Everett J. Eliason 1901-1973

EVERETT J. ELIASON, retired Head of the Forestry Research Unit in the New York State Conservation Department (U.S.A.) died on May 26, 1973, after being stricken with a fatal heart attack while working in his pine plantation near Saratoga Springs, New York.

ELIASON was born in Centerville, State of Indiana, March 1, 1901, received a forestry degree from Purdue University in 1923, and a Master of Science, Pathology, from the New York State College of Forestry at Syracuse, New York in 1925. He studied at Stockholm, Sweden, in 1927—28 as an American-Scandinavian Foundation Fellow. The following year he joined the New York Conservation Department and held the position, successively, of Forest Pathologist, Superintendent of Tree Nurseries and Head of the Research Unit before retiring in 1969.

In 1940, as a Reserve Officer in the U. S. Army he was called into active military service, from which he returned to the Conservation Department in 1946. In his military career he achieved the rank of Lieutenant-Colonel.

ELIASON is credited with the introduction of modernized seed procurement, extraction, testing and storage procedures at the New York State Forest Nurseries; overseeing the propagation of planting stock used in the experimental planting projects of the Department, many of which were in collaboration with the International Union of Forest Research Organizations; and being largely responsible for the establishment of the "Tree Orchard" program in New York. He became a charter member of the Northeastern Forest Tree Improvement Conference at its initial meeting in Williamstown, Massachusetts in 1953, and remained an active participant and strong supporter of the organization up to and following his retirement. From this he developed a vigorous interest in forest genetics, generally, and in the "Tree Orchard" system, specifically, all of which was reflected in his later publications and attendance at research meetings, both in the U.S.A. and abroad. In addition to presenting projects at a number of these meetings, he was frequently called upon for informal showings of slides, which were very well received.

During his career ELIASON authored or co-authored some 60 publications, in such journals as Phytopathology, *Silvae* Genetica, Journal of Forestry, Zeitschrift für Forstgenetik und Forstpflanzenzüchtung, and Proceedings of the World Consultation *of* Forest Genetics *and* Tree Irnprovernent (Stockholm, Sweden). In 1942 he collaborated in the revision of TOUMEY and KORSTIAN'S "Seeding and Planting in the Practice of Forestry", and the year before his retirement co-authored a definitive article on "Forestry Tree Nursery in the United States".

Those who worked closely with ELIASON will remember him, not only for his professional accomplishments, but equally for his humor, common-sense, and personality. His warm presence will be sorely missed at professional gatherings and in the hearts of his family and friends.

EDWARD W. LITTLEFIELD

Port Charlotte, Florida U.S.A.

IUFRO Norway Spruce Provenance Tests in New Hampshire and New York

By HENRY I. BALDWIN[1]), EVERETT J. ELIASON[2]), and DONALD E. CARLSON[3])

The Natural Range of Norway Spruce

Norway spruce (Picea abies) occurs naturally in parts of Central and Northern Europe from 42^0 to 69^0 N latitude and from sea level to 2100 m elevation. WAHLGREN (1922) concluded that Norway spruce had never occurred naturally in most of France, Spain, Britain, Belgium, Holland, northwest Germany, Denmark and Western Norway. The boundary in eastern Europe is hard to deterrnine because P. abies blends with P. obovata south of the White Sea and east to the Volga (KIELLANDER, 1958). Spruce is believed to have invaded Sweden from the east via Finland and according to HESSELMAN and SCHOTTE (1906) did not occur naturally in south-western Sweden.

DENGLER'S exhaustive study (DENGLER, 1912) of historical records far back in the Middle Ages, supplemented by extensive travel and field investigations caused him to conclude that Norway spruce was adapted to a cool continental climate and was also limited by precipitation. The boundary of natural distribution proposed by him followed closely the 600 mm isohyet. Norway spruce was thus excluded from the dry areas of North Germany.

DENGLER'S map covered only northern and central Germany. RUBNER (1924,1934,1953)published maps of the entire range of Picea abies agreeing in general with DENGLER. RUBNER showed the northern limit in Germany as a line running just west of Nuremberg, eastward to Looz, then south of Warsaw, and west of Brest to Danzig, whence it crossed the Baltic to southern Sweden. The western and southern boundary ran from Strassburg to Zürich, south to Geneva, then east to the Balkans. Considerable areas of non-occurrence were delineated around Prag, Brunn, Budapest and Bukarest (RUBNER, 1934, p. 340, Figure 85). In a later work (RUBNER, 1956) he proposed three main zones of occurrence of Norway spruce:

I Alpine — Meridional
II Central (Hercynien — Carpathians)
III Baltic, Northern and Western

These regions were separated by areas of no natural Picea such as the valleys of the Danube, Vistula and Bug, and it was suggested that Norway spruce may have developed characteristic traits in these isolated areas. GATHY (1960), however, contended that RUBNER'S pattern of three large zones was not justified. He concluded that the "distribution area of spruce is single and continuous".

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[2]) Mr. ELIASON died 26 May 1973.

[3]) Forester, Forest Research Unit, New York Conservation Department, Albany, NY.

Variation in Norway Spruce

Differences between individual trees as well as stands were noted by the earliest observers. The behaviour of seed was a popular field for research. The length of seed and seed wing, seed colour and seed weight was observed to differ with provenance. Kienitz (1879) noted that Norway spruce seed from higher altitudes germinated better at 7 degrees C than at 19 degrees C, while lowland sources required higher temperatures.

The diversity of crown form and branch habit was especially striking and the subject of numerous investigations, among which may be mentioned that of Rubner and Klemm (1937).

Langlet (1938) demonstrated that Norway spruce from different temperature zones exhibited variability in height growth, dry matter and sugar content in autumn and winter, and in reaction to climatic extremes. Spruce was less sensitive than Scots pine when moved from south to north, but possibly more sensitive to southward movement. In support of the latter idea, Langlet noted the slow progress of natural colonization of warmer areas by spruce.

Langlet (1962) reviewing the pioneering contributions of Cieslar and Engler, suggested that the outmoded term "climatic race" might still be applicable to Norway spruce. While spruce forms clines from south to north and from low to high altitudes, it is "minutely adapted also to the local habitat", having acquired this adaptation "because of its great sensitivity to locally-varying, late spring frosts". He proposed the term "ecological variability" as preferable to "ecotypic variability" (Turesson, 1930) which should be used only when a step-like cline or real discontinuity has been proven (see also Langlet, 1963 c).

Kiellander (1956) concluded that in Norway spruce time of flushing in spring was little influenced by environment but was under strong genetic control, while rate of growth was largely affected by environmental factors. Mergen (1960) found that 56 percent of the variation in flushing and 73 percent of the variation in rooting response was under genetic control.

Evidence of individual as well as geographic variation has also been shown by experiments with altered photoperiod. Vaartaja (1959) noted that normal seasonal shoot elongation was completely altered by a change in photoperiod; the greatest individual variation occurred at certain critical day lengths. Sources from the far north showed greatest response to variation in photoperiod. Holzer (1962) compared the effects of altitude and photoperiod. High altitude provenances produced shorter and less strong shoots at a 16 hour photoperiod than sources from medium altitudes.

Provenance Tests with Norway Spruce in Europe

Langlet (1938, 1960, 1962) pointed out that the classical work of Cieslar (1895, 1899, 1907) followed by Engler (1905, 1908, 1913) deserves better recognition. The provenance tests sponsored by the International Union of Research Organisations (hereinafter termed IUFRO) have been supplemented by extensive trials of very large numbers of sources, especially in Sweden. The results that have been published have confirmed the findings of Cieslar and Engler and the modern view of variation in *Picea abies* follows quite closely their conclusions, namely, that in most parts of its range variation is distinctly local within short distances and influenced by the microclimate determined in turn by local topography.

Confirmation of the pioneer research has increased rapidly. Baldwin (1949), working on the 1938 IUFRO series in United States, measured heights in the autumn of 1948 and found the best growth in Central European sources. Damage by *Pissodes strobi* was severe. Langlet (1953) gave results of preliminary measurements of IUFRO plots in southern Sweden. Central and southern European sources were superior in growth. A strong correlation was found between branch length at breast height and stem volume. Vincent and Flek (1953) in Czechoslovakia found positive correlations between height and diameter, total height and current height growth. Needle length varied inversely with altitude. Their plots planted at a spacing of 1.5×1.5 m in 1942 and 1943 were measured in 1945 and 1949. They concluded that Norway spruce from origins 2 degrees in latitude south of the planting site could be planted safely in the Beskyd Range in Czechoslovakia. Edwards (1955) in Scotland found Czechoslovakian provenances from the Carpathians were the tallest at 2 years.

Rubner (1957) reported 20-year results from field tests in Thuringia and Saxony. Sources from Partenkirchen and East Prussia showed superior growth. Bouvarel and Lemoine (1957) found that sources from the same latitude as their plots at Amance, near Nancy, France, grew best, while Balkan and Scandinavian provenances made poor growth. Rohmeder (1959) reported the superiority of Central European sources over those from southern Sweden. Rubner's 1936 collection showed East Prussia and Garmisch to be superior.

A thorough analysis of IUFRO Norway spruce provenance plantations in Sweden was made by Langlet (1960) who measured the trees at 19 years of age. He stressed the importance of early and late bud formation and termination of growth in relation to frost injury. He concluded that early leafing out or flushing was related to spring frost damage, and that the date of completing growth in autumn was related to frost injury and winter-killing. Day length appeared of little importance, opening of buds being controlled by temperature. As older workers had observed, early and late flushing trees were found in the same stand, and early and late provenances in the same region. He postulated that spruce has become adjusted to narrowly localized temperature pockets. Time of leafing out (or flushing) in spring evidently has an important survival value. The earliest provenances were those from the far north and from high altitudes. The latest to leaf out were from continental areas of eastern Europe, north of the Carpathians.

Langlet compared the performance of the same provenances planted on northern and southern sites in Sweden, and reached several conclusions:

1) All provenances grew slower in colder regions and faster in warmer regions.
2) Provenances from warmer climates when moved northwards reacted with greater growth changes than those from colder climates when moved southwards.
3) Northern provenances moved to the south grew as fast as in their native area in spite of the shorter photoperiod in the south.
4) Stem form was related to provenance.
5) Volume and value production continued to be greater in those individual trees and provenances that showed promise in early life.
6) Hardiness was the most important character since good growth can be of little value if the trees are not healthy.
7) Differences in heights among provenances were similar on different sites.
8) Northern provenances produced the shortest trees.
9) Southern provenances from the same latitude exhibited more variation in height than northern ones from about the same latitude.

Gathy (1960) used the means of 10 dominant trees of each provenance in a comparison of heights in 1946, 1954, and 1957 of IUFRO plots in Belgium. Sources from Stolpce, Istebna and Crucea were rated superior to Pförten taken as the standard. Provenance 21 Vadul Rau, Roumania and 35 Radom, Poland were equal to Pförten or rated as fair, while all others were inferior. He concluded that dates of flushing and height growth varied clinally from northern Sweden to southern Russia.

Vins (1963), working in Czechoslovakia, used diameter to compare different provenances. He found that mean diameter varied from 2.5 to 4.2 cms. Differences among sources decreased with increasing age. Larger differences were observed on poor soils and in harsh climates than on more favourable sites. Needles of trees of northern provenances were shorter and flatter than the needles of southern provenances. Vins concluded that the test plots in Czechoslovakia were located in an optimum region for Norway spruce. Provenances from north of the planting site and southern provenances from above 900 m were inferior in growth to local sources. Holst (1963) compared results of IUFRO and other provenance tests in Canada and USA.

Langlet (1963 b) prepared a summary for the World Consultation on Forest Genetics and Tree Improvement at Stockholm of the preliminary results of IUFRO tests in Sweden (Langlet, 1963 b). Measurements of height were compared with those at 14 and 19 years and this confirmed the observation of Vins (op. cit) that differences among provenances tend to lessen with increasing age. Langlet concluded that height was no longer a reliable measure of the value of a source and took yield in m^3 per hectare as the best measure. This was strongly correlated with 14 and 19 year heights ($r = .87$ and $.89$ respectively). As in earlier assessments (Langlet, 1953) the central European sources were superior in yield.

European workers have put great emphasis on dates of flushing and termination of growth because of the danger of frost damage. In a paper presented at the World Consultation on Forest Genetics, Langlet (1963 a) cited IUFRO experiments confirming the hypothesis that seeds of Norway spruce can be planted in regions far from their source without risk, provided the times of flushing and growth termination are in harmony with the climate of the planting site. Furthermore, he concluded that the time of flushing was not the determining factor in hardiness, but rather the time of growth cessation and the onset of dormancy. Stands of foreign origin frequently outgrow local sources in Sweden.

Since this paper was written many additional reports have been published, which unfortunately cannot be included here.

Provenance Tests of Norway Spruce in United States

In New York State Norway spruce has been used in reforestation since 1902.[4]) Special seed collections were made from the better local stands and individual trees of Norway spruce starting in 1930 and these trees were planted in experimental areas throughout the state. Since the source of the mother trees was generally unknown, the first provenance tests is taken to begin with the IUFRO seed of 1938. This and other seed was provided by Baldwin in the spring of 1938.

While Norway spruce was used extensively for reforestation in New Hampshire from about 1910 the first provenance tests were established by Baldwin on the Fox State Forest in 1936. The next series was planted in 1940, one block at the Vincent State Forest and three blocks at the Fox Forest. This was followed by one block planted in 1941 at the Vincent State Forest. The IUFRO plantings of 1942 occupied two large blocks on the same site. In one of these

[4]) Baldwin brought known Swedish provenances to New York in 1924.

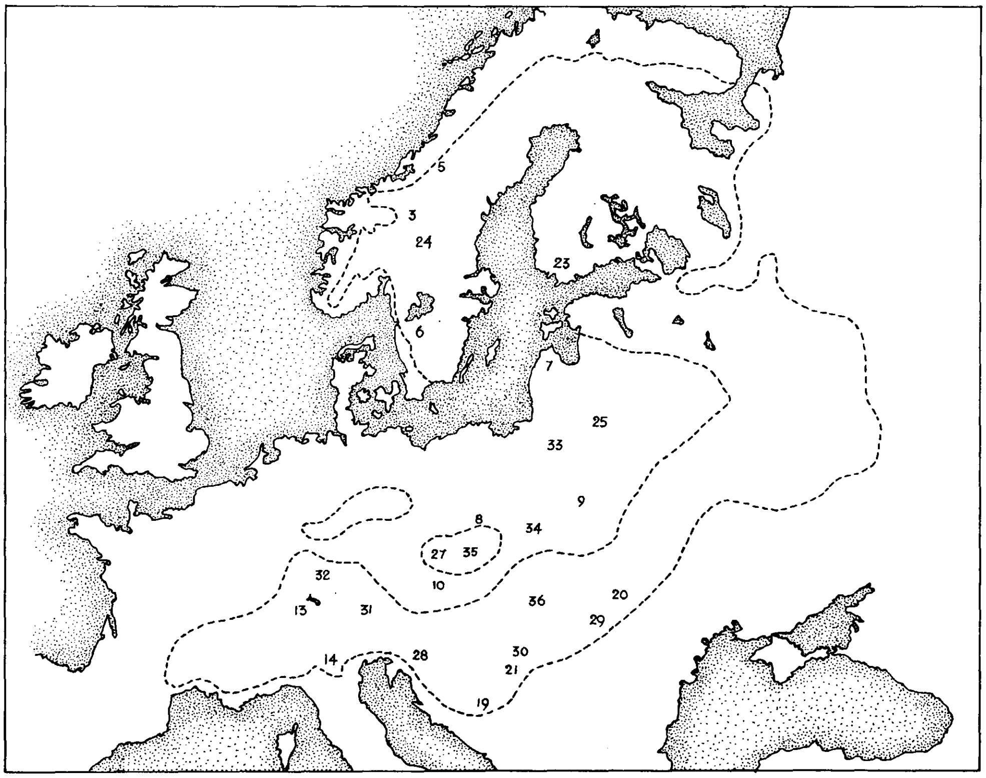

Fig. 1. — Natural range of *Picea abies* (L.) Karst. and Location of IUFRO Provenances, 1938.

16 non-IUFRO sources were included. All these plantations were assessed in 1948 and October 1962. Maps of all the plots were published by BALDWIN (1965).

Samples of IUFRO seed sent by BALDWIN, reinforced by other provenances procured elsewhere, were planted in Michigan and preliminary results reported by SLABAUGH and RUDOLF (1957) and RUDOLF and SLABAUGH (1958). A small number of IUFRO sources from seeds supplied by BALDWIN were planted at the Harvard Forest in Petersham, Mass. These were measured by MURISON in 1961 and the results reported by HOLST (1963).

The Collection of Seed Samples: Cones for the IUFRO international programme test were collected in the fall of 1937 (see *Figure 1)* and extracted and cleaned at Eberswalde, Germany, under the supervision of Professor Dr. WERNER SCHMIDT. The other (non IUFRO) samples were extracted and cleaned at several places. The IUFRO seeds were received at the Fox Research Forest in the spring of 1938 and divided into smaller lots which were distributed to other organisations in the USA as reported by BALDWIN (1953) (see *Table 1).* This unfortunately resulted in too few plants for adequate replications in New Hampshire but the plantings made in New York by the Conservation Department were well-cared for and the results of their measurement in 1962 formed an excellent check on the New Hampshire measurements. Seeds other than IUFRO samples were received partly from foreign experiment stations, foreign foresters and scientists and from seed dealers. Source data from some of the last-named were scanty and not reliable.

Provenances used in the American Experiments: Lists of the *Picea abies* provenances available for testing are given in *Tables 2 and 3.* The New Hampshire plantings lacked IUFRO No 33, but included two plots of Black Hills spruce *(Picea glauca* var. *albertiana)* and one plot of Engelmann spruce *(Picea engelmannii).* The latter two species were inferior in growth to *Picea abies.* The New York plantations lacked IUFRO Nos 3 and 5 which were not planted because the trees were too small. Three non-IUFRO lots from New York stock, not available in New Hampshire, were also planted.

Seed Testing: Upon receipt of the seed by the New York Conservation Department germination tests were made in the laboratory at the Saratoga Nursery by C. E. HEIT using

Table 1. — Distribution of Norway Spruce *(Picea abies)* Seed Samples from Fox Research Forest May 1938

Agency Receiving Seeds	Number of Seed Sources Sent IUFRO*)	Other	Total
New York Conservation Dept.	27	8	35
Harvard Forest	14	—	14
Vermont Forest Service	24	7	31
Connecticut Forest Service	9	3	12
Massachusetts Conservation Dept.	18	1	19
Lake States Forest Experiment Station	12	—	12
Fox Research Forest	25	32	57

*) Seed samples received from International Union of Forest Research Organisations.

Table 2. — IUFRO Provenances of Norway Spruce in Order of Latitude, Planted in New Hampshire and New York Plantations 1942

IUFRO No.	Place	Country	District	Lat. N.	Long. E.	Altitude M.
5	Foldsfoss	Norway	Trøndelag	63° 58'	11° 4'	80
3	Tyldal	Norway	Hedmark	62° 4'	10° 55'	550
24	Åsnes	Norway	Hedmark	60° 32'	12° 11'	180
23	Bromary	Finland	Uusimaa	60° 3'	23° 6'	15
7	Vecmoka	USSR (Ex-Latvia)	Uusimaa	57° 3'	23° 10'	80
6	Drängsered	Sweden	Halland	57° 00'	13° 00'	165
25	Griva	USSR (Ex-Latvia)	Halland	55° 58'	26° 15'	160
33	Wilmo	USSR (Ex-Poland)	White Russia	54° 40'	25° 15'	160
9	Stolpce	USSR (Ex-Poland)	White Russia	53° 28'	26° 43'	170
34	Bialowiecza	Poland	Bialystok	52° 52'	23° 47'	180
8	Pförten*)	Poland (Ex-Germany)	Slask-Dolny	51° 47'	14° 46'	70
35	Radom*)	Poland	Kielce	51° 25'	21° 10'	155
10	Istebna	Poland	Krakow	49° 35'	18° 58'	620
27	Svinosice*)	Czechoslovakia	Mähren	49° 20'	16° 30'	350
36	Dolina	USSR (Ex-Poland)	Ukraine	49° 00'	24° 00'	500
32	St. Blasien	Germany	Baden	47° 45'	8° 10'	1100
13	Winterthur	Switzerland	Canton Zürich	47° 31'	8° 43'	500
31	Garmisch	Germany	Bavaria	47° 30'	11° 10'	750
20	Crucea	Roumania	Neant	47° 21'	25° 40'	720
30	Valea Bistrei	Roumania	Torda-Aranyos	46° 25'	23° 10'	950
29	Muntele	Roumania	Csik	46° 21'	25° 50'	1100
28	Pokljuka	Jugoslavia	Slovenia	46° 20'	14° 00'	1200
14A	Val di Fiemme I	Italy	Trento	46° 16'	11° 20'	1300
14	Val di Fiemme II	Italy	Trento	46° 15'	11° 30'	1100
21	Vadul Rau	Roumania	Szoreny	45° 10'	22° 20'	1050
19	Sarajevo	Jugoslavia	Bosnia	43° 10°	18° 25'	1200

*) Planted stands of unknown origin,
"Ex" indicates name of country at time of seed distribution.

Table 3. — Norway Spruce Provenances other than IUFRO, in Order of Latitude, Planted in New Hampshire and New York Plantations 1942

Seed Lot No. (Fox)	(N. Y.)	Country	Place of Origin	Lat. N.°	Long. E.°	Alt. M.	Seed Supplied By	Date
1	Fox	Finland	Southeastern Part	60° 30'	29°	—	Jarl Lindfors Helsinki	1933
139	Fox	Finland	not given	—	—	—	Dealer	1936
242	Fox	USSR Ex Esthonia	Tartu, Jagen 90	58° 20'	27	Low	Elmer Kahh	
159	Fox	USSR Ex East Prussia	Rudezanny, Masuren Tree 5	55	—	—	Prof. Dr. Werner Schmidt	1936
247	Fox	Belgium	Groendael	55	4	—	Dr. Delevoy	1937
158	Fox	Germany	Wiesbaden	50	5	Low	Prof. Dr. Werner Schmidt	1936
5	Fox	Czechoslovakia	not given	49	37	700	Prof. J. Konsel	1934
6	Fox	Czechoslovakia	not given	49	31	700	Prof. J. Konsel	1934
234	Fox	Hungary	not given	48	—	—	Dr. Zoltan Meyer	1937
258	Fox	Austria	Kematen-Inzing, Tyrol	47° 16'*)	28° 55'*)	700	Dr. D. H. Schmied	1937
257	Fox	Austria	Leutasch, Tyrol	47° 22'*)	28° 55'*)	1100	Dr. D. H. Schmied	1937
E 856	NY	Switzerland	not given	—	—	1200 1400	Dealer	
E 877	NY	Switzerland	not given	—	—	1400 1500	Dealer	
SL 38 (5848)	NY	Germany	Black Forest	—	—	—	Dealer	
3	Fox	Italy	Val di Fiemme, Trento	46° 30'	11° 30'	1000	G. Valconover	1934
150	Fox	Jugoslavia	Suma (Zagreb)	45	16	—	Dr. Peter Georgevitsch	1937

*) Longitude east of Ferro.
The New York numbers were not planted in New Hampshire. The others were planted in plots mingled with IUFRO plots in Block I, New Hampshire.

the Jacobsen germinator. Purity and weights of 1,000 seed were also determined (see *Tables 4 and 5* and also *Figure 12* which compares German and C. E. Heit's data on the weight of 1,000 seed).

Nursery Practice: Each lot was sown in New York as one plot of 0.9 × 1.2 metres (3 × 4 feet) distributed in drills across seedbeds 1.2 metres (4 feet) wide as shown in *Figure 2*. In autumn 1938 and 1939, the heights of representative samples of seedlings were measured. In 1940, the stock was transplanted and in autumn 1941, the height of the 4-year

Table 4. — 1000-Seed Weights and Heights of IUFRO Provenances in New York Nursery

IUFRO No.	Source	1000-Seed weight (gms.)	Average of Seedlings 1—0 (cms)	2—0 (cms)	2—2 (cms)
5	Foldsfoss	5.65	1.85	8.2	14.0
3	Tyldal	5.20	1.65	5.1	—
24	Åsnes	5.76	1.75	9.8	17.8
23	Bromarv	5.59	2.15	9.2	16.4
7	Vecmoka	6.94	3.30	14.9	21.5
6	Drängsered	5.68	2.25	14.3	22.8
25	Griva	6.65	2.65	14.0	23.2
33	Wilmo	7.63	3.15	14.0	23.7
9	Stolpce	6.83	3.30	17.1	22.6
34	Bialowiecza	7.40	3.00	16.5	25.5
8	Pförten	8.33	3.85	17.1	26.9
35	Radom	7.02	3.25	11.0	27.5
10	Istebna	8.77	3.50	14.9	25.8
27	Svinosice	8.63	3.40	14.0	24.6
36	Dolina	7.12	2.65	14.0	25.1
32	St. Blasien	7.43	2.35	11.0	23.7
13	Winterthur	8.90	3.45	18.0	26.1
31	Garmisch	8.83	2.80	14.3	24.0
20	Crucea	7.76	3.55	19.0	25.5
30	Valea Bistrei	7.72	3.40	16.0	30.7
29	Muntele	8.13	2.75	15.3	23.8
28	Pokljuka	7.74	2.45	13.7	22.7
14	Val di Fiemme I	7.17	3.25	18.0	25.2
14A	Val di Fiemme II	7.81	3.10	18.6	23.7
21	Fadul Rau	10.09	4.35	18.6	29.0
19	Sarajevo	7.56	2.90	15.3	23.3

Table 5. — Seed Weights and Nursery Measurements of Non-IUFRO Provenances in New York Nursery

Seed Lot	Source	1000 seed weight (gms)	Average Height of Seedlings 1—0 (cms)	2—0 (cms)	2—2 (cms)
F-159	E. Prussia	9.15	3.60	20.1	32.2
F-247	Belgium	8.38	3.15	19.5	28.8
F-158	Wiesbaden	9.67	3.95	16.7	30.5
F-234	Hungary	8.33	3.70	15.8	23.3
F-258	Kematen-Inzing	7.57	3.35	19.5	33.5
F-257	Leutasch	8.18	3.35	16.6	27.3
E-876	Switzerland	6.69	2.30	11.3	22.4
E-877	Switzerland	7.72	2.65	11.3	25.4
SL-38	Black Forest	—	3.20	18.4	34.2
F-150	Jugoslavia	8.33	2.30	15.2	24.4

Fig. 2. — Seedbed at Saratoga Nursery, 1940. 2—0 seedlings of IUFRO nos. 2, 3, 5, 6, 7, 8.

(2 + 2) stock was again measured. Tree heights at one, two and four years appear in *Tables 4 and 5*. In spring 1942 the trees were lifted for planting.

All seeds were sown in May 1938 in the Fox Research Forest Nursery, New Hampshire on sifted Marlow loam mixed with sand. The seeds were in drills 10 cm apart, covered with sterile sand and protected by burlap until germination was complete. Lath screens gave overhead shade during the first season. Each lot was separated from the others by Scots pine. The two year seedlings were transplanted in 1940, each provenance again separated by Scots pine. There were no replications of the sowings. The trees were grown for two seasons in transplant beds before planting as 2 + 2 transplants.

Planting at the New York State Planting Area: All the IUFRO and Fox Forest lots (except Nos 2, 3 and 5 of the IUFRO series) plus 3 additional lots, 38, E376 and E377, which were available in the nursery, were shipped to Otsego County No 9 State Reforestation Area. This planting consisted of 34 lots with numbers of trees per provenance varying from 350 to 1050, with a mean of 730 trees. In addition to the above, C. E. Heit received 100 trees of each of the IUFRO and Fox Forest lots for planting near the Geneva State Experiment Station, Geneva, New York.

The Otsego 9 Area was a typical planting site formerly used for agriculture. The elevation is 579 metres (1,900 ft) at latitude 42⁰ 42' N, longitude 74⁰ 42' W. The soil is clay loam and well-drained with a north to northeast slope. The trees were planted in areas Nos. 40, 41 and 42 in small fields outlined by stone fences. The ground cover consisted of a thin sod, weeds and sparse grass. The high cover consisted of pin cherry *(Prunus pensylvanica)*, aspen *(Populus tremuloides)*, and alder *(Alnus rugosa)*. Certain provenances were planted in each of the three blocks. The trees were set out at 1.5 × 1.5 metres (5 × 5 ft) in long narrow bands, not replicated. The length of each band depended upon the number of trees in the lot. The planting was done from 20 to 27 April 1942 with a grub-hoe planting tool. Moisture conditions were good with frequent rains during the period. The plan appears in *Figure 3*.

Up to 1962 no specific data were collected nor was any cutting done. The plots were observed by E. W. Littlefield and the late E. J. Eliason in October, 1951 and by Dr. Jonathan Wright in July, 1954. Of the three small plots

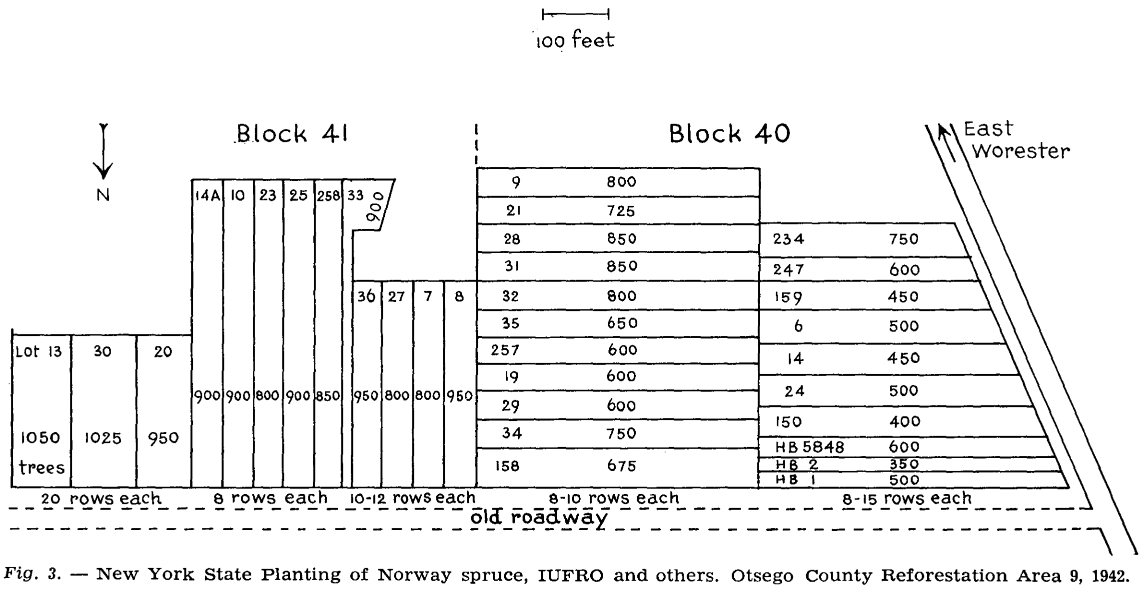

Fig. 3. — New York State Planting of Norway spruce, IUFRO and others. Otsego County Reforestation Area 9, 1942.

Table 6. — Heights of IUFRO Norway Spruce 12 Years from Seed at Geneva, New York, Ranked in Descending Order of Height (Data of C. E. Heit)

IUFRO No.	Mean Height Metres	Feet
27	5.8	1.77
30	5.2	1.58
28	4.9	1.49
31	4.9	1.49
34	4.8	1.46
6	4.7	1.43
36	4.7	1.43
25	4.5	1.37
35	4.5	1.37
21	4.3	1.31
8	4.1	1.25
20	4.1	1.25
32	4.0	1.22
13	3.9	1.19
9	3.8	1.16
7	3.4	1.04
14A	3.4	1.04
2	3.2	0.98
19	3.0	0.91
5	2.5	0.76
3	2.2	0.67

planted by C. E. Heit, near Geneva, New York, one plot survived a fire, and he reported the mean heights at the end of 12 growing seasons from seed. The data appear in *Table 6.*

Planting at the New Hampshire Planting Site: The trees were planted on the same site as the IUFRO Scots pine experiment reported by Wright ad Baldwin (1957) and the soil was identical with that described for Vincent State Forest. This is located in Deering, New Hampshire, on a level hilltop at an elevation of 335 m (1100 ft) at latitude 43° 7' N, longitude 71° 48' W. The site was once cultivated, had been cut for hay and then used as pasture. Besides various grasses, there were shrubs such as juniper *(Juniperus communis* L.), steeplebush *(Spirea tomentosa* L.), blueberry *(Vaccinium* spp.) and others. Small trees of gray birch *(Betula populifolia* Marsh.), white pine *(Pinus strobus* L.) and aspen *(Populus tremuloides* L.) occurred as scattered saplings. The soil was Paxton loam with a brown podsolic profile modified by early cultivation. A suggestion of an A_2 layer had formed by 1962. At a depth varying from 40—75 cms (16 to 30 inches) an almost impenetrable pan was encountered consisting of a compacted gray platy glacial till.

Plantation Layout: The plan proposed by Professor Schmidt (1940) called for extensive use of "standards" or trees from the same seed lot to check on site differences through the blocks. Each block was to be surrounded on two sides by 8 rows of the "standard" and also include 4 standard plots. Each plot was to contain 13 × 15 trees or about 195 plants planted at 1.3 × 1.3 m (4.3 × 4.3 feet). There were to be 5 replications of each such block. Due to lack of ground and planting stock these requirements could not be met, and the New Hampshire planting was divided into two parts, separated by a forest road, the larger one designated as Block I, consisting of 1.4 ha (3.6 acres) of level land while Block II contained 1.0 ha (2.4 acres). Each area was laid out in plots 17 × 20 m (56 × 63 feet) and the provenances were randomly distributed in each portion. Six sources were replicated in Block I and two in Block II. The borders of the areas were planted with "standards" where space permitted as shown in *Figure 4.* The soil was similar in both parts. During the autumn of 1941 the site was prepared by clearing the scattered trees and bushes and ploughing furrows at 1.3 m (4.3 feet) intervals. The plots were then laid out and permanent stakes set. The trees were planted in the furrows in April and May 1942. Only one source was

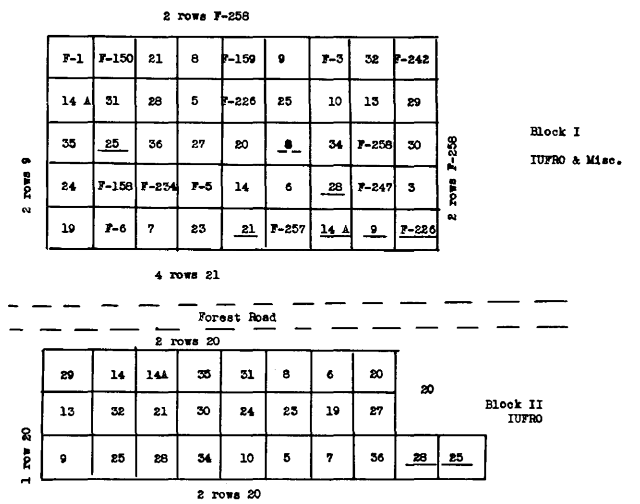

Fig. 4. — Plan of New Hampshire Spruce Plantations, Vincent State Forest, Deering, N. H. — Numbers underlined are replicates within the block. F-numbers are Fox Forest, non-IUFRO numbers.

planted at a time. The spacing was 1.3 × 1.3 m (4.3 × 4.3 feet). The planting was done by the senior author.

Interim Care: Due to World War II the plantation was not revisited until the spring of 1946 when some weeding was done. Mound-building ants *(Formica exsectoides)* had become established in some areas and ruined groups of trees. Four years after planting great variation in size of trees was evident and in later years this variation appeared to increase until the lower branches began to be killed after which the plots appeared more uniform. In 1946 white pine weevil attack was very heavy, the terminal shoot of almost every tree being killed back.

Measurements Prior to 1962: Aside from measurements in the nursery the only assessments taken in New York were those by C. E. Heit on another planting site in June 1950, 8 years from planting and 12 years from seed. These data are shown in *Figure 5 and Table 6.*

In New Hampshire during September 1948 (11 seasons after planting and 15 from seed), all plots were sampled by measuring every 5th tree for total height (Baldwin, 1949 a). These results also appear in *Figure 5.*

The 1962 Re-assessment: Following recommendations of Section 22 of IUFRO the experiments in all countries were to be re-measured in the autumn of 1962. This was done for the New York and New Hampshire plantations and the same general plan followed in both. Differences in procedure arose because the New York trees were in rows and the New Hampshire trees in plots. Details of the assessments are given for the New Hampshire experiment only.

Measurements taken in New Hampshire: The diameters at breast height of all the standing trees were measured by caliper to the nearest inch. All trees on each plot were recorded separately by rows. Data were also collected from 1500 felled sample trees:

a) Diameter over bark at 0.5 m, 1.3 m (breast height) 3.0 m and 5.0 m, measured by calipers, to nearest 1/10th inch.
b) Total height from butt to tip, in feet to nearest 1/10th foot.
c) Lengths of each of the last 5 season's terminal growth, to the nearest 1/10th foot.

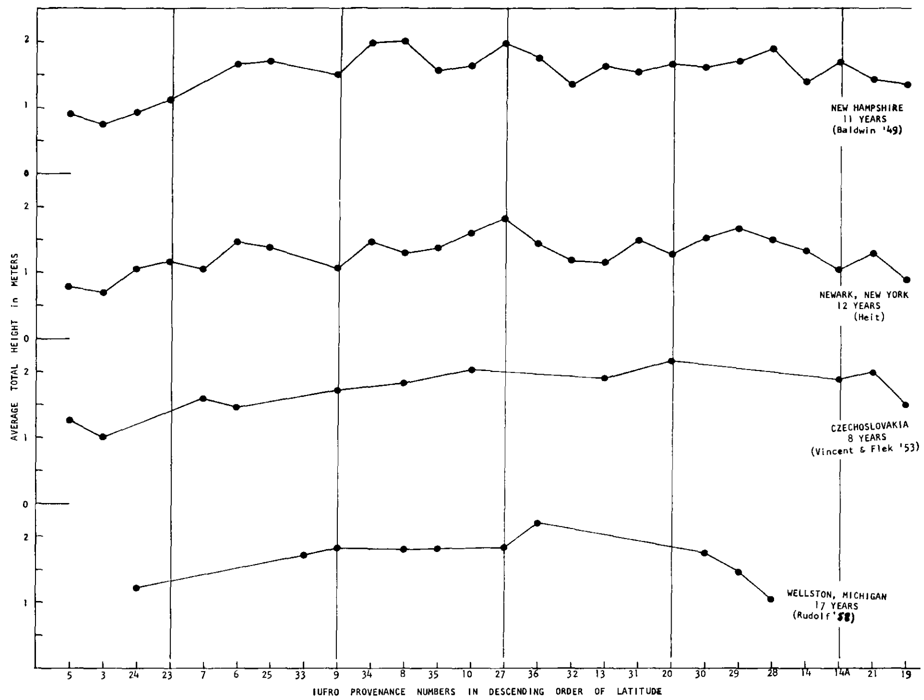

Fig. 5. — Comparison of heights of different IUFRO spruce plantations 8—17 years from seed.

d) Length of green crown to nearest foot.

e) Mean length of 10 needles in mm taken on a twig of the current year in the upper crown. One tree in 5 was sampled in New Hampshire.

f) Mean length in cm of cones on felled trees.

g) Forked stem by height of fork from the ground. Where forking occurred below breast height the group was treated as two trees.

h) Number and location of injury to terminal shoots by white pine weevil *(Pissodes strobi)*. 1962 injuries were classified as terminal or not.

i) Incidence of other insects and disease and notes of damage by squirrels and grosbeaks, crown damage by snowbreak and miscellaneous damage by deer and procupines.

j) Crown and branch characters in terms of density, branching habit, branch texture, and stem form.

We observed no evidence of frost damage and so no data were taken on the phenology of the provenances. Moreover

Table 7. — Mean Total Heights of all Sample Trees — IUFRO Provenances — at 25 Years from Seed in New Hampshire and New York (arranged in descending order of latitude)

No.	Place	New Hampshire Plantations Block I Height (feet)	No. samples	New Hampshire Plantations Block II Height (feet)	No. samples	New York Plantations Height (feet)	No. samples
5	Foldsfoss	17.01 ± 4.01	17	16.16 ± 4.34	14		
3	Tyldal	17.21 ± 4.04	18				
24	Åsnes	19.83 ± 4.02	24	19.37 ± 4.05	26	15.36 ± 3.28	49
23	Bromarv	23.23 ± 1.02	10	21.36 ± 3.53	26	21.49 ± 5.25	64
7	Vecmoka	24.63 ± 3.65	24	21.03 ± 8.49	11	21.94 ± 4.42	59
6	Drängsered	23.89 ± 5.15	26	19.38 ± 4.47	18	19.64 ± 4.65	50
25	Griva	25.61 ± 3.70	23	22.89 ± 4.04	17	21.04 ± 5.81	62
33	Wilmo					19.54 ± 5.83	59
9	Stolpce	23.68 ± 4.23	24	18.24 ± 5.50	5	19.73 ± 2.81	60
34	Bialowiecza	24.90 ± 2.57	24	20.85 ± 4.22	17	24.39 ± 5.82	59
8	Pförten	26.55 ± 4.65	22	19.87 ± 3.77	21	21.84 ± 4.62	52
35	Radom	21.12 ± 3.47	24	17.91 ± 5.63	19	21.09 ± 5.21	55
10	Istebna	22.84 ± 3.63	25	19.95 ± 4.45	16	22.63 ± 4.37	61
27	Svinosice	25.20 ± 4.34	24	20.81 ± 7.72	19	26.02 ± 4.59	59
36	Dolina	24.21 ± 5.38	27	20.28 ± 4.66	18	22.14 ± 4.95	58
32	St. Blasien	20.63 ± 4.14	24	16.49 ± 2.34	19	16.37 ± 3.04	52
13	Winterthur	22.11 ± 3.35	24	17.97 ± 3.03	15	17.01 ± 4.26	54
31	Garmisch	21.73 ± 4.06	25	18.55 ± 3.39	24	19.97 ± 4.18	55
20	Crucea	22.52 ± 3.88	24	21.86 ± 5.14	26	19.62 ± 3.70	50
30	Valea Bistrei	22.87 ± 3.90	21	21.48 ± 3.82	25	22.02 ± 6.13	52
29	Muntele	23.57 ± 4.36	20	18.44 ± 2.94	19	26.55 ± 5.41	50
28	Pokljuka	22.40 ± 3.72	21	17.51 ± 5.37	13	19.09 ± 3.80	55
14A	Val di Fiemme I	25.15 ± 3.29	22	16.19 ± 2.01	18	19.61 ± 5.52	63
14	Val di Fiemme II	22.72 ± 4.71	27	15.20 ± 3.77	26	16.29 ± 3.76	55
21	Vadul Rau	22.96 ± 3.10	20	19.60 ± 2.75	17	18.63 ± 4.11	50
19	Sarajevo	18.34 ± 4.48	22	18.89 ± 4.19	27	20.74 ± 4.51	50

Table 8. — Mean Total Heights of all Sample Trees — Non-IUFRO Provenances — at 25 Years from Seed in New Hampshire and New York

Seed Lot No.	Source	New Hampshire Plantations Height (feet)	No. samples	New York Plantations Height (feet)	No. samples
F-1	Finland	20.15 ± 3.12	11		
F-139	Finland	22.07 ± 4.02	6		
F-242	Esthonia	27.29 ± 4.18	10		
F-159	E. Prussia	21.28 ± 2.93	18	21.91 ± 5.40	56
F-247	Belgium	24.92 ± 2.81	25	21.80 ± 4.33	52
F-5	Czechoslovakia	25.37 ± 3.45	19		
F-6	Czechoslovakia	24.97 ± 3.48	23		
F-158	Germany	25.07 ± 4.01	24	21.86 ± 5.11	53
F-234	Hungary	24.48 ± 3.89	25	24.43 ± 5.08	53
F-258	Austria	23.94 ± 3.92	25	20.36 ± 4.86	56
F-257	Austria	24.59 ± 4.63	19	20.74 ± 4.97	50
E-876	Switzerland			15.31 ± 4.14	50
E-877	Switzerland			16.35 ± 5.16	48
SL-38	Germany			17.04 ± 5.36	56
F-3	Italy	20.78± 2.31	19		
F-150	Jugoslavia	19.37 ± 4.72	17	19.95 ± 5.53	50

Table 9. — Rank of IUFRO Provenances Based on Mean Total Height at 25 Years

Rank	New Hampshire Plantations Block I	Block II	New York Plantations
1	8 Pförten	25 Griva	29 Muntele
2	25 Griva	20 Crucea	27 Svinosice
3	27 Svinosice	30 Valea Bistrei	34 Bialowiecza
4	14A Val di Fiemme	23 Bromarv	10 Istebna
5	34 Bialowiecza	7 Vecmoka	36 Dolina

Table 10. — Rank of IUFRO Provenances Based on Mean Height of 10 Tallest Trees at 25 Years

Rank	New Hampshire Plantations Block I	Block II	New York Plantations
1	27 Svinosice	20 Crucea	29 Muntele
2	6 Drängsered	27 Svinosice	34 Bialowiecza
3	30 Valea Bistrei	25 Griva	27 Svinosice
4	7 Vecmoka	23 Bromarv	30 Valea Bistrei
5	14 Val di Fiemme	30 Valea Bistrei	25 Griva

no secondary or "lammas" growth was observed in the autumn, and no measurements were taken.

The results of the measurements of stem taper and volume are not reported in this paper, but are being analyzed.

Method of Measurement in New Hampshire: The field work was done during October and November 1962. During August and September two men cut branches along the plot boundaries, replaced corner stakes and painted them.

It was not possible to penetrate the plots to measure height so trees were felled on two separate rows, thus accomplishing a rudimentary thinning, and permitting detailed measurements on the felled trees. The rows felled were selected by counting in 3 rows from the east and west borders of each plot and cutting the 4th row. Since there were normally 15 rows per plot this procedure resulted in one row in seven being felled.

The intensity of sampling in the New Hampshire plots, varied from 10 to 20 percent, with an average of 14 percent in both blocks. On average 23 trees were felled and measured out of 165 trees in each plot.

Processing the Field Data: The original tally sheets of diameter and height measurements were transferred to a Plot Summary Form. The number of trees and basal area were totalled and averages computed. Final averages were then entered in a table covering (a) IUFRO sources only, (b) other sources, (c) all sources. A separate table was prepared for each block.

The diameters at breast height of all trees on felled rows were rounded to even inches, heights of "clean trees" and those of weevilled trees being kept separate. The remainder of the data was combined with that from standing trees on the same plot.

The Height Growth of Provenances

Height is used to identify differences in growth in young provenance experiments because it is relatively unaffected by stocking. But in the present case height alone was a doubtful criterion because repeated attacks of the white pine weevil had deformed the trees and reduced height. Accordingly, an attempt was made to compare the growth of undamaged trees, termed "clean trees". However, the number of such trees sampled was too few and furthermore, many large weevilled trees had greater heights than any "clean trees" on most plots.

Tables 7 and 8 summarize height data based on averages of all sample trees taken in each provenance, and the five tallest provenances are identified in *Table 9*. The ten tallest trees in each provenance represent about 20 percent of the stand and these trees probably will be included in the final crop. Therefore, it seemed logical to use the mean height of the ten tallest trees to determine the ranking of sources (see *Table 10*).

It will be noted that provenance No 27 Svinovice ranks among the highest in *Tables 9 and 10*. (It was in 6th place in Block II, *Table 9*). Furthermore, when undamaged "clean trees" only were compared this same source ranked first in both blocks in New Hampshire. When the 5 tallest trees only were averaged, No 27 ranked either first or second in all the New Hampshire and New York plantations. The same source was also first in the 14-year measurement of the independent test plantation at Geneva, New York (see *Table 6*).

Figures 6, 7 and 8 compare all provenances by the different methods for comparing total heights.

Current Height Growth of the Provenances to 1962

The annual height increment for the 5 years (1958—1962) was measured on the felled sample trees (see *Tables 12 and 13*). The totals for the 5 years and for individual years were averaged separately for "clean trees" and weevilled trees. As expected, the average growth of "clean trees" exceeded those damaged by weevil, but the number of "clean trees" was, in most cases, so small that the differences cannot be considered reliable. Furthermore, a high proportion of "clean trees" derived their freedom from weevil, at least partly, from their suppressed or crowded position in the stand. The rapidly-growing dominant trees tended to be most heavily attacked by weevil, and when 80 or more percent of the sample trees were weevilled, it seemed unwise to base comparisons among seed sources on a few non-weevilled trees. Superior current height growth was also found on both weevilled and non-weevilled trees.

Trees with a greater total height than their neighbours must have grown faster during certain 5-year periods. In order to determine if the taller trees were still growing at a rate commensurate with their height, the average 5-year terminal height growth was correlated with average total height, both being based on all sample trees. The correlation for plots in IUFRO Block I was not significant whereas in Block II and the non-IUFRO plots it was highly signifi-

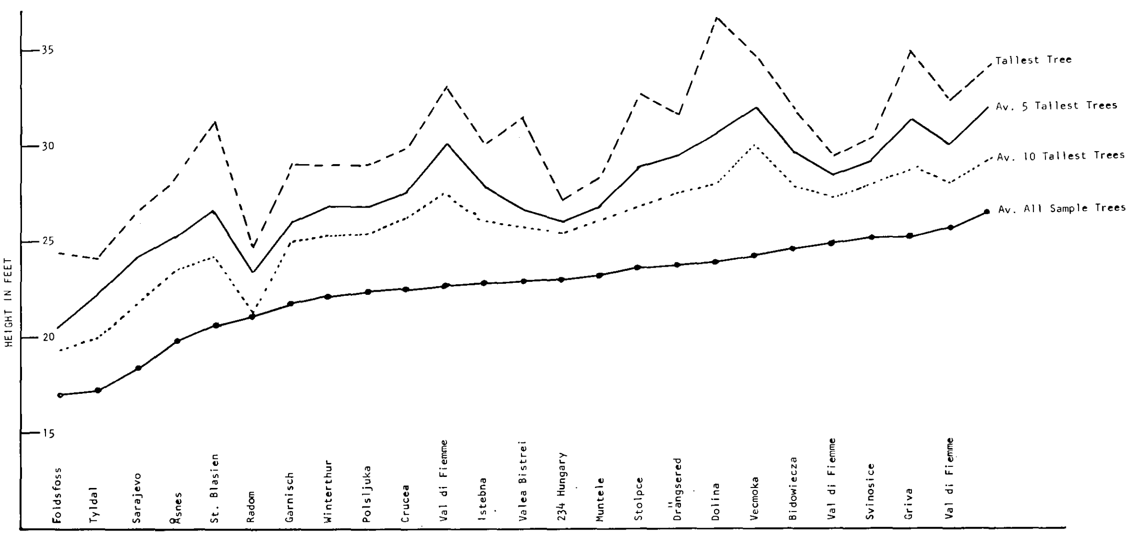

Fig. 6. — Comparison between different average heights, IUFRO block I, New Hampshire.

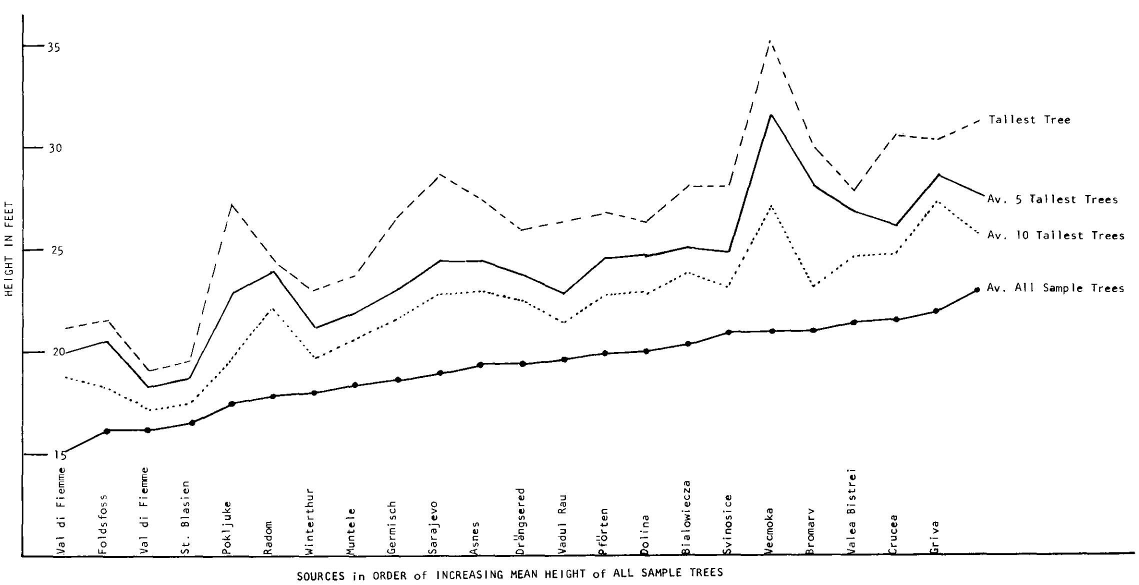

Fig. 7. — Comparison between different average heights, IUFRO block II, New Hampshire.

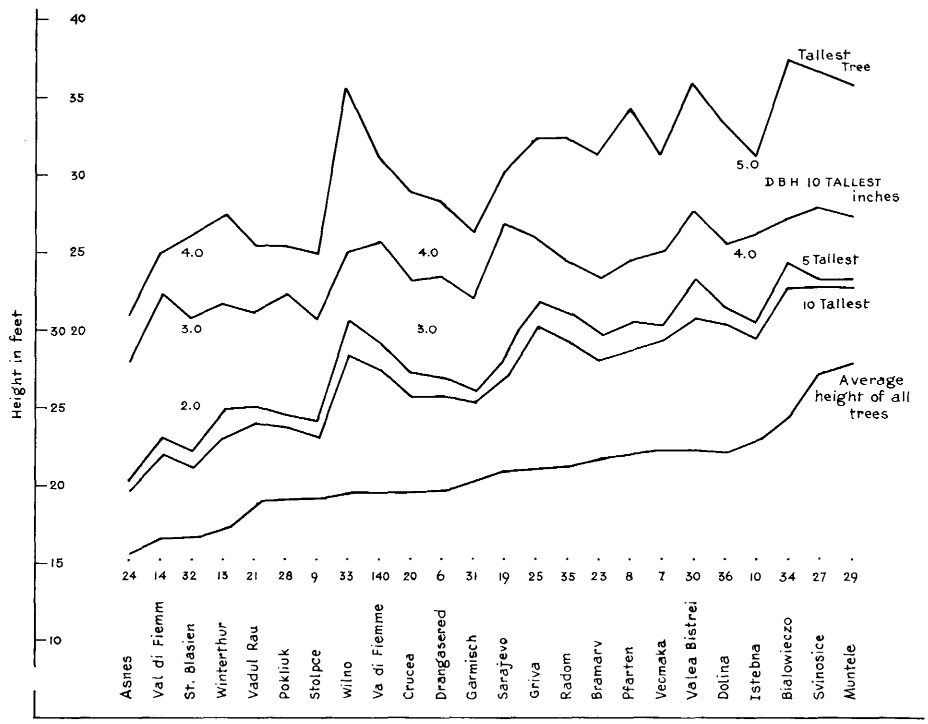

Fig. 8. — Relation between heights of trees and diameters of 10 tallest trees of IUFRO Norway spruce in New York.

Table 11. — Length of the Last 5 Years Growth in Height of IUFRO Provenances (average of all sample trees; arranged in descending order of latitude)

IUFRO No.	Place	New Hampshire Block I (feet)	New Hampshire Block II (feet)	New York (feet)
5	Foldsfoss	6.9	5.7	—
3	Tyldal	6.5	—	—
24	Åsnes	7.4	6.8	7.7
23	Bromarv	8.1	7.8	8.9
7	Vecmoka	8.1	8.7	9.0
6	Drängsered	7.5	7.7	9.1
25	Griva	8.2	7.8	8.5
33	Wilmo	—	—	8.1
9	Stolpce	7.5	6.9	9.8
34	Bialowiecza	7.6	8.1	9.1
8	Pförten	6.8	8.1	7.9
35	Radom	8.3	7.8	9.0
10	Istebna	7.3	6.6	8.4
27	Svinosice	8.1	7.7	8.3
36	Dolina	7.2	6.7	9.8
32	St. Blasien	7.2	5.7	8.3
13	Winterthur	7.8	6.4	8.0
31	Garmisch	8.0	7.4	9.6
20	Crucea	6.5	7.4	9.0
30	Valea Bistrei	7.0	7.6	8.0
29	Muntele	7.2	6.6	8.7
28	Pokljuka	7.8	6.1	9.6
14	Val di Fiemme I	7.5	6.5	9.2
14A	Val di Fiemme II	8.5	6.5	8.7
21	Vadul Rau	7.0	7.7	10.3
19	Sarajevo	6.9	7.4	8.0

cant. This can perhaps be explained by more intense weevil injury in Block I, but the non-IUFRO plots intermingled with the IUFRO plots on the same area showed the highest correlation.

Table 12. — Mean Length of the Last 5 Years Growth in Height of Non-IUFRO Provenances (averages of all sample trees; arranged in descending order of latitude)

Seed Lot No.	Source	New Hampshire (feet)	New York (feet)
F-1	Finland	7.0	—
F-139	Finland	7.8	—
F-242	Esthonia	9.4	—
F-159	E. Prussia	6.6	9.3
F-247	Belgium	7.9	10.3
F-5	Czechoslovakia	8.6	—
F-6	Czechoslovakia	8.2	—
F-158	Germany	7.4	8.5
F-234	Hungary	8.4	8.7
F-258	Austria	7.2	9.7
F-257	Austria	9.0	9.3
E-876	Switzerland	—	7.6
E-877	Switzerland	—	8.0
SL-38	Germany	—	8.5
F-3	Italy	6.6	—
F-150	Jugoslavia	7.2	8.8

As an indication of the effect of weevil, a similar correlation of average 5-year terminal height growth with average total height in the non-IUFRO plots and based on "clean trees" only, gave a very highly significant correlation of 0.911.

Variation in Diameter Growth Among the Provenances

Since all the trees in each plot in New Hampshire were calipered for diameter, sampling error could be obtained directly. The mean diameters appear in *Tables 13 and 14.* The average sampling error for diameter obtained by comparing sample trees with the complete tally was —2.8% for Block I, —0.8% for Block II and +1.6% for Block 1A (Non-IUFRO provenances). The average diameter per plot

Table 13. — Mean Diameters of IUFRO Provenances After 25 Years (arranged in descending order of latitude). Number of sample trees the same as in *Table 7*

IUFRO No.	Source	New Hampshire Block I (inches)	New Hampshire Block II (inches)	New York (inches)
5	Foldsfoss	2.88 ± 0.97	2.41 ± 1.08	—
3	Tyldal	2.84 ± 1.18	—	—
24	Åsnes	3.02 ± 0.94	2.62 ± 0.86	2.13
23	Bromarv	3.75 ± 0.82	3.08 ± 0.67	2.79
7	Vecmoka	3.21 ± 0.72	2.87 ± 1.60	2.66
6	Drängsered	3.01 ± 0.84	3.07 ± 0.50	2.80
25	Griva	3.75 ± 0.98	3.98 ± 0.79	2.73
33	Wilmo	—	—	2.57
9	Stolpce	3.16 ± 0.91	2.62 ± 0.31	2.44
34	Bialowiecza	3.40 ± 0.66	2.95 ± 0.85	3.23
8	Pförten	3.59 ± 0.81	3.13 ± 0.82	2.78
35	Radom	3.27 ± 1.03	2.63 ± 1.10	2.89
10	Istebna	3.36 ± 0.92	3.16 ± 1.69	3.04
27	Svinosice	3.58 ± 1.04	2.88 ± 1.23	3.32
36	Dolina	3.68 ± 1.06	2.98 ± 0.66	2.87
32	St. Blasien	3.34 ± 0.74	2.95 ± 0.72	2.59
13	Winterthur	3.35 ± 1.01	2.85 ± 1.12	2.48
31	Garmisch	3.20 ± 1.46	2.59 ± 0.71	2.59
20	Crucea	3.31 ± 0.75	3.07 ± 0.91	2.74
30	Valea Bistrei	3.51 ± 0.93	3.24 ± 0.93	2.91
29	Muntele	3.19 ± 0.85	2.72 ± 0.72	3.81
28	Pokljuka	3.43 ± 0.95	2.52 ± 1.10	3.71
14A	Val di Fiemme I	3.66 ± 1.04	2.66 ± 0.56	2.66
14	Val di Fiemme II	3.29 ± 0.74	2.45 ± 0.98	2.52
21	Vadul Rau	3.34 ± 1.29	2.78 ± 0.83	2.43
19	Sarajevo	3.30 ± 0.69	3.30 ± 1.16	3.49
Means		3.34 ± 0.93	2.85 ± 0.97	2.80

Table 14. — Mean Diameters of Non-IUFRO Provenances After 25 Years (arranged in descending order of latitude; based on all sample trees)

No.	Source	New Hampshire (inches)	New York (inches)
F-1	Finland	3.25 ± 0.89	—
F-139	Finland	3.40 ± 1.31	—
F-242	Esthonia	4.10 ± 1.09	—
F-159	E. Prussia	3.34 ± 1.81	3.08
F-247	Belgium	3.41 ± 0.74	2.92
F-5	Czechoslovakia	4.06 ± 1.08	—
F-6	Czechoslovakia	3.72 ± 0.92	—
F-158	Germany	3.59 ± 1.03	3.35
F-234	Hungary	3.34 ± 0.72	3.37
F-258	Austria	3.06 ± 0.95	2.71
F-257	Austria	3.75 ± 1.08	3.39
E-876	Switzerland	— —	2.33
E-877	Switzerland	— —	2.47
SL-38	Germany	— —	2.55
F-3	Italy	3.28 ± 0.86	—
F-150	Jugoslavia	3.02 ± 0.73	2.87
Means		3.49 ± 0.95	2.90

Table 15. — IUFRO Provenances Ranked in Order of Mean Diameter at Breast Height

Rank	New Hampshire Block I	New Hampshire Block II	New York
1	23	30	29
2	25	19	19
3	30	10	27
4	14A	8	34
5	8	23	10
6	27	6	30
7	21	20	35
8	35	27	36
9	14	32	6
10	34	36	23

was obtained (1) by basal area, (2) by averaging the diameters of all trees on the plot, and (3) by averaging the diameters of the felled sample trees. About one-half of the ten plots with the tallest trees were also among the first ten plots with the largest diameters *(Table 15)*.

Correlation Between Diameter Growth and Height Growth

There was no way of determining how good was the sampling for height. Indirectly, it can be shown that tree heights were correlated with diameter and *Figures 9 and 10* show examples of these correlations. In every case mean plot diameter based on the sample trees was highly significantly correlated with the mean height based on the same trees.

The use of the 5 tallest trees or the 5 trees with largest diameters as an expression of rate of growth is open to criticism because of the varying number of trees from which they were drawn. The correlation between the mean diameters of all sample trees and the mean heights of the 5 tallest trees had a coefficient of 0.623 (significant at the 1% level). The correlation between the mean diameters of the 5 trees with largest diameters and the mean heights of the 5 tallest trees had a coefficient of 0.328 and was not significant. The correlation between the mean diameters of all sample trees and the mean diameters of the 5 trees of largest diameter was also not significant.

Crown and Stem Characteristics of the Provenances

Length of Live Crown was measured on all felled trees and averaged for each plot. Usually the taller the tree, the

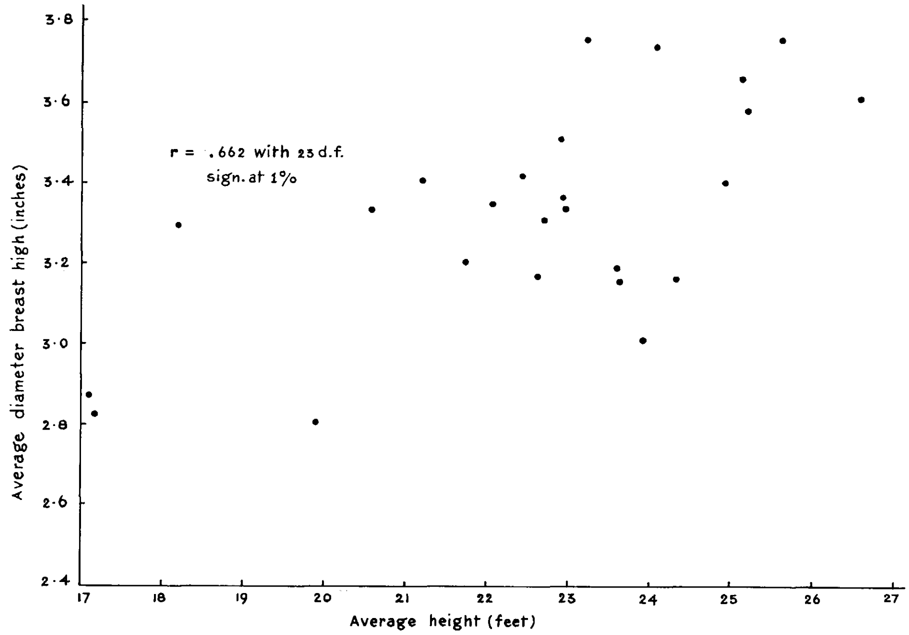

Fig. 9. — Correlation at 25 years between average diameter and average height of all sample trees (New Hampshire, block I).

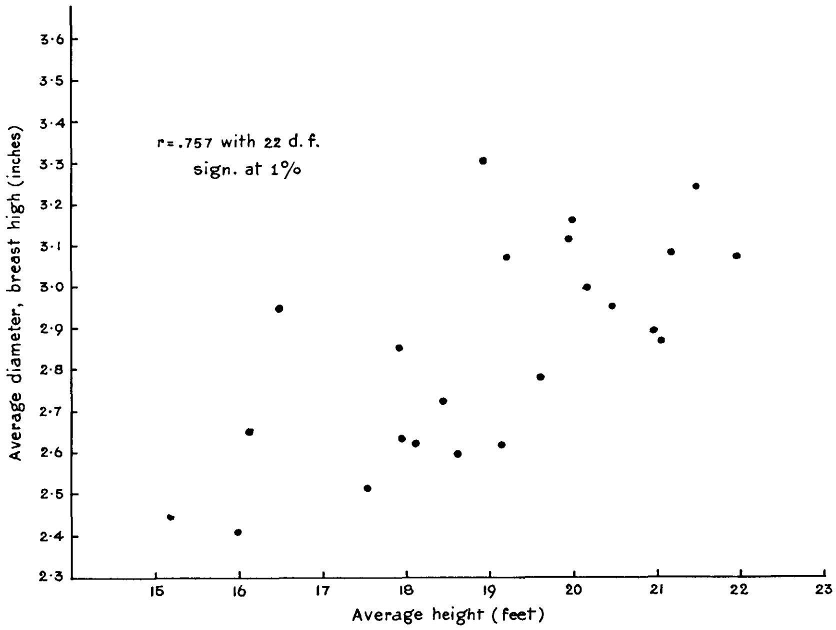

Fig. 10. — Correlation at 25 years between average diameter and average height of all sample trees (New Hampshire, block II).

longer was the crown. When crown length was expressed as a percentage of total height, northern sources appeared to have longer crowns than southern sources.

Stem Form was generally straight in all trees and crook, sweep or curves were very rare. Taper was aso very similar in trees of the same height. The most common defect was forking or double or multiple stems caused mostly by the white pine weevil in the early years.

Needle and Cone Length

Twig samples were taken from the ends of side branches near the top of felled trees. Ten needles of the current year on shoots that held the longest needles in each sample were measured to the nearest millimeter. Tree numbers with their mean needle lengths were then tabulated as a group falling in the same plot and averaged. Considerable range in length occurred within the same plot. When a twig sample was inadvertently drawn and measured a second time, as occurred in some 20 cases, different values were sometimes obtained for the average length of 10 needles; in other cases averages identical or very close to the first measurement were made. This indicates a large sampling error. Nevertheless, the results were consistent enough to permit conclusions to be drawn about the extreme groups.

Coarse, rapidly-grown shoots appeared to have longer needles than thin, slow-grown twigs. There was great variation in the arrangement of needles, their density (number per unit of stem length) and orientation. Coarse, rapidly-grown new shoots had needles on all sides of the shoot, while thin twigs often had needles arranged in one flat plane. Coarse shoots had widely-spaced curled needles. There was variation on the same tree as well as among trees of the same source. As a rule however the central and southern European sources had the longest needles, while provenances from the far north the shortest needles.

Needle length was highly correlated with cone length and mean total height at 20 years and negatively correlated with latitude of source (*Figure 11*). The correlation between needle length and current height growth (5-year intersect) was not significant.

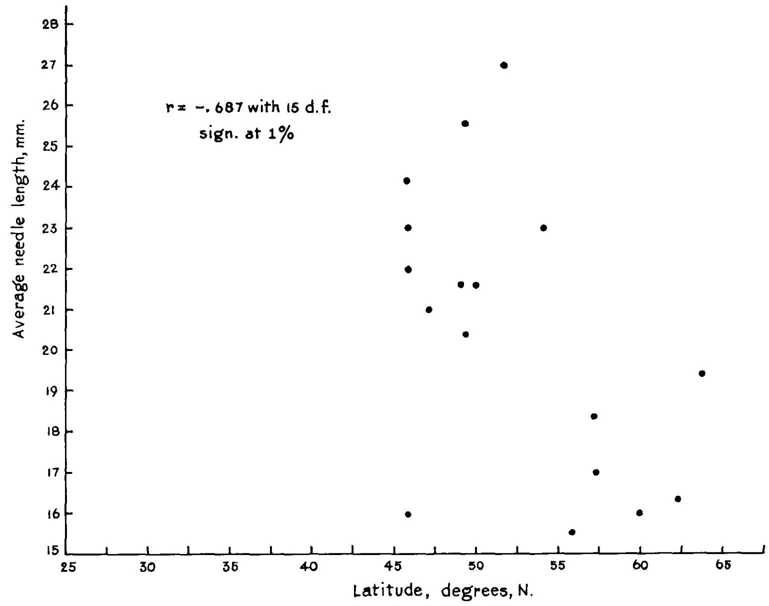

Fig. 11. — Correlation at 25 years between average needle length and latitude of source (New Hampshire, block I).

The Occurrence of Injuries

No matter how fast the growth and how excellent the quality of the trees, if a provenance suffers too severely from insects, disease or other agencies, it may be wholly unsuitable to grow. Aside from the white pine weevil, the spruce plots described here were free from really serious pests. An attempt was made, however, to rate different provenances according to prevalence of injury as a further means of distinguishing differences among them.

White Pine Weevil: The extent of damage caused by *Pissodes strobi* has been so great that planting of Norway spruce has been virtually abandoned in some parts of north-eastern North America. The terminal shoots are killed back year after year, and the trees reduced to stunted bushes during the first ten years after planting. Where trees are densely spaced as in the plots here considered, most of the trees recover and eventually produce straight, single-stemmed trees, albeit with reduced height. This is because side buds on the leaders develop upon death of the tip, and produce a new shoot with little crook. The injury is later overgrown, and an acceptable bole form eventually results. A proportion remain forked, but with increasing age better trees emerge.

Weevil damage was assessed by determining the percentage of undamaged trees among the felled samples, and by comparing the trees attacked in 1962 with injuries during the previous five years. In the first instance, the percentage of undamaged trees in the felled samples subtracted from 100 was taken to represent percent weevilled. Many early cases of weevil attack were no longer evident, and no doubt many of the so-called "clean trees" had been attacked in early life. Since forking was believed in almost every case to be due to the weevil, this factor was included in rating the sources. Finally, the sources that appeared in both blocks in these lists of the best and worst, were tabulated as evidence of consistency. It was noted that there were much lower percentages of forking in Block II compared to Block I, although the percentages of weevilled trees varied little. This may have been due to greater hardwood competition and overtopping in Block II. Comparison of the same source of Norway spruce under an aspen overstory and in the open on the Fox Research Forest showed a heavier weevil damage under the aspen than in the open (Baldwin, 1949 a).

Weevil damage was so severe in all plots that no source or sources could be said to be outstanding in freedom from attack. Inspection of the tables listing the least damaged plots showed that five sources consistently scored highly in freedom from weevil damage:

7 Vecmoka
23 Bromarv
24 Åsnes
5 Foldsfoss
25 Griva

These are all relatively northern sources. 28 Pokljuka, Jugoslavia, 27 Svinosice, Czechoslovakia, and 13 Winterthur, Switzerland also rank high.

Dr. Jonathan Wright of Michigan State University visited the Otsego 9 Plantation in New York State in July 1954. He observed the percentage of weevilled trees in Block 40E and his figures are compared in *Table 16* with those taken in 1962.

There was no obvious trend in the incidence of weevilled trees among the various sources in relation to latitude, except possibly No 24 Åsnes from Norway which showed the lowest weevil incidence while the two highest scores were in non-IUFRO Lots 247 and 234 from middle latitudes. The mean height of No 24 Åsnes was shorter (15.36 feet) than

Table 16. — Proportion of Trees Attacked by White Pine Weevil in New York Plantations

Rows Block 40 E	Lot No.	Source	Lat.	Wright (1954) %	Weevilled Trees Once or More (1962) %	Twice or More (1962) %	Incidence in all Trees Sampled %
24—29	IUFRO 24	Norway	60	1	12	2	7
44—50	159	E. Prussia	55	10	45	13	41
51—59	247	Belgium	55	22	48	21	38
11—18	SL 38	Germany	50	5	29	10	26
37—42	IUFRO 6	Sweden	49	3	36	14	29
60—74	234	Hungary	48	35	40	15	31
1—6	E 876	Switzerland	46	3	26	14	26
7—10	E 877	Switzerland	46	11	25	8	16
30—36	IUFRO 14	Italy	46	1	30	7	26
19—23	150	Jugoslavia	45	5	16	4	26

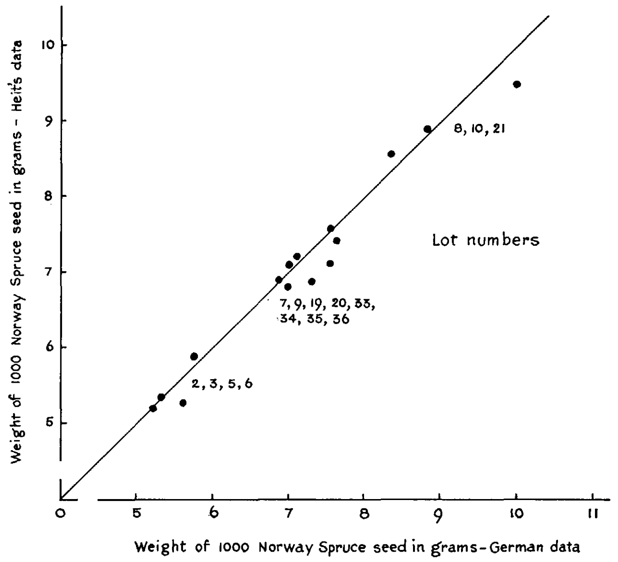

Fig. 12. — Comparison of German and C. E. Heit's data on weight of 1000 Norway spruce seed for 15 IUFRO lots.

that of the two adjacent lots on each side (No 150 with 19.95 feet and No 14 with 16.29 feet). This differential in height may have protected No 24 from weevil flight and reduced the incidence of damage.

Possibly because of a different method of scoring weevil damage, the figures for "percent weevilled trees" were greater for most of the New Hampshire plots (cf. *Figure 16).*

There was little in the data to confirm the New York results, except that some of the northern and Baltic provenances appeared to escape weevil injury more commonly than others. There is also the possibility in these plots that lower tree height may have protected the trees.

Tabulation of weevil damage for IUFRO provenances in the two New Hampshire blocks showed a slight trend toward less damage in northern sources. But simple correlations gave a very low r value which was not significant. There was little similarity in damage levels between the two blocks. Exceptions were numbers 13 Winterthur, and 35 Radom (low in both cases) and 8 Pförten and 20 Crucea (heavily damaged in both cases). A highly significant (r = .745) correlation was found between weevil injury and tree height in 1962 *(Figure 16).*

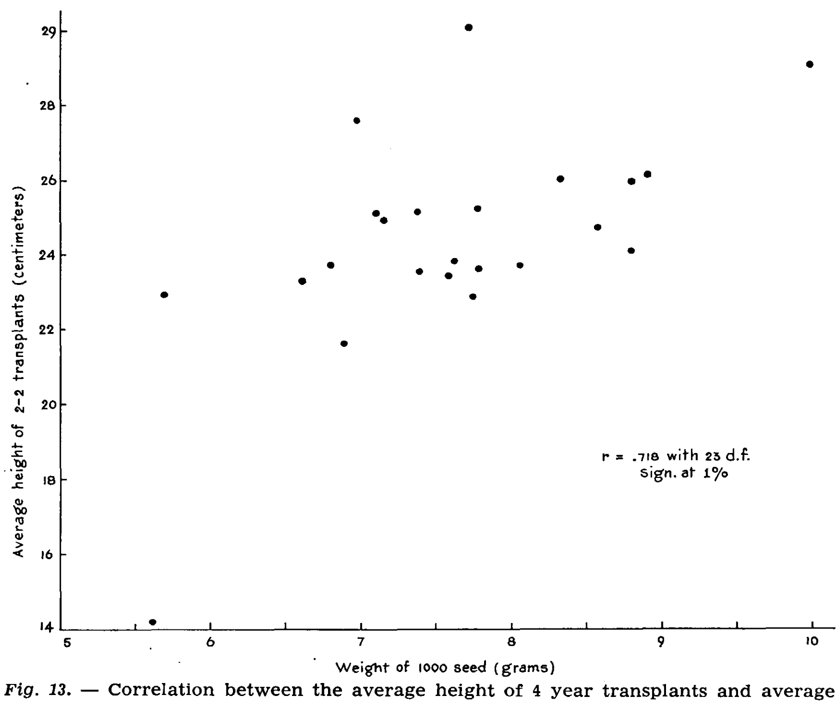

Fig. 13. — Correlation between the average height of 4 year transplants and average weight of 1000 seed (New York plots).

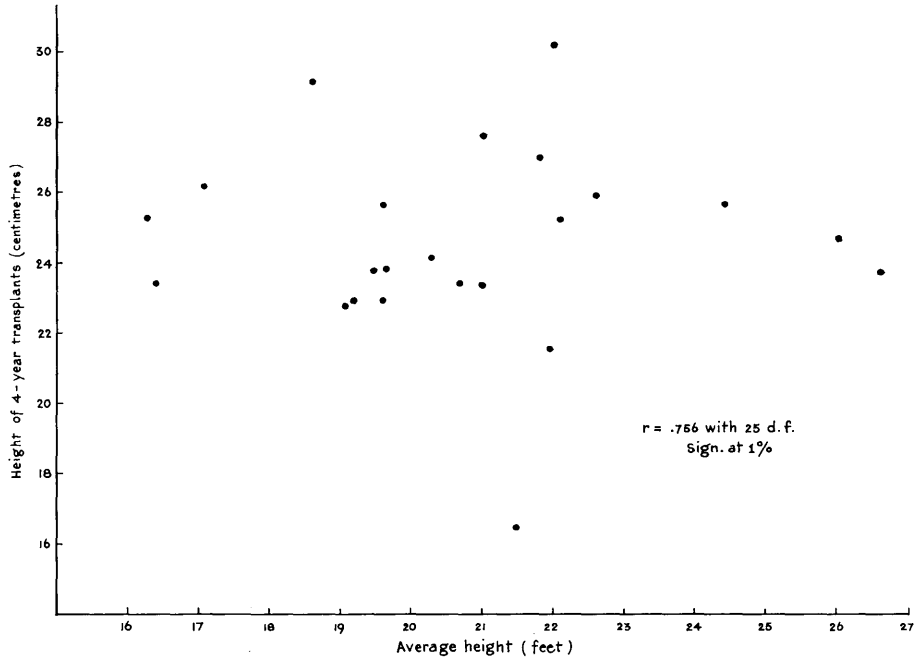

Fig. 14. — Correlation at 25 years between average height of 4-year transplants and average height of all sample trees (New York plots).

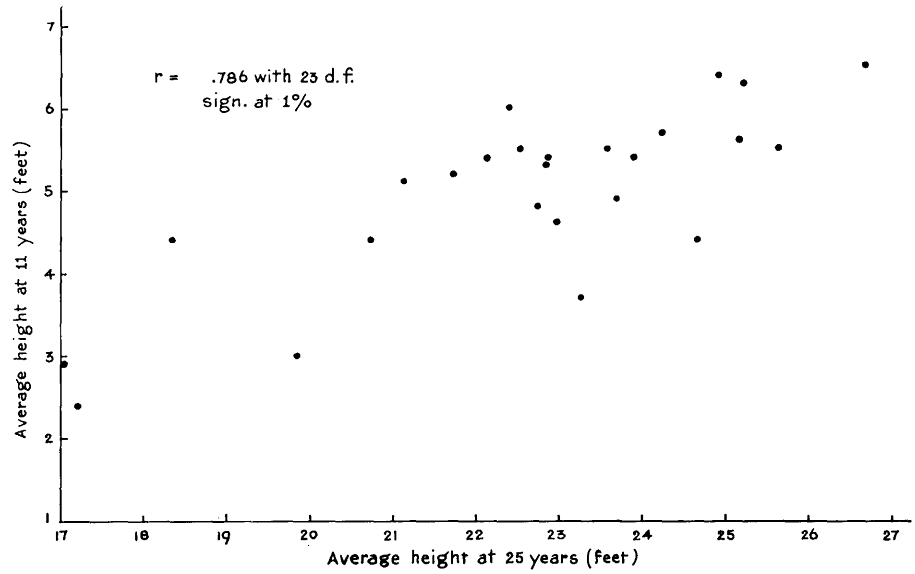

Fig. 15. — Correlation between height at 11 years and height at 25 years (New Hampshire, block I).

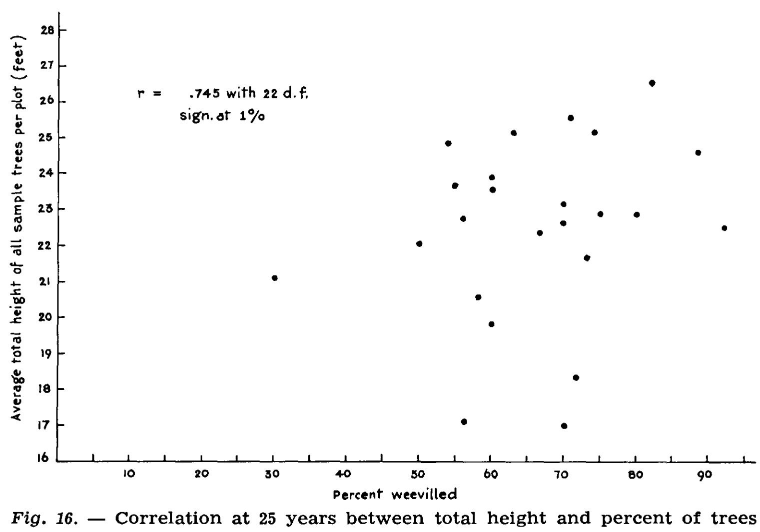

Fig. 16. — Correlation at 25 years between total height and percent of trees weevilled (New Hampshire, block I).

Bud Gall (Chermes): Since Norway spruce is commonly infested by the gall-forming insect, *Chermes abietis* L., it was surprising that most of the plots were free from this pest. The presence of the insect was attested by the very severe attack suffered by the plots of white spruce, especially the Black Hills spruce *(Picea glauca* var. *albertina).* Infestation of *Chermes* was scored on all sample trees as absent, light, medium and heavy. Most attacks were so light that presence was tabulated by percentages of trees in each plot which had evidence of the insect, mostly on the lower branches. Often it was on dead lower branches only suggesting that *Chermes* had once been more prevalent, but had decreased as the stand closed and shading increased. LANGLET (1938) observed that southern sources of Norway spruce were more heavily attacked than northern provenances, and this is confirmed by these observations *(Table 17).* Ranking provenances according to percentages of trees on which *Chermes* was present is done in *Table 17.* It is apparent that all 6 most heavily infested provenances are the same in both blocks, although they occur in a slightly different order.

Summary of Injuries: Examination of the tables and records show that these provenances that suffered the heaviest damage from one agency, were also damaged by one or more other causes. It should be emphasized that the only really serious damage resulted from the white pine weevil. However, combination of several types of injury could result in the provenance being classified as undesirable relative to others.

Direct Ocular Comparison of Provenances

The general quality of the different plots and the appearance of the trees within them were recorded as notes. A further test of this subjective judging was made in mid-April 1964. Snow was still deep in the stand and the scoring was done on a bright, sunny day using the classes:

A. branches fine, boles clean, whorls distinct, bark smooth with a reddish cast. Stocking of tall straight stems good;
B. intermediate; containing many good trees;
C. excessively branchy stems, coarse branches, many forks.

Plots were graded without knowledge of the provenance, and identity numbers were then inserted. Two passes were made on each block, one facing east and one facing west. The results showed good agreement between the different scorings, and these were then compared with the notes made in 1962. Generally the provenances that ranked highest in growth rate received the highest scores on this assessment of appearance in 1964.

Table 17. — Proportion of Trees Attacked by *Chermes* in New Hampshire Plantations

IUFRO	Block I Source	%	IUFRO	Block II Source	%
32	St. Blasien	33	19	Sarajevo	50
19	Sarajevo	25	28	Pokljuka	50
14A	Val di Fiemme	23	28	Pokljuka	41
21	Vadul Rau	15	32	St. Blasien	35
28	Pokljuka	10	14A	Val di Fiemme	28
14	Val di Fiemme	8	21	Vadul Rau	23
10	Istebna	8	6	Drängsered	18
27	Svinosice	8	14	Val di Fiemme	12
5	Foldsfoss	6	25	Griva	11
29	Muntele	5	35	Radom	10

Diseases: No diseases were positively identified. However pitch flow on stems and branches was typical of *Cytospora.* This bark canker is believed to be secondary and typical of depressed vigour due to lack of soil moisture. Crowded conditions in dense stands may lead to conditions favourable to attack. Canker was present in relatively few plots and no mortality was observed. No 13 Winterthur had the highest infection in both blocks. In general, the same sources infested by *Chermes* suffered most frequent attack of *Cytospora.*

Mound-building Ants: These were the only pests that killed trees in significant numbers. The Allegheny Mound Ant *(Formica exsectiodes)* caused large openings in some plots during the early years of the plantation, thus reducing the stocking and number of samples that could be masured.

Frost and Snow: There was no evidence of damage by either late or early frost. Crowns broken or deformed by snow were uncommon and it was assumed that damage of this sort was caused by masses of wet, heavy snow. Roosting by heavy birds has been known to cause similar damage. No bending of trees was noted, even in the case of very slender whip-like stems. Now that row thinning has been made, some damage may occur.

Table 19 lists the sources most prone to snow damage. Again this list shows similarity to those of damage by *Chermes* and *Cytospora.* It is remarkable that the northern provenances from snowy regions exhibited so much injury. But the injury was caused by heavy wet snow and such conditions are less common in Northern Europe.

Table 18. — Proportion of Trees with Evidence of *Cytospora* in New Hampshire

Block I

IUFRO No.	Source	%
13	Winterthur	12
14	Val die Fiemme	12
27	Svinosice	11
28	Pokljuka	10
28	Pokljuka	8
14A	Val di Fiemme	5
8	Pförten	5
32	St. Blasien	5
34	Bialowiecza	5

Block II

IUFRO No.	Source	%
13	Winterthur	6
25	Griva	5
	All Others 0	

Table 19. — Proportion of Trees Damaged by Snow in New Hampshire Plantations

IUFRO No	Block I Source	%	IUFRO No	Block II Source	%
23	Bromarv	20	34	Bialowiecza	18
25	Griva	13	23	Bromarv	12
7	Vecmoka	12	32	St. Blasien	10
27	Svinosice	11	27	Svinosice	10
24	Åsnes	9	20	Crucea	8
28	Pokljuka	8	14	Val di Fiemme	8
3	Tyldal	6	5	Foldsfoss	7
14A	Val di Fiemme	5	6	Drangsered	6
34	Bialowiecza A.	5	10	Istebna	6
28	Pokljuka	5	25	Griva	5
13	Winterthur	5	21	Vadul Rau	5
20	Crucea	4	19	Sarajevo	4
31	Garmisch	4	30	Valea Bistrei	4
35	Radom	4		All Others	0

Block 1A, Non-IUFRO

Fox No	Source	%
6	Czechoslovakia	26
5	Czechoslovakia	21
257	Austria	15
158	Germany	13
134	Hungary	8
258	Austria	5
	All Others 0	

Correlations Between Different Measurements

Simple correlation coefficients were computed to show the relationship between different sets of data. These are summarised in *Table 20* and appear in *Figures 9 to 16* inclusive.

Discussion of Results

The object was to determine what provenance of Norway spruce, among those tested, developed best in north-eastern United States. Previous studies (Hosley, 1936) have shown that Norway spruce possesses exceptional growth potential and has performed well in many parts of the north-east and middle Atlantic states, holding its own and usually surpassing native spruces in spite of the handicap of severe weevil attack.

To answer the question "what is the best source for the north-east" "best" is here considered as a combination of fast growth, fine branching habit, straight stem, and resistance to or capacity to overcome and recover from injuries. The results can be interpreted only by considering such factors as spacing, stocking, competition from other species, overtopping by wolf trees and similar factors. Soil differences are believed to have been of minor importance.

Not to be overlooked is the "general appearance" of the trees and the plot. Some provenances give the impression of having better health and more vigour and being well adapted to the site.

Ploughing furrows before planting was designed to make planting more uniform and reduce variation. However, planting was more difficult in some places than others and the trees were set less perfectly than their neighbours. Variation in spacing due to the ploughing being forced out of line by boulders, tree roots and stumps caused some plots to have more or fewer rows than others.

The edge or border trees appear to be unaffected on Blocks I and II due to the rows of the "standard" and the close proximity of other trees of similar size. There was some overtopping by large hardwoods and pines. Thus no trees were *larger* just because they were on the edge or borders of plots but many were stunted because of overtopping.

In 1962 variation in size of trees within any given plot was still great, but less than in 1947. The possibility of individual differences in growth and in susceptibility to weevil and other pests should not be overlooked. Holst (1955) observed that slender trees of Norway spruce with narrow brush-like crowns were associated with light weevil damage whereas stout trees with broad comb-like crowns were severely damaged.

Trees from far northern sources grew more slowly than those from Central Europe but the correlation between height or diameter and latitude proved not to be significant (*Table 20*). However, diameter was more closely correlated with latitude than was height.

Cieslar and Engler (loc. cit.) both found that Norway spruce provenances from higher altitudes grew more slowly than spruce from lower altitudes. A test of all plots in Block I gave a low negative correlation (not significant) between the mean heights of the 5 tallest trees and altitude. A slightly higher correlation between plots originating within latitude 44° and 48° only was also not significant in regard to the mean height of the 5 tallest trees. Even less relation was noted when altitude and the mean heights of all sample trees were compared.

No significant correlation could be found between the latitude of origin and proportion of trees injured by white pine weevil. In provenance tests with eastern white pine (*Pinus strobus*) trees grown from seed collected in Canada suffered less injury than trees originating farther south (Pauley *et al.*, 1955).

Since the same IUFRO provenances were also planted in many countries, it is of interest to compare the performance of the trees in New Hampshire and New York with provenance tests in other countries. Height is the

Table 20

	r value	degrees of freedom	significance
I. CORRELATIONS INVOLVING HEIGHT			
A. *Height and Diameter* (Means of all sample trees)			
Block I IUFRO provenances	.662	23	**
Block II IUFRO provenances	.757	22	**
Block IA Non-IUFRO provenances	.737	11	**
B. *Height and 5 Year Terminal Growth*			
Non-IUFRO ("Clean trees" only)	.911	11	**
Block I IUFRO (all sample trees)	.350	23	NS
Block II IUFRO (all sample trees)	.712	22	**
Block IA Non-IUFRO (all sample trees)	.745	11	**
C. *Height at Different Ages* *Nursery Stage*			
1 + 0 and 2 + 2	.706	32	**
2 + 2 and 8 years	.481	22	*
2 + 2 and 20 years	.303	34	*
2 + 2 and 25 years	.756	25	**
Plantation Stage			
8 and 20 years	.528	20	*
Block I IUFRO	.786	23	**
Block II IUFRO	.404	22	*
D. *Heights of Different Plantations Compared* New Hampshire and New York at 25 years			
Mean height of all sample trees Block I IUFRO	.514	21	*
Mean height of all sample trees Non-IUFRO	.416	15	NS
New Hampshire at 25 years and Sweden at 19 years. Mean height of all sample trees Block I IUFRO	.619	22	**
New Hampshire and Belgium. Mean heights of 10 tallest trees Block I IUFRO	.422		NS
II. CORRELATIONS INVOLVING DIAMETER			
A. *Diameter and height*			
Mean diameter of all samples and mean height of 5 tallest trees Block I IUFRO	.623	23	**
Mean of 5 largest diameters and mean height of 5 tallest trees	.328	23	NS
B. *Diameter and diameter*			
Mean diameter all sample trees and mean diameter of 5 thickest trees	.328	23	NS
Block I IUFRO at 25 years and mean diameter all plots at Dobra, Czechoslovakia	.335	10	NS
C. *Diameter and Growing Spacc per tree*			
Mean diameter of all sample trees Block I IUFRO	.062	28	NS
III. LATITUDE AND ALTITUDE			
A. *Latitude*			
1. Height and latitude			
Mean height of 5 tallest trees and latitude of provenance			
Block I IUFRO	—.272	23	NS
Block IA IUFRO	—.105	11	NS

(Continued from Table 20)

	r value	degrees of freedom	significance
2. Diameter and latitude			
Mean diameter all sample trees and latitude of provenance	—.374	23	NS
3. Weevil injury and latitude			
Block I IUFRO	—.125	22	NS
Block II IUFRO	—.310	22	NS
B. *Altitude*			
Mean height of 5 tallest trees and altitude of provenance All provenances Block I IUFRO	—.151	23	NS
Provenances from 44°—48° only 5 tallest trees IUFRO	—.232	9	NS
Mean height of all sample trees	—.053	9	NS
IV. NEEDLE AND CONE LENGTH			
A. *Needle length and cone length* (New Hampshire data)	.644	23	**
B. *Needle length and height*			
Mean needle length and 2 + 2 height (New York)	.381	34	*
Mean needle length and 20 year height (New York)	.584	34	**
Mean needle length and 25 year height (New York)	.366	23	NS
Mean needle length and 5 year intersect (New York)	—.137	22	NS
C. *Needle length and latitude*			
Block I—II New Hampshire IUFRO	—.687	15	**
New York IUFRO	—.473	22	*
V.INJURIES (New Hampshire data)			
Percent weevil injury and total height Block I IUFRO	.745	22	**
VI. SEED WEIGHT (New York data)			
Weight of 1000 seeds and height of 1 + 0 seedlings	.304	24	NS
Weight of 1000 seeds and height of 2 + 2 transplants	.718	23	**
Weight of 1000 seeds and latitude of provenance	.260	24	NS

factor most commonly measured although it is not always clear what is included in "average" height or "total" height. No average of all trees in a provenance was obtained in the present measurements, but such height data as were taken can nevertheless be used.

The Swedish plots reported by LANGLET (1960) contain only few of the same provenances present in the New Hampshire plots and vice versa. Four of the first ten in rank in Sweden are also found in the first ten of each of the New Hampshire blocks.

VINCENT and FLEK (1953) reported the results of plots in Czechoslovakia at 11 years. They gave average heights on three blocks in 1945 and 1949. Again only some of the provenances coincided with those represented in the present study. These and other measurements are compared in *Figures 5 and 17.*

Average heights of all sample trees in the New Hampshire test showed a high correlation (significant at the 1% level) with the measurements at 19 years by LANGLET at Dönjelt in Sweden (LANGLET, 1963 b). On the other hand no significant correlation could be found between the mean heights of the 10 tallest trees in New Hampshire and the 10 tallest reported by GATHY (1960) for Belle Étoile in Belgium, nor did a comparison of average diameters of New Hampshire and Czechoslovakian trees at Dobra (VINS, 1962) reveal any relationship *(Table 20).* Further notes on this comparison were given by Baldwin (1967).

Conclusions

Provenances of Norway spruce grew well on two experimental sites in Eastern United States. In spite of the repeated destruction of the leading shoot by white pine weevil, heights rivalling those of weevil-free stands in Europe were attained.

In general the growth of central and eastern European provenances was superior and so resembled the results of similar European tests. All provenances proved fully hardy and produced healthy trees. It would be prudent, however, to avoid sources from the far north and far southern extensions of the natural range.

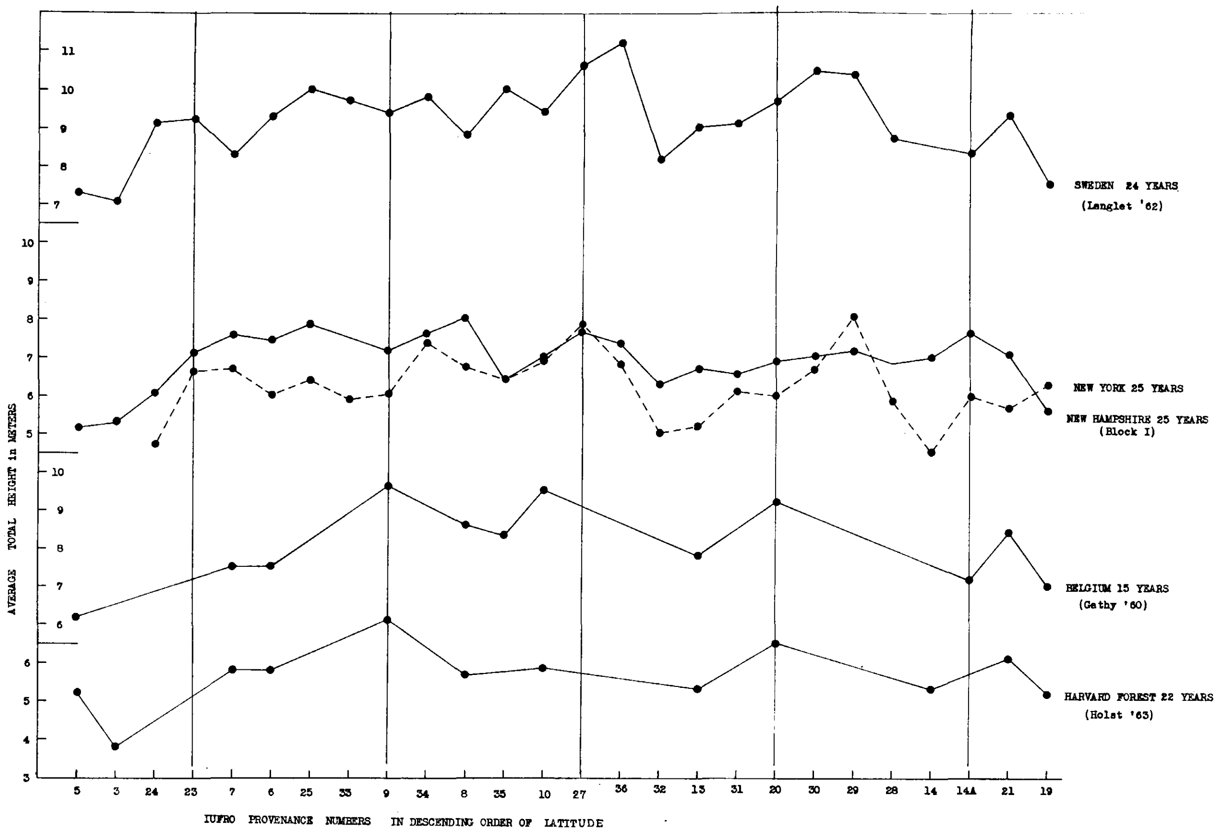

Fig. 17. — Comparison of total heights of different IUFRO Norway spruce plantations at 15 to 25 years from seed.

1. Provenances from northern latitudes grew more slowly in height than those from central Europe, but no regular clinal trend was apparent.
2. Heavy damage to terminal shoots by the white pine weevil obscured differences between provenances. Undamaged trees were too few to enable differences in total height between provenances to be based on them and undamaged trees were not always the tallest in the sample.
3. Correlations between heights of the transplants at 4 years and those of trees at 8, 11 (see BALDWIN, 1949 a), 20 and 25 years (see *Figures 14 and 15)* were significant or highly significant, suggesting that the relative performance of the provenances could have been ascertained at 4, 8 or 11 years. Current height growth (5 year intersect) was usually but not always highly correlated with total height at 25 years.
4. A highly significant correlation was found between mean heights at 25 years in New Hampshire and mean heights at 19 years in Sweden. But there was no significant relation between the New Hampshire and Belgian data. The mean heights at 25 years for Block I in New Hampshire and the same provenances in New York were correlated at the 5% level of significance.
5. Sources that attained the greatest mean height in 25 years were, in descending order:
   27 Svinosice, Czechoslovakia
   8 Pförten, Poland (ex Germany)
   6 Drängsered, Sweden
   25 Griva, USSR (ex Latvia)
   29 Muntele, Rumania
6. The correlation between mean stem diameter and mean heights of all the sample trees at 25 years was highly significant. The same was true of the mean diameters of all sample trees and the mean heigths of the 5 tallest trees per plot. But the mean diameters of all sample trees and of the 5 tallest trees were not significantly correlated with those of the 5 trees of largest diameter.
7. Shorter needles and shorter cones were typical of provenances from northern latitudes when compared with those from southern latitudes. The correlation between needle length and latitude was negative and significant or highly significant (see *Figure 11).*
8. There were highly significant correlations between needle length and cone length and between needle length and height at 20 years, but not between needle length and height at 25 years. However there was no significant correlation between needle length and terminal growth during the past 5 years. The correlation between needle length and height of 2 + 2 transplants was significant at the 5% level.
9. The weights of 1000 pure seed were highly correlated with the heights of 2 + 2 transplants *(Figure 13* from New York data) but not with the heights of 1 + 0 seedlings. The heights of 1 year seedlings were highly correlated with those of the 2 + 2 transplants.
10. Concerning damage by insects, fungi, birds and animals, the same provenances suffered most damage from several causes. Attack by *Chermes* was not serious.

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Summary

Data are presented on the 25-year measurement of IUFRO *Picea abies* tests in New Hampshire and New York, USA. Comparisons with earlier measurements of the same plantings and with those of tests at Harvard Forest and Michigan are made. The measurements at 25 years confirmed those made at a younger age. Sources from central and eastern Europe produced faster growth in the northeastern US. Scandinavian sources were slow growing, but possibly more resistant to pests. All provenances were severely attacked by the white pine weevil *(Pissodes strobi)* so that the terminal shoots were killed back year after year. No injury from early or late frost was observed on any provenance, nor were there any cases of secondary shoot growth in the autumn of 1962. The average diameters and heigths of all sample trees gave a strong positive correlation, as did current growth and total height, and 11 year and 25 year heights.

References

Baldwin, H. I.: Height Growth of Norway Spruce Plantations. Fox Forest Notes 38, 22 pp. mimeo, 1949 (a). — Baldwin, H. I.: Growth and weevil damage to Norway Spruce growing under aspen. Fox Forest Notes 45, 1949 (b). — Baldwin, H. I.: Provenance Tests of Common Exotics in the Northeast. Proc. 1st. Northeastern Tree Improvement Conference, 33—38 1953. — Baldwin, H. I.: An Inventory of Seed Sources. Bull. 15, Fox Research Forest Hillsboro, N. H., 48 pp., 1965. — Baldwin, H. I.: Comparative Results of the 1938 Provenance Test of *Picea abies*. Proc. XIV IUFRO Kongress III: 782—786, 1967. — Bouvarel, P., and Lemoine, M.: L'Éxperience Internationale sur les Provenances d'Épicéa *(Picea excelsa* Link). Silvae Genetica 6: 91—97 (1957). — Cieslar, A.: Über den Einfluß der Größe der Fichtensamen auf die Entwicklung der Pflanzen nebst einigen Bemerkungen über schwedische Fichte und Weißföhrensamen. Centralbl. f. d. gesamt. Forstw. 13: 149—153 (1895). — Cieslar, A.: Neues aus dem Gebiete der forstlichen Zuchtwahl. Ibid 25: 99—117 (1899). — Cieslar, A.: Die Bedeutung klimatischer Varietäten unserer Holzarten für den Waldbau. Ibid 33: 1—19; 49—62 (1907). — Cook,D. B., and Littlefield, E. W.: Grosbeak damage to Scots Pine. Jour. For. 43: 269—272 (1945). — Dengler, A.: Untersuchungen über die natürlichen und künstlichen Verbreitungsgebiete einiger forstlich und pflanzengeographisch wichtigen Holzarten in Nord- und Mittel-Deutschland. 11. Die Horizontalverbreitung der Fichte *Picea excelsa* Link. Mitt. aus dem forstl. Versuchswesen Preußens, 1—122, Neumann, 1912. — Edwards, M. V.: Norway Spruce Provenance Experiments. Forestry Commission. Report on Forest Research 1954: 114—126. London H.M.S.O., 1955. — Engler, A.: Einfluß der Provenienz des Samens auf die Eigenschaften der forstlichen Holzgewächse. Mitt. d. Schweiz. Centralanstalt f. d. forstl. Versuchsw. 8 (2): 81—236 (1905). — Engler, A.: Tatsachen, Hypothesen und Irrtümer auf dem Gebiete der Samenprovenienz-Frage. Forstwiss. Centralblatt 30: 295—314 (1908). — Engler, A.: Einfluß der Provenienz des Samens auf die Eigenschaften der forstlichen Holzgewächse. Mitt. Schweiz. Centralanstalt f. d. forstl. Versuchsw. 10: 191—386 (1913). — Gathy, P.: L'Expérience Internationale sur l'Origine des Graines d'Épicéa *(Picea abies* (L.) Karst.). Resultats en Belgique. Travaux Station de Recherches des Eaux et Forêts Belgique Serie B, No. 24, 25 pp. (1960). — Hart, A. C.: Red Squirrel Damage to Pine and Spruce Plantations. Jour. For. 34: 729—730 (1936). — Hesselman, H., and Schotte, G.: Granen vid sin sydvästgräns i Servige. Svenska Skogsvårdsf. Tidskr. 4: 455—502 (1906). — Holst, M. J.: Breeding for Weevil Resistance in Norway Spruce. Zeit. f. Forstgenetik und Forstpflanzenzüchtung 4: 33—37 (1955). — Holst, M. J.: Growth of Norway Spruce *(Picea abies* (L.) Karst.) Provenances in Eastern North America. Canadian Dept. of Forestry Pub. 1022, 15 pp., 1963 a. — Holzer, K.: Genetically Determined Photoperiodic Reactions of Spruce Seedlings. Proc. 13th Cong. IUFRO Vienna 2 (1), Sec. 22/7, 1962. — Hosley, N. W.: Norway Spruce in the North-eastern United States. Harvard Forest Bull. 19, 1936. — Kienitz, M.: Vergleichende Keimversuche mit Waldbaumsamen aus klimatisch verschieden gelegenen Orten Mitteleuropas. Bot. Untersuchungen 2 (1), Heidelberg, 1879. — Kiellander, C. L.: Über eine spättreibende Rasse von *Picea abies* in Schweden und eine Schwierigkeit bei der Plusbaumauswahl. Zeit. f. Forstgenetik und Forstpflanzenzüchtung 5: 181—185 (1956). — Langlet, O.: Proveniensförsök med olika trädslag. Svenska Skogsvårdsföreningens Tidskr. 36: 55—278 (1938). — Langlet, O.: Några data från det internationella granproveniens försöket av 1938 i Sverige. Skogen 40: 238—239; 244—245 (1953). — Langlet, O.: Mellaneuropeiska granprovenienser i Svensk Skogsbruk-Särtr. Kungl. Skogs-och Lantbruksakademiens Tidskr. 1960 (5—6); 259—329. — Langlet, O.: Ecological Variability and Taxonomy. Tree Growth. ed. by T. T. Kozlowski, Ronald Press N. Y., pp. 357—369 (1962). — Langlet, O.: Practical Results and Current Problems in Provenance Research in Sweden. World Consultation on Forest Genetics and Tree Improvement, Stockholm, 1963 a. — Langlet, O.: The Norway Spruce Provenance Experiments at Dönjelt and Hjuleberg. Excursion Guide, World Consultation on Forest Genetics and Tree Improvement, Stockholm. Processed 8 pp., 1963 b. — Langlet, O.: Patterns and terms of intraspecific ecological variability. Nature 200: 347—348 (1963 c). — Mergen, F.: Variation and Heritability of Physiological and Morphological Traits in Norway Spruce. Proc. 5th World Forestry Congress Sp. 105/11, 1960. — Pauley, S. S., Spurr, S. H., and Whitmore, F. W.: Seed Source Trials of Eastern White Pine. Forest Science 1: 244—256 (1955). — Rohmeder, E.: Beispiele für die Überlegenheit fremder Provenienzen über die einheimische Standortsrasse bei den Baumarten *Pinus silvestris* und *Picea abies*. Allg. Forstzeitschr. 1959 (43): 11—15. — Rubner, K.: Die pflanzengeographischen ökologischen Grundlagen des Waldbaus. Neumann, Berlin, 1934. — Rubner, K.: Beitrag zur Kenntnis der Fichtenformen und Fichtenrassen. Tharandt. forstl. Jahrb. 87 (2): 101—188 (1936). — Rubner, K.: Die pflanzengeographischen Grundlagen des Waldbaus. Neumann, Berlin, 1953, 583 pp. — Rubner, K.: Ergebnisse eines heute 20jährigen Fichtenherkunftsversuches. I. Die Fläche in Bayern. Silvae Genetica 6: 65 (1957). — Rubner, K., und Klemm, H.: Fichtenformen und Fichtenrassen mit besonderer Berücksichtigung des schlesischen Gebirges. Jahrb. d. Gruppe Preußen-Schlesien im Deutschen Forstverein, Breslau, 1936: 79—88 (1937). — Rudolf, P. O., and Slabaugh, P. E.: Growth and Development of 12 Seed Sources of Norway Spruce in Lower Michigan. Techn. Note 537, Lake States Forest Experiment Sta., 1958. — Schmidt, W.: Protokoll über die Konferenz in Kopenhagen, Januar 1940. Rundschreiben, Kommission für Forstsaatgut- und Baumrassenfragen des Internationalen Verbandes Forstlicher Forschungsanstalten. Mimeo., 7 pp., 1940. — Schönbach, H.: Ergebnisse eines heute 20jährigen Fichtenherkunftsversuches. II. Teil: Die Flächen in Thüringen und Sachsen. Silvae Genetica 6: 74 (1957). — Slabaugh, P. E., and Rudolf, P. O.: The Influence of Seed Source on the Development of Scots Pine and Norway Spruce Planted in Lower Michigan (15-yr. results) 1956. Papers of Mich. Acad. Sci., Arts and Letters 42: 41—52 (1957). — Turesson, G.: Genecological units and their classificatory value. Svensk Bot. Tidskr. 24 (4): 511—518 (1930). — Vaartaja, O.: Evidence of Photoperiodic Ecotypes in Trees. Ecol. Mon. 29: 91—111 (1959). — Vincent, G., and Flek, J.: Pokusne plochy preveniencni se Smrkem. (Norway Spruce trial plots.) Práce Vyzkum ust. Lesn. Č.S.R. (3): 205—236 (1953). Briefed in Forestry Abstracts 16 (2): 197, No. 1616, 1955. Trans. IUFRO Sec. 22, Mimeo. May 21, 1956. — Vins, B.: Report on the State and Preliminary Evaluation of Czechoslovak. Provenance Trial Plots of Norway Spruce in the International Series from the year 1938. World Consultation on Forest Genetics and Tree Improvement Stockholm, Mimeo., 10 pp., 1963. — Wahlgren, A.: Skogsskötsel. Stockholm, 1922, 732 pp. — Worrall, J., and Mergen, F.: Environmental and genetic control of dormancy in Norway Spruce. Physiologia Plantarum 20: 733—745 (1965). — Wright, J. W., and Baldwin, H. I.: The 1938 International Union Scots Pine Provenance Test in New Hampshire. Silvae Genetica 6: 1—14 (1957).