for photoperiodic ecotypes. New Phytol. 119: (in press) (1992). —— PICCAROLO, G.: Report from 3. Committee for seeds and races study. Proc. 10th IUFRO 1948 Congress, Zürich; 220 (1949). —— PRAVDIN, L. F.: Scots pine. Variation, Intraspecific Taxonomy and Selection. Izd. Nauka, Moskva 1964; Israel Program for Scientific Translations (1969). —— PRZYBYLSKI, T., GIERTYCH, M., BIALOBOK, S.: Genetics of Scots pine (Pinus sylvestris L.). Annales Forestales 7(3): 59—105 (1976). —— ROTH, G.: Report of the 9th IUFRO Congress, Hungary: 1—113, (see pages 61—62) (1936). —— RZEŹNIK, Z.: Scots pine (Pinus sylvestris L.) of European provenances in Supraśl forest inspectorate. Roczniki Akademii Rolniczej w Poznaniu 28: 55—67 (in Polish with English summary) (1991). —— SAATÇIOGLU, F.: Results of the 25 years provenance experiment established by using 16 Scots pine of European and 1 native provenances in Turkey. Silvae Genetica 16: 172—177 (1967). —— SCHMIDT, W.: Protokoll über die Konferenz in Kopenhagen, Januar 1940, Rundschreiben, Kommission für Forstsaatgut und Baumrassenfragen des Internationalen Verbandes Forstlicher Forschungsanstalten. Mimeo: 1—7 (after BALDWIN et al. 1973) (1940). —— SCHREIBER, M.: Zur Bedeutung der Eigenschaftsforschung bei Oekotypen unserer Wirtschaftsbaumarten mit Hinweisen auf einige Frühtestergebnisse bei Standortsrassen der Weissföhre (Pinus sylvestris L.) und Douglasie (Pseudotsuga taxifolia Britton). Forstpflanzen-Forstsamen 4: 23—29 (1966). —— SCHULTZE-DEWITZ, G., GÖTZE, H. Untersuchungen über Rindenanteil, Kernausbildung und Faserlänge an 10 Kiefernprovenienzen. Beiträge für die Forstwirtschaft 21(3): 111—114 (1987). —— VAN SOEST, J.: Herkomstonderzoek van de Groveden (Pinus sylvestris L.) Uitvoerige Verslagen 1 van het Bosbouwproefstation T. N. O., Wageningen: 1—49 (1952). —— SPEER, J.: IUFRO 1892—1972. IUFRO booklet, Ås, Norway: 1—25 (1972). —— SYRACH LARSEN, C.: Provenance testing and forest tree breeding Proc. 11th IUFRO Congress, Rome: 467—473 (1953a). —— SYRACH LARSEN, C.: Study of forest plants Section 22. Proc. from discussion at the section meeting Proc. 11th IUFRO Congress; Rome: 119—121 (1953b). —— SYRACH LARSEN, C.: Report of Section 22: Study of Forest Plants Proc. 13th IUFRO Congress, Vienna 1: 143—144 (1961). —— TOCCI, A. V.: Esperienze sulle provenienze del pino silvestre (Pinus sylvestris L.). Ann. Inst. Sperimentale per la Selvicoltura 7: 203—232 (1976). —— VEEN, B.: Report of a tour of inspection along the test areas of the International Provenance Trials with larch, pine and spruce of 1938/39 and 1944/45 and suggestions for future treatment and assessments. /Duplicated/ : 1—45 (1953a). —— VEEN, B.: Report on the test areas of the international provenance tests with larch, pine and spruce of 1938—39 and 1944—45 and suggestions for future treatment and assessments. Proc. 11th IUFRO Congress. Rome: 536—551 (1953b). —— VINCENT, G.: Evidenzführung der forstlichen Samen und Pflanzen nach ihrer Herkunft. Proc. 7th IUFRO Congress, Stockholm: 343—347. Summaries: 146—147 (1929). —— VINCENT, G.: Wie ließe sich die internationale Evidenz der Samenherkunft durchführen? Proc. 8th IUFRO Congress, Nancy: 238—254 (1932). —— WIEDEMANN, G.: Die Versuche über den Einfluß der Herkunft des Kiefernsamens. Ztsch. f. Forst. u. Jagdwesen 62: 498—522, 809—836 (1930). —— WILUSZ, W., GIERTYCH, M.: Effects of classical silviculture on the genetic quality of the progeny. Silvae Genet. 23(4): 127—130 (1974). —— WRIGHT, J. W.: Introduction to Forest Genetics. Acad. Press. New York, pp. 463 (1976). —— WRIGHT, J. W., BALDWIN, J. H.: The 1938 International Union Scots Pine provenance test in New Hampshire. Silvae Genet. 6: 2—14 (1957).

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

By P. KRUTZSCH

National Board of Forestry, Jönköping, Sweden

(Received 24th March 1992)

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 northeastern 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