growth cessation processes. Photoperiod has been recognized as a primary factor in control of growth cessation processes in many tree species (Nienstandt, 1974). Morgenstern (1969) considered temperature to be an important secondary factor in growth cessation of *Picea mariana* (Mill.) B.S.P.. The lack of perfect correlation of fall phenology dates with latitude indicates that genetic differences in dormancy initiation among populations were probably selected for in response to a combination of photoperiod and temperature regimes endemic to individual provenance locations.

A high percentage of western populations retained leaves through the 1975—76 winter *(Tables 5* and *7)*. The high degree of winter leaf retention could be a response to water limitations in the prairie environment. Deneke (1975) found that trees from the more western populations survived better than trees of eastern populations in Kansas. Water availability is the most important factor limiting growth and survival (Zimmerman and Brown, 1971). Retention of leaves in the winter would allow snow trapping during the horizontal prairie snowstorms, providing additional moisture. Also, shading from the leaves would reduce the rate of snow melt and lower soil temperature around the tree thus reducing evaporation.

Trees were observed with various levels of leaf retention indicating that leaf drop is controlled by quantitive genes and/or different processes. Auxins are responsible for the formation of the abcission layer according to research reviewed by Kramer and Kozlowski (1960). Weather conditions and the strength of the vascular connections are also factors which determine rate of leaf fall. Potential for some degree of leaf retention is present in trees from most provenances. High leaf retention in western populations is probably due to natural selection within ancestral populations. The characteristics of the Sangamon paleosol suggest that prior to the Wisconsinan glaciation, eastern North American forests may have extended further west then present day boundaries (Ruhe, 1965). Thus, the range of *Q. rubra* may have originally advanced as much as 100 miles west of its present distribution and selection favoring leaf retention likely occurred in response to decreasing annual moisture.

The rankings in the multiple range test *(Table 6)* and partial correlation coefficients *(Table 7)* involving the days between leaf flush and fall color indicate the lack of clinal variation patterns within the species for this characteristic. The number of days between leaf flush and leaf color change appears to have no meaningful biological association with leaf flushing or dormancy processes.

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Summary of results on Scots pine (Pinus sylvestris L.) volume production in Ogievskij's pre-revolutionary Russian provenance experiments

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Summary

On the basis of the available Russian literature data on volume per hectar was analysed from the provenance experiments on Scots pine (*Pinus sylvestris* L) established in pre-revolutionary Russia in the years 1910—1916 by V. D. Ogievskij. Using the latest published data on volume/ha for each provenance the deviation from an experimental mean in units of standard deviation was calculated. These deviations are presented graphically for individual provenances on maps showing the location of the planting sites within a schematic outline of Imperial Russia. By using this method it is possible to compare simultaneously the productivity and adaptability of the studied provenances. In general local provenances have had a relatively satisfactory growth. The analysis has generally confirmed the earlier reports made separately from various planting sites that pine provenances from the pre-revolutionary provinces Volynia, Minsk, Mogilev and Chernigov are of exceptional value. Also good are provenances from the Baltic region and from a narrow belt between latitudes 54° and 57° (provinces Moscow, Vladimir, Nizhni Novgorod, Kazan, Samara). The outlier provenances from the southern fringe of the range had poor survival and growth. Northern provenances, particularily beyond 60° Lat., in spite of good survival are useful only locally due to very poor growth. Decidedly the worst provenances were those from provinces Vologda, Viatka and Perm. The northwestern and southeastern provenances have generally grown below average and those from central Poland were around average. The information gathered allowed us to divide the range of Scots pine in the former Imperial European Russia into 5 zones on the basis of volume production and adaptability. The most adaptable and productive provenances originate from the zone of mixed forests. The results were discussed in the light of a review of literature on Russian provenances of Scots pine.

Key words: Pinus sylvestris, provenance, adaptability, Genotype × environment interaction.

Zusammenfassung

Zusammenfassung der Ergebnisse über den Massenzuwachs der gemeinen Kiefer (*Pinus sylvestris* L.) in Ogievskij's vorrevolutionären russischen Provenienzversuchen.

Angaben über den Massenzuwachs/ha in Kiefernprovenienzversuchen *(Pinus sylvestris* L.), angelegt im vorrevolutionären Rußland in den Jahren 1910—1916 von V. D. Ogievskij, wurden auf Grund der verfügbaren russischen Literatur zusammengefaßt und analysiert. Die neuesten Literaturangaben wurden berücksichtigt und die Abweichungen der Massenleistungswerte/ha vom Versuchsflächenmittel wurden in Einheiten der Standardabweichung ausgedrückt. Diese Abweichungen sind getrennt für jede Provenienz in Landkarten der Provinzen des Kaiserlichen Rußland eingezeichnet worden, die alle Versuchsorte umfassen. Auf diese Weise wurde es möglich, die Massenzuwachsleistung und die Anpassungsfähigkeit der einzelnen Provenienzen gleichzeitig zu vergleichen. Es stellte sich dabei heraus, daß sich im allgemeinen die lokalen Provenienzen durch relativ befriedigende Wuchsleistung auszeichneten. Die Analyse bestätigte im großen und ganzen die Angaben der früher getrennt veröffentlichten Berichte über Ergebnisse aus den Messungen an verschiedenen Versuchsorten, aus denen hervorging, daß sich Kiefernprovenienzen aus den vorrevolutionären Provinzen Wolhynien, Minsk, Mogilew und Tschernichow durch hervorragende Massenwuchsleistungen auszeichnen. Wertvoll sind auch Herkünfte aus dem Baltikum und aus dem schmalen Landstreifen zwischen den geographischen Breitengraden 54° und 57° (Provinzen Moskau, Wladimir, Nischni, Novgorod, Kasan, Samara). Die vom südlichen Teil des natürlichen Verbreitungsgebietes isolierten Provenienzen wuchsen schlecht und die Zahl der Ausfälle war groß. Die nördlichen Provenienzen, besonders aus Gegenden nördlich des 60. Breitengrades sind trotz guten Überlebens nur von lokaler Bedeutung, weil ihre Wuchsleistung sehr schwach ist. Die absolut schlechtesten Kiefernherkünfte stammen aus den Provinzen Wologda, Wiatka und Perm. Die nordwestlichen und südöstlichen Provenienzen weisen Leistungen auf, die unter dem Versuchsmittel liegen, und die aus Mittelpolen stammenden, schwanken um diesen Mittelwert herum. Die erhaltenen Ergebnisse in Massenleistung und Anpassungsfähigkeit ermöglichen es, das Verbreitungsgebiet der gemeinen Kiefer im ehemaligen kaiserlichen Rußland in 5 Zonen einzuteilen. Die produktivsten und anpassungsfähigsten Herkünfte stammen aus der Mischwaldzone. Die Ergebnisse werden im Lichte einer Nachprüfung der Literaturangaben über die russischen Provenienzen der gemeinen Kiefer diskutiert.

Р е з ю м е

На основании доступных советских литературных источников анализируются данные по запасу/га в провененционных опытах сосны обыкновенной /Pinus sylvestris L. / заложенных в дореволюционной России в 1910-1916 гг. по инициативе В.Д. Огиевского. Используя последние из опубликованных данные по запасу для каждой из провененций подсчитано в единицах стандартного отклонения, отклонение от средней для данного варианта опыта. Величины этих отклонений по каждой из провененций представлены графически на схематических картах б. Русской Империи. Благодаря применению этого метода возможным является одновременное сравнение запасов и пластичности исследуемых провененций. В общем местные провененции показали относительно хорошие результаты. Проведенные сравнения до некоторой степени подтвердили мнение высказываемое ранее на основании анализа данных по отдельным опытным площадям, о хорошей продуктивности провененций с б. губерний: волынской, минской, могилевской и черниговской. Хорошими оказались также провененции балтийские и из узкой полосы между 54° и 57° сев. шир. /б. губерни: московская, владимирская, нижнегородская, казанская и самарская/. Плохими показателями прироста характеризуются островные провененции южной части ареала. Северные провененции, особенно севернее 60°, несмотря на хорошую сохранность, в результате очень замедленного прироста перспективны для применения лишь по месту сбора семян. Самыми плохими на большинстве опытных участков оказались провененции с б. губерний: вологодской, вятской и пермской. Северо-западные и юго-восточные провененции росли плохо, а с центральной Польши занимают среднее положение. Сумма сведений полученных в результате сравнения исследуемых провененций послужила для разделения территории б. Русской Империи на 5 зон по величине запаса и пластичности в условиях провененционных опытов. Самые продуктивные и пластичные провененции происходят с зоны смешанных лесов. Полученные нами результаты обсуждаются на основании литературных источников по русским опытам с сосной обыкновенной.

Introduction

Having reviewed the IUFRO provenance experiments on Scots pine (Giertych 1979) it is natural that our interests turned eastwards, to Ogievskij's great series of provenance experiments established in pre-revolutionary Russia. The history of Poland has resulted in our provenances being included in both the west European (IUFRO) and east European (Russian) experiments. Thus it is on the example of our pine races that the degree of concurrence of results of these two separate research efforts is best seen.

It is the unfortunate fate of forest experiments that with the death of the man who established them they tend to become forgotten. This is true both East and West and the problems of tracing records are akin. When history is as turbulent as that of Eastern Europe in the XXth. century the task becomes formidable indeed.

It is hardly surprising therefore that so few efforts were made to review these old Russian experiments. The first to do so was Samofal (1924, 1925) who analysed jointly the results from 3 locations. This is the only paper that has been known better in the west due to being quoted extensively in Wiedemann's (1930) and Kalela's (1937/1938) review papers. Then came a paper by Obnovlenskij (1940 b) reviewing data from 4 locations and finally by Fomin (1940) with data from 7 locations. The latter is not only the most extensive review but it is also the most knowledgable and best organized one. It deserves to be known better. Having appeared in 1940 it became almost completely forgotten. It is quite unknown in the West and even in the USSR it is scarcely ever quoted. As far as we know there were no more reviews after that. One cannot help quoting Fomin (1940) in this context: "Extent of provenance experiments established in Russia surpasses those done elsewhere both in terms of number of locations and number of provenances, yet the extent to which they were studied and to which the results were put to practical use leave much to be desired". These words remain true till this day.

One must also add two further advantages of the Russian experiments over the western ones. Seed collected at the beginning of XXth century comes almost certainly from indigenous trees, since in early or mid- XIXth century seed transfers were not practiced there. Also the Russian experiments had large plots so that in all cases an estimate of volume production per unit area was possible.

However there are also disadvantages relative to IUFRO experiments. The pre-revolutionary Russian studies used a province (gubernja) as the basic unit and not a stand. Seed from several stands in one province were usually pooled together or used alternatively at different locations. Exact origin is in most cases unavailable. Thus a knowledge of the pre-revolutionary province frontiers is needed in order to define the provenances. *Fig. 1* shows the split up of the European part of the Russian Empire into provinces, with the names given to those provinces that are mentioned in this paper.

There were two major efforts to study Scots pine provenances in pre-revolutionary Russia.

The first in the years 1877-92 was by M. K. Turskij (Timofeev 1974). In compartments 4 and 5 of the Petrovskaja Agricultural and Forest Academy (now Timiriazev Rural Academy, Lat. 55°50', Long. 37°14') he established permanent sample plots where pine provenances were studied. An area with 4 provenances, Arkhangelsk, Moscow, Kiev and Lublin was established in 1883 in Comp. 5. On this plot the last assessment available to us was made in 1938 (Obnovlenskij 1951 a, b; Timofeev 1973).

In comp. 4 Turskij planted provenances Vladimir, Tambov, Moscow and Germany in 1889, Vologda, Kostroma, Vladimir, Moscow, Livland and Germany (Erfurt) in 1880, Vladimir and Vologda in 1891, and Moscow, Vladimir, Perm and Arkhanggelsk in 1892. Results for 80 years old trees of some provenances from this study were published by Timofeev (1974).

Turskij's experiments are primarily of historical interest. They are oldest existing experiments with continued periodic reports (Nesterov 1912, 1935; Obnovlenskij 1951 a, b; Timofeev 1965, 1973, 1974, 1975). We shall try to use results from them in the discussion. Papers by Nesterov (1935) and Timofeev (1965) have maps indicating location of these experiments.

Basic data on Ogievskij's experiment

The second Russian series of provenance experiments on Scots pine, which so far is the largest made ever, was established in the years 1910—1916 by V. D. Ogievskij of the St. Petersburg Institute of Forestry. It included at least 45 provenances and was established on about 20 locations (Ogievskij 1910, 1911, 1912, 1913, 1914, 1915, 1916;

Fig. 1. — Frontiers of European provinces (gubernjas) of pre-revolutionary Russia with the names used in this paper indicated.

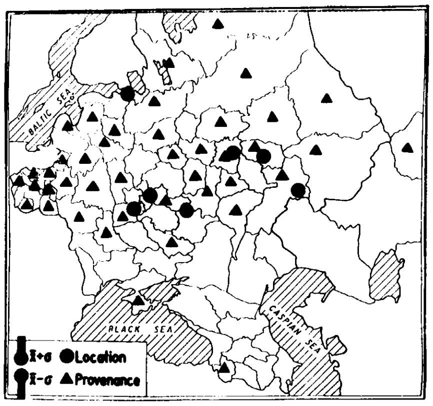

Fig. 2. — Location of OGIEVSKIJ's Scots pine provenance experiments (black circles) and of the provinces from which seed material was used (triangles). The magnitude of one standard deviation from the experiment mean shown in the legend defines the units used in the presentations on figures 4—11.

SANNIKOV 1966). Very few of these are known to exist and they are definitively under exploited. We have traced publications with volume production data per hectar for 7 of these locations and it is on these that this paper is based. *Fig. 2* indicates the 7 locations of the experiment and the provinces from which the seeds were collected for them.

Since so little is known about this magnificent study we believe it necessary to introduce the western reader to details of the whole experiment and the literature pertaining to it.

In the years 1907—1909 A. N. SOBOLEV, head of the Chair of Silviculture of the St. Petersburg Institute of Forestry has established a provenance experiment on spruce in the experimental park of the Institute (SAMOFAL 1925) and then in the Ohtenskoe experimental forest a study of pine including 23 provenances from European Russia, France and Germany. Simultaneously experiments were also lied out on larch and oak (RED'KO 1974). The death of A. N. SOBOLEV in 1911 and the loss of all documentation of these experiments make it impossible to draw any results from them (RED'KO, personal information).

The studies started by A. N. SOBOLEV have been continued by his successor V. D. OGIEVSKIJ (*Fig. 3*) under whose supervision in the years 1910—1916 several provenance experiments on Scots pine and other species were established in various parts of European Russia. The purpose of the investigation was to answer the following questions (SANNIKOV 1957):

1. Is it possible to obtain healthy stands giving wood of high quality using seeds collected far from the planting site?
2. Does Scots pine found in various parts of Russia represent different "geographic species", or is there only one species characterized by considerable variability depending on geographic conditions?

The establishment of these experiments was discontinued in 1916. The two World Wars and the civil war have resulted in that out of about 20 planting sites only few remain.

Methods of establishing the experimental area

In order to obtain seeds for the experiment V. D. OGIEVSKIJ has sent letters to foresters in various parts of Russia asking to select pine stands typical for the Forest District, to describe them on an enclosed questionaire, to collect about 4—5 buckets of cones, to extract the seeds by the method considered best in the Forest District and to send them to the Station of Seed Control of the Forest Department (OGIEVSKIJ 1911 a, b, 1912, 1913, 1914, 1915).

In the experiment use was also made of seeds sent to the above Station for the checking of quality. This type of seeds however were used only when all the needed information about their origin was available.

In order to reduce errors in the collection and preparation of seeds by incompetent people each of the studied regions was represented by several Forest Districts.

The experimental areas were usually established on flat ground. An attempt was made to employ in planting only a small group of labourers under the supervision of technicians. It has to be underlined however that the uniform method of planting was maintained only in the case of areas that were established under personal supervision of OGIEVSKIJ himself or his close associates. In some of the Forest Districts which received seeds for planting, in spite of the fact that they were chosen for the quality of

Fig. 3. — Photograph showing Prof. V. D. OGIJEVSKIJ supervising the establishement of experiments. Archival photograph by curtesy of Prof. G. I. RED'KO.

Table 1. — Location of planting sites. There are some discrepancies in reports by different authors.

Pre-revolutionary Forest District	Present province (oblast)	Lat. N	Long. E	Author
Ohtenskoe	Leningrad	59°57’	30°00’	Obnovlenskij 1940 b
		59°57’	30°25’	Fomin 1940
Lykovskoe	Gorki	56°20’	44°12’	Losickij 1951
		approximate		
Kazanskoe	Tatar Aut. Rep.	55°30’	48°10’	Obnovlenskij 1940 b
		55°50’	48°10’	Fomin 1940
Brianskoe	Briansk	53°12’	34°35’	Obnovlenskij 1940 b
Borovoe	Orenburg	53°00’	52°30’	Obnovlenskij 1940 b
		52°50’	52°30’	Fomin 1940
Faščevskoe	Lipeck	52°25’	39°20’	Fomin 1940
Sobičskoe	Suma	51°52’	33°30’	Obnovlenskij 1940 b

local foresters, certain changes were introduced into the method of establishment. Detailed information concerning the differences and descriptions of the planting sites are given below.

On the basis of publications which appeared in the last 60 years from this study we were able to find results of volume measurements from only 7 Forest Districts with experimental areas. Geographic coordinates of these are shown in *Table 1* and their location in *Fig. 2*. The last published data from these areas are shown in *Table 4*.

Ohtenskoe Forest District

The Forest District lies in the eastern suburbs of Leningrad. The forest is a typical one for the natural conditions of northwestern USSR. Climate in this region is a transitory one between a continental and a maritime one. Frequent changes in air masses coming from various directions are the results of large fluctuations of weather even over short periods of time (Red’ko et al. 1975).

Ogievskij established several experimental areas in this Forest District with Scots pine provenances. Two of these are still existing.

In Compartment 8 an experiment was established in 1913 on an area of 1.4 ha with 16 provenances. The area was clearfelled in 1912 and 1-year old pines were planted at a 1.42 × .35 m spacing which corresponds to a stocking of 20.000 per ha. Actually the planting was made into hand made .40 × .40 m pits with two seedlings per pit. The whole area was divided into 5 parts between which gaps of 4.5 m were left. An accurate description of the plan of the experiment and data on latest results are to be found in a script prepared for summer practices of forestry students from Leningrad (Red’ko et al. 1975). In 1921 and 1932 in the experimental area thinnings were performed removing also pines and other species that seeded in naturally (Obnovlenskij 1940 b).

In Compartment 33 another experiment was established by sowing in 1913 on an area of 2.82 ha, using seeds from 5 provinces. The area was clearfelled in 1911 and the soil was prepared for sowing by raking 0.35 m strips 1.42 m apart. The sowing was made in the strips every 0.35 m.

A detailed analysis of other experimental areas in the Forest District has shown (Red’ko et al. 1975) that they are unsuited for further analyses. The cause was primarily the considerable devastation of parts of the forest by the expansion of urban Leningrad and the proximity of polluting chemical plants (Podzorov 1965, 1966, 1973).

The provenance experiments established in this Forest District have been regularily under investigation due to the proximity of the Leningrad Forest Academy which uses the area as its experimental forest. Publications from this study were numerous (Samofal 1924, 1925, Fomin 1940, Obnovlenskij 1940 b, Preobrazenskij 1950 a, b, 1959, Sannikov 1957, 1958, 1966, Podzorov 1963, Branovickij 1974, Red’ko et al. 1975).

Table 2. — The split up of provenance sample plots in Forest District Sobičskoe into groups as identified by various authors in the literature.

Year of seed sowing	1910	1911	1912	1912	1912	1912	1913	1913	1913	1914	1915
Old Comp. no.		32	32	49	25	32	32	44	44	52	42
New Comp. no.		46	46	41	39	46	46	25	25	26	36
Sample plots	68	355	287	379	110	254	277	395	391	409	416
		356	288	380	383	255	280	396	392	410	
		357	289	381	384	256	387		393	411	
		358	290			257	388		394	412	
							389			413	
							390			414	
Author											
Samofal 1925	а	б	в	г	д	д	е-ж	з	—	и	к
Wiedemann 1930	2	3	1	4	5	—	—	—	—	8	11
Kalela 1937	III	II	I	—	V	IV	—	—	—	VIII	—
Sannikov 1957, 1966	—	б	а	в	г	—	е	—	ж	и	к
Patlaj 1977	—	—	—	в	—	г	—	и	з	к	к
Giertych and Oleksyn	A	B	C	D	E	F	G	H	I	J	K

Table 3. — Description of groups of provenance sample plots in Forest District Sobičskoe.

Identification of variants as in *Table 2*	Type and age of material	Year of establishment	Spacing	Soil preparation	Age when last measured	Notes
A	2-yr seedl.	1912	1.0 × 0.5	ploughed	14	Data found only in Samofal 1925
B	1-yr seedl.	1912	1.5 × 0.5	turf removed	45	
C	seeds	1912	1.5 × 0.5	" "	44	Groups of 20 seeds sown, reduced to 3 seedlings after 3 years
D	1-yr seedl.	1913	1,0 × 0,5	" "	60	
E	1-yr seedl.	1913	1,0 × 0,5	ploughed	44	
F	1-yr seedl.	1913	1,0 × 0,5	"	60	Provenances Minsk and Vladimir had a spacing 1.0—0.25
G	1-yr seedl.	1914	1.25 × 0.25	"	43	
H	1-yr seedl.	1914	2 × 1 plots spaced 3 × 2.5	turf removed	59	On each plot 50 plants were planted
I	1-yr seedl.	1914	rows 1 m apart		59	
J	1-yr seedl.	1915	2 × 1 plots spaced 4 × 5	turf removed	58	On each plot 25 plants were planted
K	1-yr seedl.	1916	2 × 1 plots spaced 4 × 5	" "	57	On each plot 50 plants were planted

Lykovskoe Forest District

The pine provenance experiment was established here in 1913 on an area clearfelled in 1911. The pine was sown, ten seeds per 5.5 × 0.5 pit, with the 14 provenances having plots 0.016 to 0.037 ha in area. The area has a slight slope in the southeasterly direction. The soil is sandy, strongly podsolic.

As far as we know there is only one publication from this experiment (Losickij· 1951) and all the information we have come from it. The coordinates given in *Table 3* are only approximate, extrapolated from the distances Losickij quotes from some towns.

Losickij gave his results separately for four site types distinquished by him in the area. We have made only two groups out of this (*Table 4*) differing in moisture status. The variation of data for the same provenances within these two groups showed no major differences.

Kazanskoe Forest District

The provenance experiments on pine were established in this Forest District in the years 1915—1916 using two year old plants raised in a local nursery. The area was clearfelled in the years 1910—1911. The soil is sandy podsolic. The climate is a continental one with a long winter, rapidly entering spring, a hot summer and frequent spring and autumn frosts (Fomin 1940).

The seedlings were planted 8000—8800 per ha at a spacing of 1.05 × 1.05 m and 1.19 × 1.05 m. A more detailed description of these experiments is to be found in the paper by Murzov et al. (1975). Earlier Fomin (1940) described the area and there are some discrepancies in the two descriptions. They concern primarily the number of experiments, time of planting out and number of provenances. It appears Murzov et al. did not know the paper by Fomin. In 1948 measurements were made there by Starčenko (1952). However the data presented by the latter author are of limited utility since they do not give original measurements but only percentage deviations from a local provenance and for groups of provenances only. Murzov et al. (1975) were unable to reach at the data even from Starčenko's manuscripts because provenances are grouped without specifying what the groups include.

Murzov *et al.* (1975) recognize two variants in the experiment differing in the year of establishment. The first one with 16 provenances was established on a more southern plot in 1916 or in 1915 according to Fomin (1940). The latter author does not mention provenance Mogilev while Murzov reports data for 6 seed lots from that province. The other variant comprising 10 provenances was established on a more northern plot in 1915 or in 1916 according to Fomin (1940). Murzov et al. (1975) provide data on two seedlots from the Kars province while Fomin (1940) basing on an evaluation made in 1935 claims that all the trees from that provenance have died. Murzov et al. (1975) have excluded from consideration three provenances, Volynia, Orel and Smolensk, located on a forest edge, and being in a poor state of conservation.

Brianskoe Forest District

Two experimental series were established here in the years 1912—1913. The climate is a moderately cold one (Fomin 1940). The planting material were 1 year old pine seedlings raised in a local nursery primarily from seeds supplied by V. D. Ogievskij. Only in a few cases the seeds came directly from the place of origin. In Compt. 10 of this Forest District (poor site, type *Pinetum vacciniosum* and *Pinetum vaccinio-myrtillosum),* in 1913 an experiment was established representing 16 provinces and in 1912 in Comp. 16 (fertile site, type *Pinetum tiliosum)* with pine from 5 provinces. The planting spacing was 0.45—0.53 × 1.40 m, that is about 13.000 plants per ha.

A plan of the experimental areas, location of their site type variants, a description of the mother stands and the assesment made at age 23—24 years of heights, diameters and numbers of trees are given in the paper by Obnovlenskij (1940 a). In Fomin's (1940) paper the volume per hectar is also given. Obnovlenskij also wrote on this experiment in 1951 a, b, 1953.

Borovoe Forest District

This Forest District is part of the famous Buzulukskij Forest. The climate here is a severe continental one. Frosts occur in May and September, more rarely in June and August. Only July is free of frost danger. The transition from winter to spring is a very rapid one.

The experimental areas were established in 3 compartments. The first one having 0.8 ha is in Compt. 75 on a *Pinetum subinundatum* site type. The soil is a sandy chernozem. Two years old seedlings were outplanted in 1914 at a spacing of 1.07 × 0.53 m, that is at about 17,800 plants per ha.

Table 4. — Average volume per hectar in OGIEVSKIJ's Scots pine provenance experiments.

Forest District	Othenskoe		Lykovskoe		Kazanskoe		Brianskoe		Borovoe	
Plot site	Planted	Sown	Dry	Moist	S	N	Poor	Fertile	1914	1915
Age when measured	61	61	37	37	56	57	23	24	23	22
Akmolinsk										
Arkhangelsk										79
Chernigov			200			344				
Grodno	248		41		264		147		179[1])	
Kalisz							137			
Kars						261[2])				
Kazan					269	306	113,5	168	224	351
Kharkov								88		
Kielce					250					
Kiev	216			141					200	
Kostroma		97								
Kurland					236		139			
Livland										
Lublin	212			159	238					
Lomza	244[3])	169								
Minsk		278		142						221[4])
Mogilev			97		292					
Moscow	193									
Nizhni Novogorod			167	223	218					
Novgorod						291				
Olonets	294						48	31		
Orel	280							159	284	
Penza					140					
Perm	228			145	188	185	32,5		122	
Plock					349					
Pskov										
Ryazan		135					122[10])			
Samara							90,3		294	385
Saratov				117						
Siedlce	124									
Suwalki				156	287	329				
Tambov	168				248		147		192	215
Tavrida						263[11])				
Tver		150								
Ufa							125		191	
Viatka	333			185	266		125,5		167	198
Vilna			55		267	254	164[12])			
Vitebsk						240				
Vladimir	110			209	282	285			265	
Vologda	252									
Volynia	289		81				150,5	122	221[16])	
Warsaw					148				217[18])	
Mean	227,9	165,8	106,8	164,1	246,4	275,8	118,6	113,6	213,0	241,5
Literature	48	48	18	18	19	19	9	9	9	9

1) From Grodno and Suwalki provinces treated together
2) Possibly from natural regeneration after death of experimental material
3) Extrapolated from data on height, basal area and no. of trees.
4) This is a NW Bialorussian provenance with no data on pre-revolutionary province whence it came.
5) From Minsk, Volynia and Chernigov provinces treated together
6) From Mogilev and Minsk provinces treated together
7) From Nizhni Novgorod and Kazan provinces treated together
8) From Novgorod and Vitebsk provinces treated together
9) From Penza and Saratov provinces treated together
10) From Ryazan, Vladimir and Moscow provinces treated together

The second plot 0.1 ha in area is in Compt. 84, within an old nursery, now an arboretum. The site conditions are similar as above but the soil is somewhat richer. Two year old seedlings were outplanted in the Spring of 1915 at a spacing of 1.07 × 0.74 m i. e. 12,000 plants per ha.

The third experiment was established in Compt. 26 on a *Pinetum declino-pleuroziosum* site type. The soil is sandy here, poor and dry. The water table is very low. Two years old seedlings were outplanted in 1916 at a spacing of 1.07 × 0.53 that is 17,800 per ha.

Faščevskoe			Sobičskoe							
1916	1915	1916	B	C	E	D + F	G	H + I	J	K
21	22	21	45	44	44	60	43	59	58	57
										184
64			409	450	359	506		414	519	350
					353		353			
23		15								
	121	207	318	304				272		445
										166
				342	332	401		402	437	
	79							223		
							316			
								412		
	111[5])		428	380			296	368		352
	105[6])									
81[7])										
55[8])		239								
	97									
	115[9])						298			
41	85	19			105		206		250	176
									457	
				274						331
104	114	155			116					
				283			308		420	303
		174						376		
	154	199		316	289	371				380
	124									
	83	193						167		309
	116[13])				375[14])					407[15])
57		122			340	470	363		419	409
			71			177				
	116[17])				440		359			
	114[19])									
60,7	109,6	147,0	306,5	335,6	301,0	385,0	312,4	329,3	417,0	317,7
9	9	9	55	53	53	37	55	37	37	36

11) Possibly from natural regeneration after death of experimental material
12) From Vilna and Suwalki provinces treated together
13) From Vilna, Suwalki and Kurland provinces treated together
14) From Vilna and Kovno provinces treated together
15) In Samofal's and Sannikov's papers this plot is referred to as coming from Vilna province but Patlaj refers to it as Volynia
16) From Volynia and Grodno provinces treated together
17) From Volynia, Minsk and Grodno provinces treated together
18) From Warsaw, Radom, Kielce and Płock provinces treated together.
19) From Warsaw, łomza and Kielce provinces treated together.

The planting material was raised in a local nursery in a similar manner.

Apart from the three experimental areas mentioned above in this Forest District an experiment was established with seed obtained from Cieslar, Austria. Ten small plots were planted with two rows representing one provenance. The study included seeds from Hungary, Poland Austria and France. According to Fomin (1940) these trees perished almost 100% and the remaining ones are crooked and generally useless.

Volume data from experiments in Borovoe Forest District were written upon by Fomin (1940) and Obnovlenskij (1940 b). The latter paper is difficult to interpret because instead of pre-revolutionary provinces Obnovlenskij used imprecise descriptions of regions. For example what he describes as "eastern Germany" probably concerns former province Kalisz, which at the time, in 1940, was incorporated into Wartegau and the Reich and not treated as occupied territory together with the rest of central Poland. In a paper by JUNAŠ (1953) 1947 and 1949 measurements are given on height and diameter but without volume per hectar. There are some disagreements with FOMIN (1940) in the list of provenances employed and their grouping, thus we have not used the data of JUNAŠ (1953).

Faščevskoe Forest District

This Forest District lies in a moderately dry climate (FOMIN 1940). Two experimental areas were established there. The first is in Compt. 86 (formerly Compt. 115) on a sandy soil. Two years old plants were outplanted in 1915 at a spacing of 1.07 × 0.53 m i. e. 18,000 plants per ha. The seedlings were planted on a clearfelled area that was temporarily under agriculture. On 2.1 hectars 39 seed lots were planted.

The second area (0.95 ha) was established in 1916 on a clearfelling made in 1912 using 12 seed lots and 2-year old plants. The spacing was the same as above.

On experiments in this Forest District both FOMIN (1940) and OBNOVLENSKIJ (1940 b, 1950) wrote.

Sobičskoe Forest District

Provenance experiments were established in this Forest District in the years 1910 to 1916. The climate is a moderately continental one. It is under the influence of Atlantic air masses. Winters are moderately cold. In all 49 experimental areas were planted here including about 200 experimental variables (SANNIKOV 1966). The state of conservation of these experiments is fairly satisfactory. They were under good local care and the District is far from major roads and urbanized regions. SAMOFAL (1925) has combined some of the experimental variables into groups on the basis of planting year, spacing and site conditions.

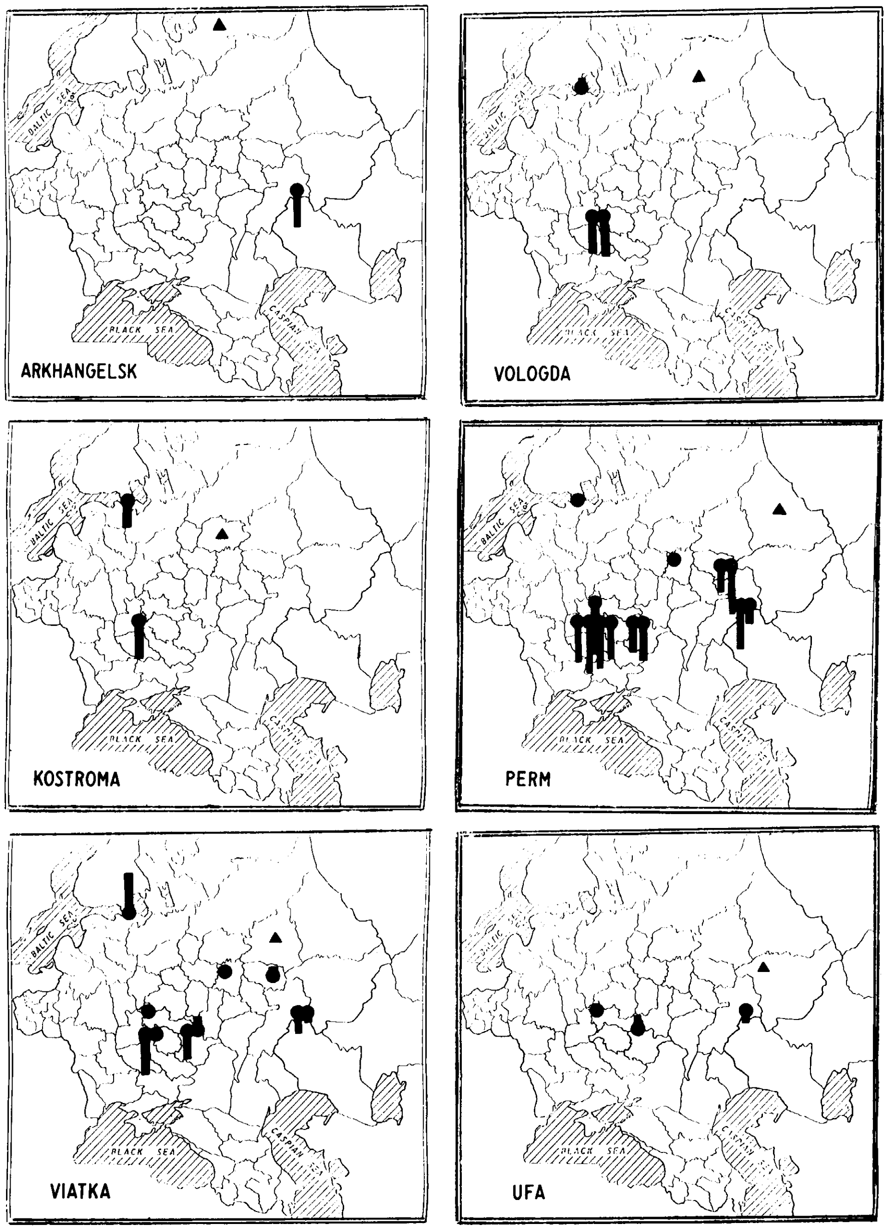

Fig. 4. — Maps showing the preformance of pine from various northern and northeastern provinces of European Russia in various experiments. A black circle indicates a deviation from the experimental mean of less than 0.30 standard deviation. The magnitude of one standard deviation is defined in *fig. 2*. Triangle indicates province from which pine was tested in the given experiments.

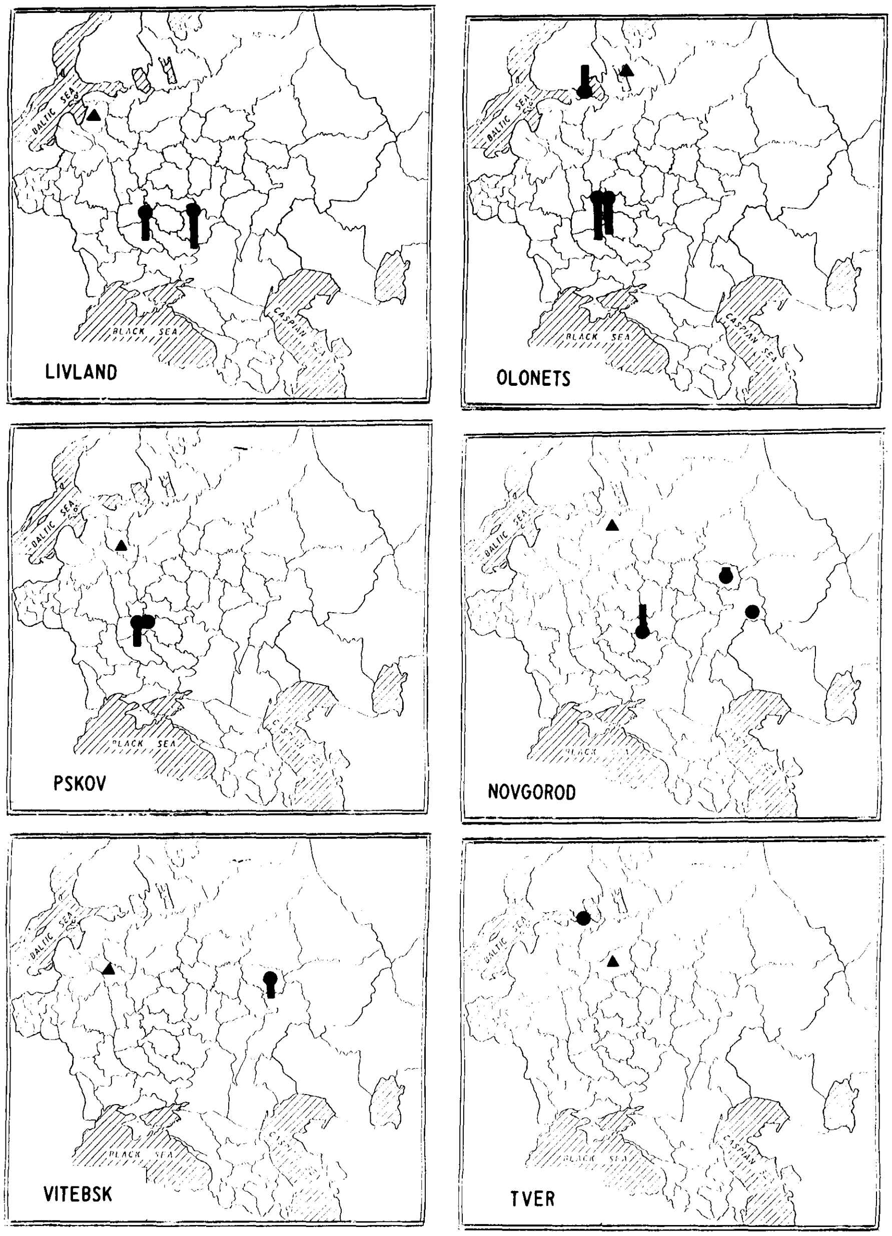

Fig. 5. — Maps showing the performance of pine from various northwestern provinces of European Russia in various experiments. Explanation of signs in subscript to *fig. 4.*

The initial documentation of these experiments was partially lost. In the years 1954—55 these were reconstructed for almost all of them on the basis of earlier publications and local manuscripts. This information together with location maps has been published by SANNIKOV (1966). Presumably because of the loss of some records and the resultant confusion there continue to be some discrepancies between authors in the grouping of data. Authors writing in the USSR have not always correctly interpreted SAMOFAL's (1925) initial groupings and foreign authors have used the material selectively adding other groups from experiments in overgrown nurseries that SAMOFAL excluded. Consequently it was necessary to return to initial plot numbers to decipher the groups. In *Table 2* the various symboles given to these groupings by various authors are shown. We have found it necessary to give our own (capital letters) to make it clear what groups we are speaking of.

In *Table 3* a detailed description of the different variants (groupings) of the experiment is given using our symbols as defined in *Table 2*. The data in *Table 3* was obtained from the papers by SAMOFAL (1925), SANNIKOV (1957, 1966) and PATLAJ (1973, 1977). Where there were disagreements between authors we have used the data given by SAMOFAL who was a colaborator of OGIEVSKIJ and a participant in the establishment of the experiments.

When comparing the results of the different variants *(Table 4)* we have pooled together the data for variants D and F and for variants H and J. In both cases the experiments were established in the same year, using identical planting material and similar spacing.

Results from this Forest District were published several times (SAMOFAL 1924, 1925, FOMIN 1940, OBNOVLENSKIJ 1951 a, b, SANNIKOV 1957, 1966, PATLAJ 1965, 1973, 1977).

In 1931 P. K. FALKOVSKIJ has established an experiment on 0.8 ha using seed collected from 20 pine provenances used in the 1912—1916 study. This second generation study was written upon by PATLAJ (1973).

Other experimental areas

Apart from the 7 Forest Districts mentioned above we known that other experimental areas were established elsewhere.

There was one in Nikolskoe Forest District (Kiev) (Lat. 50°27', Long. 30°30') from which Samofal (1925) published height measurements at age 11—12 years. This data was later quoted by Wiedemann (1930), Kalela (1937/38) and Fomin (1940).

Ogievskij (1913) mentions also experiments established in Forest Districts Tripol'skoe (Kiev), Turskoe (Volynia), Cel'skoe (Mogilev), Kerenskoe (Penza) and in the Department of Silviculture of the Moscow Agricultural and Forest Institute. In the latter area in Comp. 10f one year old seedlings were planted in 1911 from provenances Perm, Ufa, Moscow, Vitebsk, Kiev, Kielce and western Norway. A map of the area was published by Nesterov (1935) but no results. We have not found any further mention of this experiment in the literature. Timofeev (1965, 1973, 1974) in his papers on other provenance studies in this Forest District does not mention this experiment. It is no longer shown on the map of compartment 10 published by him (1965). Presently the experimental forest of the Timiriazev Rural Academy lies inside Moscow city surrounded by the urban and industrial agglomeration that negatively affect the plant, particularily conifers, thus probably the 1911 experiment is no longer utilisable.

Sannikov (1966) mentions a few other Forest Districts where the experiments were established but giving no data. They were Severnoe (Arkhangelsk), Zaokskoe (Gorki) Veljatičskoe (Minsk), Oršanskoe (Vitebsk), Grodiščenskoe (Penza) and Duhoviščenskoe (Smolensk).

In the annual reports from the Forest Research in prerevolutionary Russia there is also information (Anonym 1911) that an area was established in the Ruda experimental station of the Novo Aleksandrijski Institute which existed in Pulkawy (Poland).

Thus there were initially at least 20 Forest Districts or research stations which participated in the experiment. By now most are presumably untracable and there may be even difficulties with some of those described above from which we have not seen any measurements made since World War II (Brianskoe and Faščevskoe). However if they are tracable every effort should be made to do so.

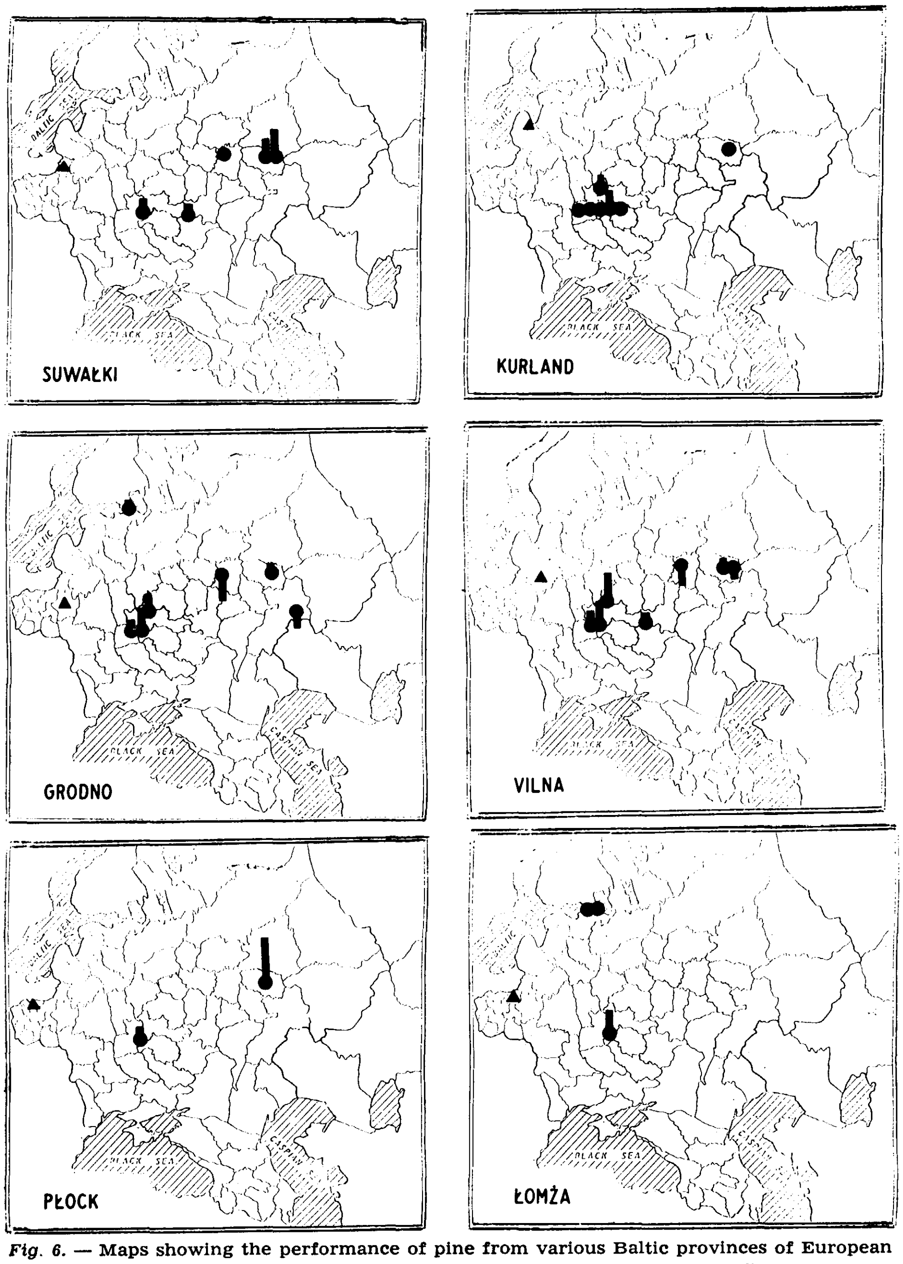

Fig. 6. — Maps showing the performance of pine from various Baltic provinces of European Russia in various experiments. Explanation of signs in subscript to *fig. 4*.

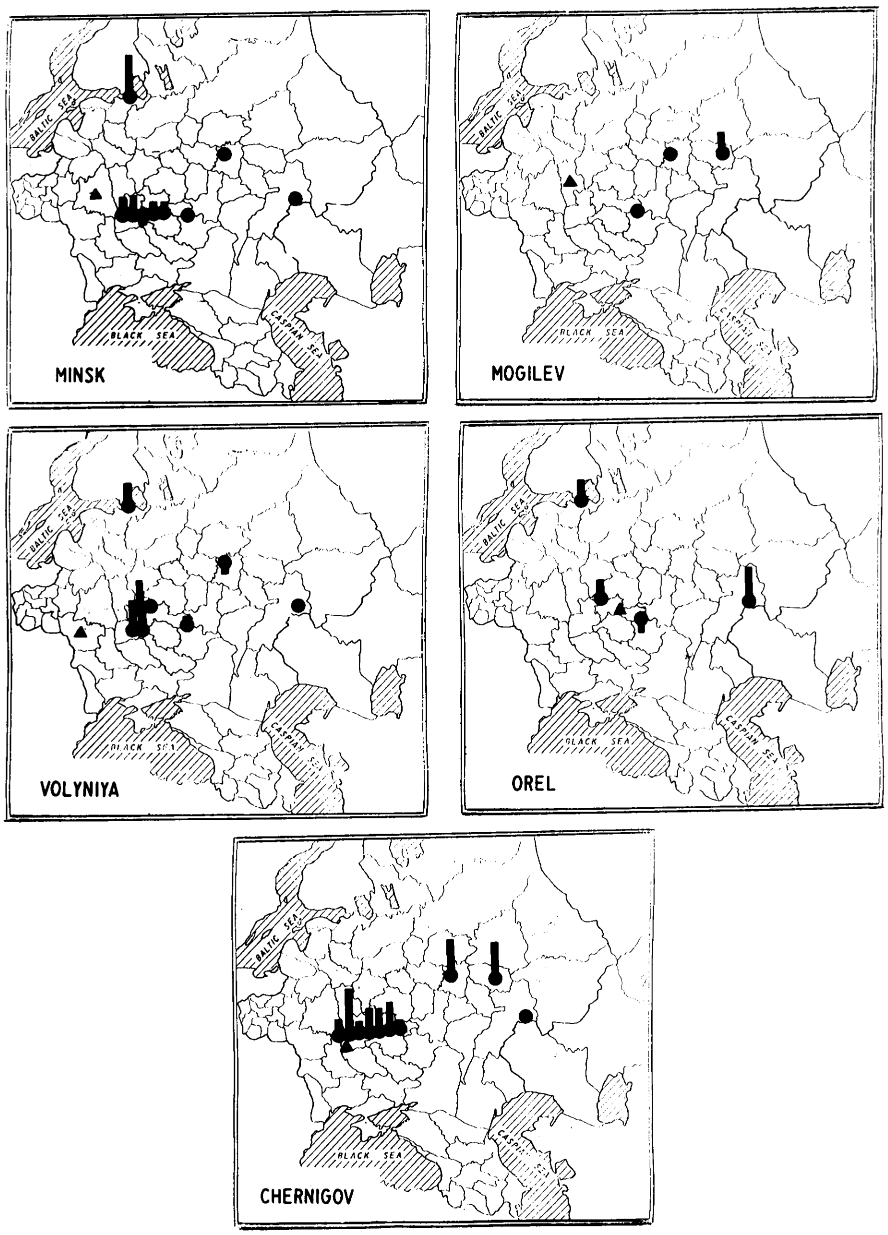

Fig. 7. — Maps showing the performance of pine from the southwestern provinces of European Russia in various experiments. Explanation of signs in subscript to *fig. 4*.

Materials and Methods

The latest published data on standing volume per unit area constituted the basic material for our investigations. *Table 4* shows this data for the 7 locations, with a split-up into variants as discussed above in the descriptions of the experiments. At all locations there were more than one experiment established. It was possible to pool together some of them, but where there were major differences in planting year, spacing or site quality it was necessary to keep the experiments separate because their averages differed and genotype × experiment interactions were expected. They were treated in the same manner as the two plots of the 1938 IUFRO experiment in Finowtal differing in planting densities (Giertych 1979). This gave us 21 variants of the experiment differing substantially in tree age at the time of the latest volume measurement that was published, ranging from 21 to 61 years. The data on these variants in *Table 4* is presented for the pre-revolutionary provinces the geographic extent of which is shown in *Fig. 1*. When an experimental variant gave separate data for two or more provenances per province these were averaged in *Table 4*. In some instances the published data was already pooled not only within a province, but for two or more adjacent provinces. In these cases the data in *Table 4* is shown for the most central or major province and all the provinces involved are indicated in the subscripts. In *Figs. 4—11* the province to which a given map refers is indicated as a triangle.

The data in *Table 4* was averaged per variant and expressed in units of standard deviation from these averages (as in Giertych 1979). The deviations are plotted for each variant onto separate maps for each province (*Figs. 4—11*). The magnitude of one standard deviation is indicated in the legend to *Fig. 2*. A black circle alone indicates a deviation of less than $\pm$ 0.30 σ. The data for variants of one location are plotted side by side in a row, always the centre of the row corresponding to the exact location. The geographic coordinates at each location are shown in *Table 1*.

Similarily as in contemporary western experiments there were no replicates in these studies. The different variants in a location, or locations themselves constitute replicates for the needs of the presentation given here.

The advantages and disadvantages of this method of presentation of data have been discussed in the review of the IUFRO 1938 Norway spruce provenance experiments (GIERTYCH 1976) and they are equally pertinent here.

Results

On the basis geography and relative volume production in the different variants and locations of the experiment the provenances (provinces) were grouped into units of 4 to 6 for the ease of data presentation. Each group of provenances is shown separately in *Figures 4 to 11*.

Starting from the north and northeast pine from provinces Arkhangelsk, Vologda, Kostroma, Viatka, Perm and Ufa *(Fig. 4)* are of very poor quality indeed. They show poorest volume production and only close to their place of origin they may have an average growth. They are decidedly unsuited for seed transfers, particularily southwards. Unexpectedly JUNAŠ (1953) reports that Arkhangelsk pine had good height, diameter and stocking in Borovoe but he gives no volume data.

Also poorly growing are pines from the northern and northwestern provinces Livland, Olonets, Pskov, Vitebsk and Tver *(Fig. 5)*. These are more consistently satisfactory when planted locally, for example near Leningrad, and the Novgorod pine is also relatively fair when transferred southwards.

Further south there is a much better pine. Among these there are the western provinces Suwalki, Kurland, Grodno, Vilna, Plock and Lomza *(Fig. 6)*. Presently this region lies in northern Poland and the Baltic Republics. Pine growing there is highly productive on a variety of sites. Only northward transfers and very far to the east require caution.

Further in the south there originate the decidedly most productive and highly adaptable pine races from provinces Minsk, Mogilev, Volynia, Orel and particularily Chernigov

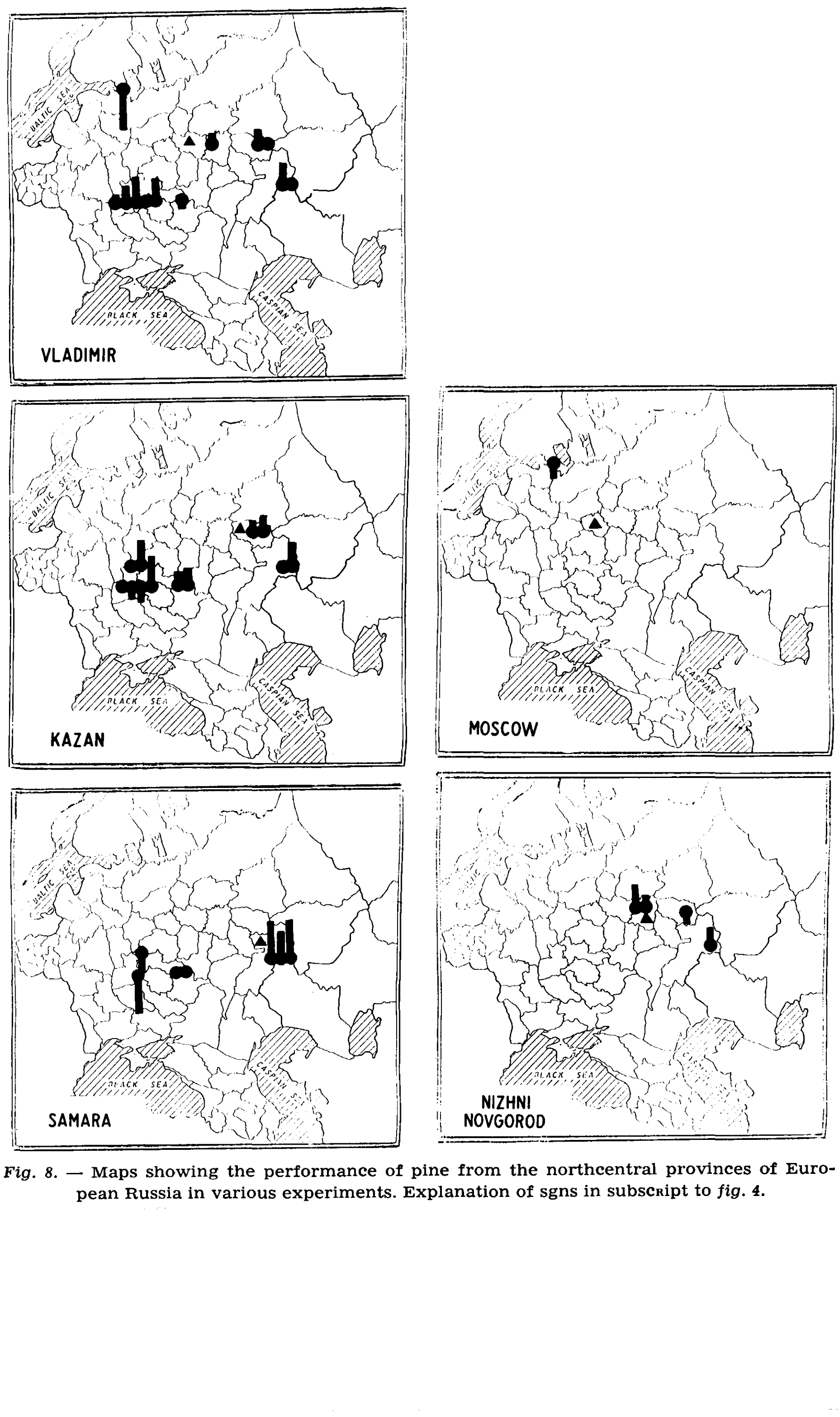

Fig. 8. — Maps showing the performance of pine from the northcentral provinces of European Russia in various experiments. Explanation of sgns in subscript to *fig. 4*.

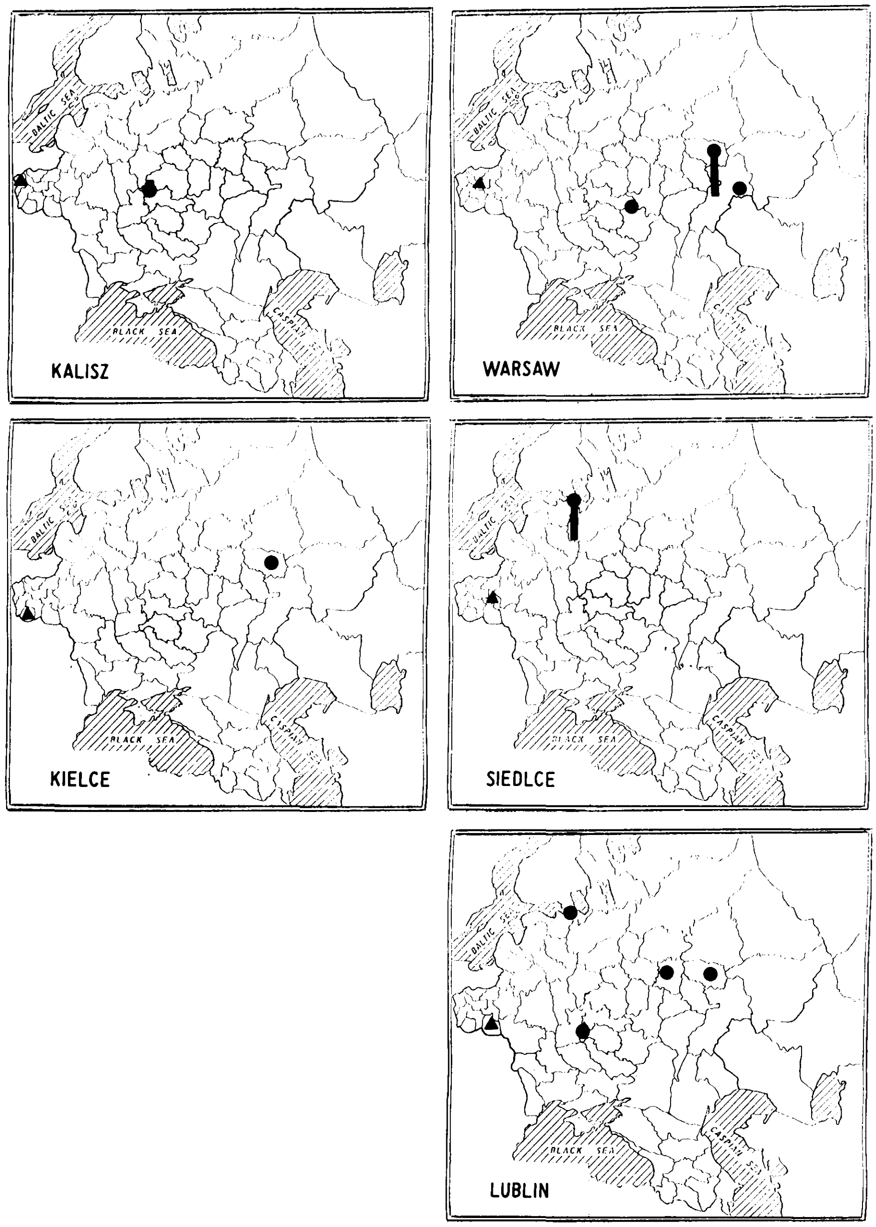

Fig. 9. — Maps showing the performance of pine from the central Polish provinces of Imperial Russia in various experiments. Explanation of signs in subscript to *fig. 4*.

(Fig. 7). There appear to be few restrictions in seed transfer possibilities, even northwards and far to the east. Pine from Chernigov province has been treated as the local one for the experiments in Sobičskoe Forest District, which has been studied and written about most. Thus the performance of Chernigov provenance in Sobičskoe is often quoted as evidence for the value of local races. Here it appears that the provenance is good not only locally but wherever tested, and this concerns not only the pine from Chernigov but also from several provinces northwest of it.

In the northcentral region there exists a string of productive provenances of Scots pine from provinces Vladimir, Nizhni Novgorod, Kazan and Samara *(Fig. 8)*. The pine races from that region are very productive locally and suitable for longitudinal transfers except for the easternmost population from Samara that is not too good when moved far to the west. Provenances from this region including Moscow are generally unsuitable in the North.

From the most westerly provinces Kalisz, Warsaw, Kielce, Siedlce, Lublin (now in central Poland) the pine populations are not exceptionally good *(Fig. 9)*. They are interesting in that they are of medium growth wherever planted, thus extensive transfers are possible except northwards, but nowhere is the volume production truly satisfactory.

At the southern fringe of the continuous range of Scots pine in provinces Ryazan, Penza, Tambov and Saratov *(Fig. 10)* there originate pine populations that have poor volume production in all experiments. Only the Tambov provenance is satisfactory locally. This group of populations represents the southern fringe of an already disjointed range of Scots pine *(Fig. 12)*.

Finally there is a group of outlier pine populations from provinces Kiev, Kharkov, Tavrida (Crimea), Kars (now in Turkey) and Akmolinsk, which are very poorly growing *(Fig. 11)*. The population from Akmolinsk is the only one

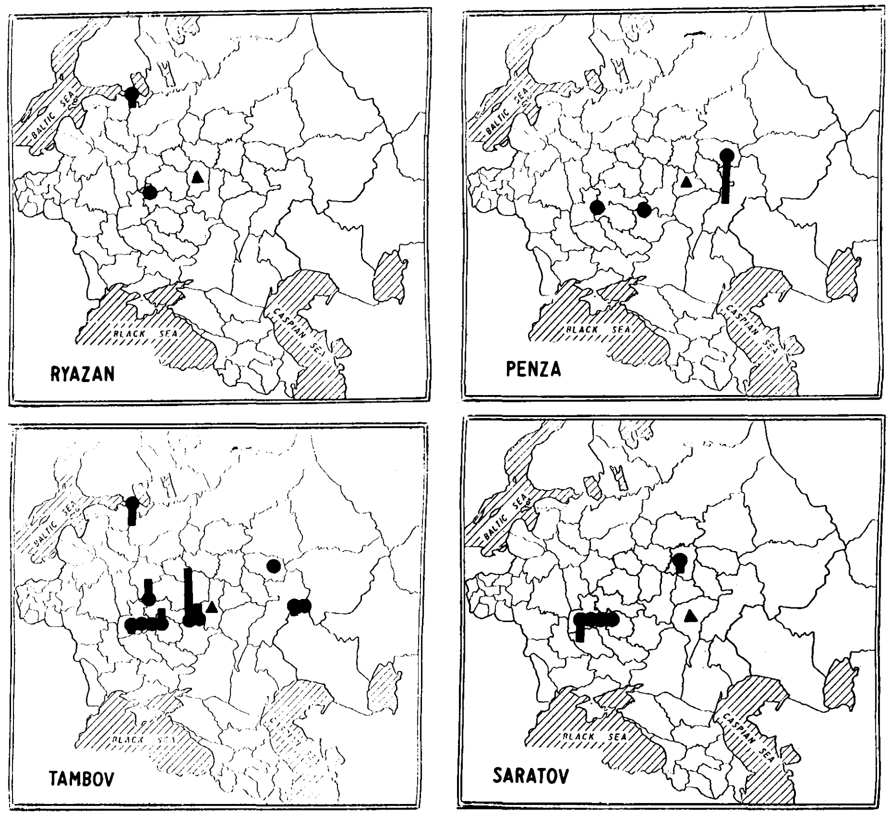

Fig. 10. — Maps showing the performance of pine from the southeastern provinces of European Russia in various experiments. Explanation of signs in subscript to *fig. 4*.

from beyond the Urals. Another one from Semipalatinsk perished. Akmolinsk was a very large province and only a fragment of it is shown on the maps used here. Bulk of it was in what is now central Kazakhstan, and thus the indicated place of origin in *Figs. 2* and *11* at the north. western tip of the province is possibly much displaced relative to the actual seed collection site.

These southern outlier populations have not been tested locally and further north they are useless. The Kars and Tavrida provenances in Kazanskoe have died completely according to Fomin (1940) thus the data published by Murzov et al. (1975) are dubious. Possibly local pines seeded in onto the plots. This would explain why the Kars and Tavrida provenances near Kazan are not as bad in volume production as expected *(Fig. 11)*. In Borovoe the Kars pine still reported by Fomin (1940) is no longer mentioned by Junaš (1953) — thus it probably died.

To summarize the results the groups of provinces presented in *Figs. 4 to 11* were assigned scores on a 5 point scale (+ +; +; + −; −; − −) indicating pine quality in terms of volume production and adaptability as discussed above. These are presented in *Table 5* and were plotted onto a map of the range of Scots pine (after Critchfield and Little 1966) superimposed over the map of province boundaries *(Fig. 12)*. In this map the darker is the area the better quality were the pines sampled from the province in question (several seed lots represent a province). Range of Scots pine in regions from which no material was represented in the existing experiments of Ogievskij is shown stippled. *Fig. 12* cleary shows the location of superior provenances relative to the range of the species. By superior we mean here those which are high volume producers on a variety of sites.

Discussion

The first to consider is the relation of results obtained to those published earlier.

The 57 year old trees from Turskij's experiments growing now inside Moscow (Obnovlenskij 1951a, Timofeev 1973) support well the data from Ogievskij's study. Pine from Arkhangelsk is a decidedly poorer producer than the other three provenances (Moskow, Kiev, Lublin) which come from regions where we expect good populations.

The 80 years old data shows the local Moscow and Vladimir provenances to be highest producers. The others appear too good relative to what we expected, particularily, the Arkhangelsk provenance produced too much. The differences appear to lie primarily in the volume of thinnings while the standing volume tends to equalize for the different provenances with age. Possibly natural regeneration in poorly stocked plots could have obscured the issues. Timofeev (1973, 1974) recognizes only 3 groups, local, southern and northern in order of decreasing productivity. This regionalization of pine races as well as those discussed below is compared in a summary form with our groupings of provenances in *Table 5*.

Samofal's (1925) evaluation of 3 experimental areas (Ohtenskoe, Sobisčskoe and Nikol'skoe) led to a division of USSR into three zones differing in "climatic races of pine", the northern (north of 56°Lat. N) with poor growing trees, the Central European one, with medium qualities and the southern and southeastern one with better growth but unsuited for northward transfers. This division is based primarily on other characters than growth. Pravdin (1964) believes that Samofal's groupings correspond to taxonomic divisions on a sub-species level *(Table 5)*.

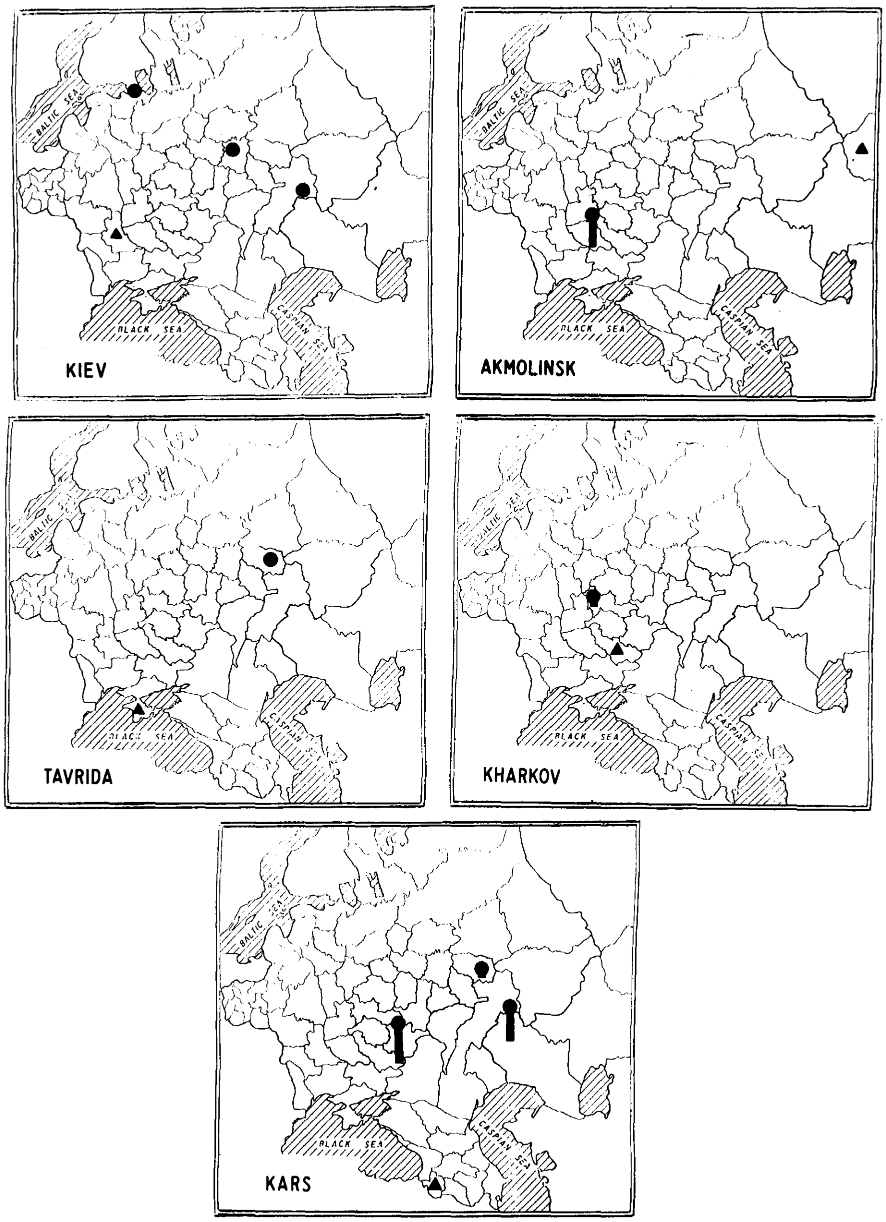

Fig. 11. — Maps showing the performance of pine from the southern outlier populations of pine in various experiments. Explanation of signs in subscript to *fig. 4.*

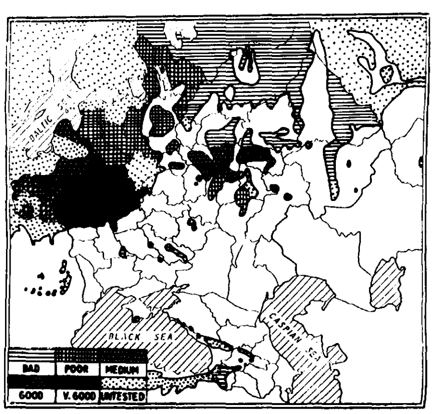

Fig. 12. — A map of distribution of Scots pine in eastern Europe (after CRITCHFIELD and LITTLE 1966) superimposed over the map of European provinces of pre-revolutionary Russia, indicating with intensity of shading the productivity of pine as demonstrated in this paper on the basis of many provenance experiments. Range of pine in provinces from which no data is available are shown stippled.

FOMIN (1940) on the basis of his evaluation of data from 7 OGIEVSKIJ's experimental areas (Okhtenskoe, Kazanskoe, Brianskoe, Borovoe, Faščevskoe, Sobičskoe and Nikol'skoe) proposed a split up of European Russia into 14 regions of pine origin. The split up considers both growth and quality characters. In terms of growth the agreement with our groupings is very good.

OBNOVLENSKIJ (1951 a) analysed the performance of pine provenances from the Brianskoe experiment and from the 1928/29 experiment established in Trostjanec (Ukraine) by A. I. KOLESNIKOV. The results were compared to the local provenance and on this basis the range of pine was split into 5 regions. Here the growth performance of southern races appears overestimated *(Table 5).* PATLAJ's (1965) evaluation of the same experiment yielded a split up into 11 regions that correspond to our results much better *(Table 5).*

In an area established in 1959 and 1963 near Arkhangelsk after 7 and 3 years respectively the height growth indicated that best results are obtained by pine from local

Table 5. — Division of Scots pine range in pre-revolutionary Russia into zones as proposed by various authors on the basis of provenance experiments (++ very good, +good, +− medium, − poor, −− bad in terms of productivity).

Giertych and Oleksyn		Timofeev 1974	Samofal 1925	Pravdin 1964	Fomin 1940	Obnovlenskij 1951	Patlaj 1965	Ruby and Wright 1976, Wright 1976, Cunningham 1973	Teich, Holst 1970, Klein 1971
Northern and Northeastern	Fig. 4 −−	3 −	1	ssp. lapponica	1, 2 −− 9 +−	IV, V −/−− III +−	I −− VIII +	var. lapponica −− var. uralensis +−	−
Northwestern	Fig. 5 −		1	" "	5 +−	III +−	II −	var. septentrio nalis −	
Baltic	Fig. 6 +		2	ssp. silvestris	6, 10 ++/+	III +−	IV +	var. rigensis +	
Southwestern	Fig. 7 ++		2	" "	6, 7, 8, 10 ++/+	II +	V, VI ++	var. balcanica ++	++
Northcentral	Fig. 8 +	1 +	2	" "	3, 13 +	II, III +/+−	III +	var. rossica −	+−
Central Polish	Fig. 9 +−		2	" "	10 +				
Southcentral	Fig. 10 −	2 +−	2	" "	8 +	III, I, II ++/+−	VII ++		
Southern outliers	Fig. 11 −−		3	ssp. hamata	11, 12 −− 14 dead 4 −	I ++ II +	X − XI −−	var. armena −	−

and slightly more southern locations, between 57⁰—64⁰ Lat. N, from Karelia, Leningrad, Vologda, Kostroma, Novgorod, Svierdlovsk, Perm, Tomsk and Omsk. More northern and below 57⁰Lat. provenances are unsuited in these extreme conditions (Popov and Vojčal 1971).

In Lithuania better growth than local pine (15 years old) was demonstrated by a mixed lot of provenances: Arkhangelsk, Kazan, Penza, Cherkassy (Ukr. SSR), Kharkov, Voronezh and Volgograd, but others from similar regions grew poorly. The study indicates great local variability and is not ready yet for generalized conclusions (Barniškis 1978).

On central Don (southern Russia) the best growing provenances at age 16 years were from our northcentral and southcentral regions. The northern and eastern (Akmolinsk) pines were poorer. A Bialorussian (Brest) provenance grew satisfactorily (Kravčenko and Mel'nikov 1975).

In Siberia (Minusinsk) north European races (Estonia, Leningrad, Arkhangelsk) as well as southern outlier ones (Rostov) grow poorly. Pine from Voronezh has a height growth akin to the local ones (Čerepnin 1977). Viatka, Perm and central Ural provenances grow somewhat below local average near Kransnojarsk. The best European provenances were not tested in Siberia (Irošnikov 1977).

In the West pine provenances from the USSR were little tested. The IUFRO investigation of 1907 had two Latvian provenances and one from Perm. The former were adaptable high producers on most sites and the latter a useless failure everywhere (Giertych 1979). The 1938 IUFRO series had 2 provenances from Latvia and 3 from what was then eastern Poland. These are very good or above average on most sites (Giertych 1979). The 1939 IUFRO series had the same Latvian provenances, one from Vladimir and one from Poltava (Kharkov). They were all above average in Canada (Holst 1953) and the Poltava provenance was also very good in Turkey (Saatçioglu 1967).

A wide study started in 1958 in USA yielded a proposal for the split up of the species into taxonomic varieties primarily on the basis of qualitative characters and usefulness as Christmas trees. The reported growth performance of these varieties is generally consistent with our results (Ruby and Wright 1976, Wright 1976, Cunningham 1973) as is shown in *Table 5*. Similarily in Canada a study established in several locations in 1957 and 1960 (Teich and Holst 1970, Klein 1971) has split the Russian provenances into three groups the best growing ones coming from our southwestern region, the medium one from central Russia and the worst from the North and from beyond the Urals *(Table 5)*.

The summary of data shown in *Table 5* clearly shows a general agreement of most results with those obtained from our evaluation of Ogievskij's experiment. Usually our northern and northeastern region *(Fig. 4)* is split into two, the northern Ural provenances being treated separately, growing somewhat better than the northern ones, however they are poorer then the more western ones of similar latitude (or northcentral region). Also our southern outlier group *(Fig. 11)* is often split into several ones, more on the basis of geography than on performance which is generally very poor. Our other groups are sometimes subdivided further on the basis of qualitative characters.

Perhaps the most significant differences between our evaluation and those of other investigators concerns our southcentral region *(Fig. 10)* which is generally estimated to be more productive than our results indicate. Particularily in the southern planting sites pine from this region is considered to be of value *(Table 5)*.

As regards seed transfer recommendations we agree that local material can often be very good *(Figs. 5, 8)*. However transfers are possible and sometimes very successful giving better productivity than local material. Fomin (1940) suggests that a westward transfer of 20⁰ longitude is acceptable but an eastwards one not at all. This is not always true. Pine from Samara is not suited for extensive westward transfers *(Fig. 8)* while the Baltic and southwestern provenances sustain eastward transfers *(Figs. 6, 7)*. The same provenances can also be moved northwards while pine from the north and southcentral region *(Figs. 6, 7, 8 and 10)* cannot. Fomin (1940) allows only a northward transfer of 2—3⁰ latitude and southwards up to 5⁰. From our data it appears that the Baltic and northcentral pines *(Figs. 6 and 8)* can be moved south but the northern *(Fig. 4)* ones cannot. Thus the extent of permissible transfers appears to depend not so much on climatic adaptations or distances as on the choice of a population.

The adaptable (plastic) ones sustain very large transfers and almost everywhere outproduce local pines. Thus it is the identification of these best races contributing least to genotype environment interactions that is most important when recommending major seed collection zones. Our study points to the southwestern, Baltic and northcentral regions *(Figs. 7, 6* and *8)*. PATLAJ (1965) agrees with this but adds the southcentral region which we question *(Table 5, Fig. 10)*. FOMIN's (1940) recommendations are similar but he ignores the Baltic region and western Ukrainian SSR. In contrast to other authors we have not considered quality characters at all, however these can be readily improved by individual selection from almost any populations, while productivity cannot.

To conclude, best European pine sources are to be found in the western parts of the USSR and in a narrow central belt between 54° and 57° Latitude N. This result ties in with the conclusions from the IUFRO experiments (GIERTYCH 1979) indicating that provenances from central European lowlands (particularily the Baltic countries and northern and western Poland) are best. Our Polish provenance experiments confirm that pine from central Poland is of lower quality (CIERNIEWSKI and GIERTYCH 1981).

The evaluations of pine provenance studies made here and earlier (GIERTYCH 1979, CIERNIEWSKI and GIERTYCH 1980) clearly show that the location of adaptable provenances is unrelated to site or climate. However the good adaptable provenances appear to agree with the location of the mixed forests landscape type as distinct from the taiga and forest steppe (see *fig. 71* in BERG 1962). Thus it is a mistake to speak of ecotypes or climatypes in this context. An adaptation to greater competition could be involved here. To answer OGIEWSKIJ's second question, quoted in the Introduction, the variability does not depend on geographic conditions, but there are geographically localized races, although no one would call them "geographic species" today, and even assigning a subspecies or variety taxonomic rank to them as PRAVDIN (1964) and RUBY and WRIGHT (1976) do is questionable. Populations differ substantially in adaptability, an economically extremely important characteristic that is of little taxonomic value. This feature determines seed transfer possibilities, which are enormous — to answer OGIEVSKIJ's first question.

Investigations into the genetic nature of this adaptability are clearly needed. The old provenance experiments will therefore continue to be useful. The IUFRO 1907 study could be considered as a complement to the OGIEVSKIJ's 1910—1916 experiments. Both series have been underexploited and frequently forgotten. Consecutive papers ignore previous ones grouping and subdividing units irrespectively of earlier evaluations. Generally maps of the experimental plots are not published which hinders later work. The experiments are so valuable that they deserve greater care and supervision and possibly mutual evaluations under the auspices of IUFRO.

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Charakterisierung von Fichtenklonen (Picea abies Karst.) II. Korrelation der Merkmale

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Zusammenfassung

Für 500 Klone mit 3 Pflanzen je Klon (= 1.500 Pflanzen) wird die Abhängigkeit der erhobenen 99 Merkmale untereinander untersucht. Dafür werden die phänotypischen Korrelationen (n = 1500), die genetischen Korrelationen auf dem Klonniveau (n = 500) und die genetischen Korrelationen auf dem Herkunftsniveau (n = 10) errechnet. Zusätzlich werden partielle und multiple Korrelationen für die Interpretation herangezogen. Für Identifikationszwecke sind die gering korrelierten biochemischen und chemischen Merkmale besonders gut geeignet.

Die sehr unterschiedlichen Korrelationskoeffizienten, die für Herkünfte i. a. höher sind als für Klone und Einzelpflanzen, zeigen, daß Populationen einheitlicher reagieren als ihre Komponenten. Bei ähnlicher Gesamtwuchsleistung der Herkünfte kann das Variationsmuster der Einzelklone dieser Herkünfte in den phänologischen Merkmalen sehr unterschiedlich sein. Bei der Selektion von Einzelklonen nach der Höhe tritt in den Merkmalen Austrieb und Abschluß keine signifikante Veränderung der Variation ein. Andere Merkmale werden dagegen in ihrer Verteilung verändert (z. B. Johannistriebbildung, Zweiglänge, Nadelmerkmale, Baumform).

Die Wuchsleistung der Herkünfte wird durch weniger Merkmale eindeutig bestimmt als die der Klone und Einzelpflanzen.

Das Ergebnis zeigt, daß die Ableitung allgemeiner Gesetzmäßigkeiten (z. B. Abhängigkeit Höhe - Austrieb, Höhe - Vegetationsabschluß) für die Baumart Fichte aus der Untersuchung nur einer Herkunft nicht möglich ist.

Summary

The correlations of 99 characteristics were analysed for 500 clones with 3 replicates each (= 1500 plants). Simple linear correlations were calculated for single plants (pheno-

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