that monoterpene composition could be used as a means of checking the purported origin of seed lots in seed certification.

The data also show that one should avoid characterizing a species by sampling trees in only a few portions of the species range. With as much variation as is found in slash pine, results could be very misleading.

Abstract

Oleoresin obtained from cortical tissue was analyzed for monoterpene composition in slash pines throughout the natural range of the species. Composition varied greatly among individual trees, families and seed sources. Trees were classified as having high or low levels of each monoterpene. Frequency distributions for 4 of the 5 major constituents, β-pinene, myrcene, limonene, and β-phellandrene, were bimodal, but the distribution for α-pinene was not. Percentages of trees having high amounts of each monoterpene varied greatly among seed origins and revealed distinctive geographic patterns. Plantation effects were negligible, suggesting that wild trees in their native habitats can be used for studying geographic variation in monoterpene composition. Results suggest the possibility of using monoterpene composition in seed certification and in identifying the seed origin of plantations of unknown origin.

Key *words:* Pinus elliottii ENGELM. races, geographic variation, clinal variation, turpentine composition, essential oils.

Zusammenfassung

Die Untersuchung der Rinde von Pinus elliottii ENGELM. an 54 Herkünften aus dem natürlichen Verbreitungsgebiet (Provenienzversuch) ergab zwischen den Individuen, Familien und Herkünften eine z. T. erhebliche Variation, was die Monoterpen-Zusammensetzung betrifft. Die Frequenzverteilungen waren für 4 der 5 Hauptbestandteile, β-Pinen, Myrcen, Limonen und ß-Phellandren bimodal, für a-Pinen dagegen nicht. Die auf den Standort und die Kultur der aus Samen gezogenen Pflanzen zurückzuführenden Effekte hatten nur einen geringen Einfluß, so daß die Untersuchung der Monoterpenzusammensetzung zur Herkunftsbestimmung geeignet erscheint.

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Summary results of the IUFRO 1938 Norway spruce (Picea abies (L.) Karst.) provenance experiment. Height growth*)

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Introduction

There have been several attempts to summarize the results of the IUFRO 1938 experiment on Norway spruce (VINCENT and VINCENT 1964, GØHRN 1960, BALDWIN 1967, LINES 1974). VINCENT and VINCENT (1964) have divided the provenances into latitudinal groups and discussed them jointly. They concluded on the basis of French, Belgian, Swedish and Czechoslovak results that only limited northward transfers are justifiable. GØHRN's (1966) was a descriptive approach consisting of a consecutive evaluation of results on each site followed by a summary comment about some of the provenances. BALDWIN (1967) looked only at the recommendations arrising from each study and considered the degree of their concurrence. LINES (1974) tabulated jointly all data on height for each site and provenance and calculated by three different methods the percentage deviation of each provenance from the mean at a given site. From these data he calculated the average percentage deviation for each provenance over all the sites. In this way he presented an estimate of the average quality of each provenance. This approach has two defects arrising from the existence of interactions and lack of orthogonality. One, admitted by the author, is that for an experimental site with relatively more of the good provenances the percentage estimates will be generally undervalued while for another with more of the poor ones the bias will be in the other direction. This difficulty could not be overcome even if a standard provenance appeared on all experimental sites, because the standard's value relative to other provenances need not be the same on all sites. Thus the difficulty will remain with us, it need not be exaggerated however, because the choice of provenances for each site can be considered as random (since no data about the possible value of the provenances were available in 1938) and therefore the averages comparable.

The other bias LINES' approach is that the overall percentage height estimates are based on different numbers of sites. This would be of no consequence it there were no provenance X site interactions, as has been frequently claimed for Norway spruce, (GØHRN 1966, BALDWIN 1967, LINES 1974), but as it will be shown this is not always the case.

LINES' (1974) review is by far the most comprehensive, yet it does not easily allow a simultaneous look at the performance of a provenance on all the sites where it was

* Dedicated to Professor LANGNER on the occasion of his 70th birthday.

tested. This is necessary to be able to judge the range of sites for which it is suitable. We are looking not so much for the best provenance for a given site, nor for the best average performer, but for regions from which seeds can most reliably be taken for successful planting in a given general area.

Methods

In order to get maximum information on growth performance the data on height published so far was compiled into a single table as LINES (1974) has done *(Table 1)*. This is basically the same data on which LINES calculated his percentages, except that in each case the latest publication

Table 1. — Average heights (in m) of Norway spruce trees of various provenance as reported for different experimental areas.

Experiment no as in table 2.	3	4	6	7	8	9	11	12	13	17	18	19	20	21	22	23	24	25
Mean or Dominant Height	M	D	D	M	D	M	M	M	M	M	D	D	M	M	M	M	M	M
Age when measured	25	25	27	17	25	25	19	25	30	25	26	26	11	22	23	17	25	12
IUFRO Provenance no as in table 3																		
1			7.9				2.5	4.5	5.7									
2	6.0	7.6	9.8	3.5	6.0	6.4	5.7	7.2	6.3		11.6	10.0	1.0	5.1	7.5			
3		7.1	8.1		6.3		4.3	5.8	4.4	5.2	11.5	11.7	0.8	3.8	6.9			1.0
4	7.5	8.1	8.2		6.6	5.9	5.7	7.4	5.5		11.3	10.5	1.2		7.7			0.7
5	6.6	7.8	8.2	3.6	5.4	5.5	4.9	7.2	5.8	5.1				5.2	6.3			0.8
6	8.9	8.9	8.6		7.3	6.5	6.0	7.5	5.2	6.6	11.7	11.1	1.2	5.8	6.0		6.0	1.4
7	7.8	8.8	10.7		7.0		5.9	8.1	6.2	7.0	11.5	11.7	1.3	5.8	7.3		6.7	1.0
8	10.4	9.4	7.7		6.7	6.5	6.0	7.4	1.7*	7.1	11.4	12.7	1.2	5.1	7.8	1.8	6.7	1.3
9	12.1	9.5	9.1		5.8	6.5	6.0	8.2	5.5	6.4	11.4	11.6	1.2	7.1	5.3		6.0	1.2
10	10.9	10.1	9.7	6.4	7.2		6.3	8.4	3.7	6.5	12.4	12.3	1.4	5.9	5.3		6.9	
11	10.4		8.9				6.6		3.5						5.9			
12	9.3	8.8	8.0				5.8	7.5	3.5				1.5		6.8			
13	9.1	8.9	8.9	5.9	6.2	6.6	5.8	7.8	3.5	6.1	10.4	11.5	1.3	5.3			5.2	1.2
14 (14 + 14a + 40)	9.8	8.6	7.1	5.8	6.8		5.1	6.3	3.7	6.0	9.8	11.6	1.3	5.3	7.7		5.5	1.0
15	10.2	9.6	6.5	4.9			6.4	8.3	1.9*		10.9	12.5	1.5		7.4			
16	10.3	9.9	8.8	6.1	7.0	7.6	5.9	7.3	2.1*		10.7	11.6	1.4					
17	7.3	7.5	6.5	4.5	6.6	6.0	4.7	5.7	3.1		9.4	10.9	1.0					
18	9.0	9.1	8.0		6.1		5.6	7.0	3.1		10.1	11.1	1.4					
19	7.3	9.0	8.4	4.8	4.9		4.6	6.8	1.5*	5.7	8.6	10.6	1.1	5.1			6.3	0.9
20	11.6	10.4	11.0	4.9	7.1		6.5	8.9	5.8	6.8	12.3	13.1	1.4	6.5			6.0	1.3
21	11.5	9.7	8.3	4.5	7.1		5.8	8.0	4.9	6.5	11.1	11.6	1.5	6.1			5.7	
22	9.7	8.9		3.3			5.4		3.7									
23							5.5	7.2	5.9	6.8							6.6	
24						7.3	5.4	7.3	5.5	6.0						1.2	4.7	
25							6.3	8.5	6.0	7.4							6.4	1.4
26							4.8	6.0	2.9									
27							6.7	7.9	3.1	7.0						1.8	7.9	1.8
28							5.3	6.9	3.5	6.1						1.2	5.8	1.5
29							5.9	8.1	5.7	6.4						1.5	8.1	
30							6.5	8.3	5.9	6.8						1.7	6.7	1.6
31							5.6	7.4	3.4	6.1							6.1	1.5
32						6.2	5.0	6.5	3.9	5.7							5.0	1.2
33							6.2	8.5	6.1							1.7	6.0	
34							6.0	8.1	5.4	7.0						1.8	7.4	1.5
35	10.7	9.0					6.3	7.7	5.5	6.0						1.8	6.4	
36							6.4	8.4	5.7	6.8						2.2	6.8	1.4
Exp. mean.	9.35	8.89	8.49	4.85	6.47	6.45	5.65	7.41	4.74	6.37	10.95	11.54	1.25	5.54	6.76	1.66	6.31	1.24
Reference	13	13	6	3	11	14	9	8	8	2	17	17	15	7	10	7	2	2

* From measurement at age 19 when mean was 3,95 m (ref. 9). In later measurements not included due to complete suppression.

Table 2. — Location of experimental sites.

IUFRO Experiment no.	Locality	Country	Lat.	Long.	Alt in m.
3	Belle Étoile	Belgium	50° 50' N	4° 25' E	125
4	St. Hubert	Belgium	50° 00' N	5° 25' E	525
6	Ruotsinkyla	Finland	60° 25' N	25° 05' E	55
7	Amance	France	48° 47' N	6° 18' E	240
8	The Bin	U.K.	57° 27' N	2° 50' W	170—180
9	Leikanger	Norway	61° 13' N	6° 45' E	325
11	Dönjelt	Sweden	56° 56' N	12° 46' E	170
12	Bornsjön	Sweden	59° 14' N	17° 46' E	15
13	Södra Bäcksjö	Sweden	63° 56' N	20° 24' E	65
17	Deering N.H.	USA	43° 07' N	71° 48' W	335
18	Dobra	Czechoslovakia	49° 41' N	18° 26' E	340
19	Horni Mohelnice	Czechoslovakia	49° 32' N	18° 32' E	850
20	Kobzok	Czechoslovakia	49° 33' N	18° 32' E	920
21	Petersham Mass.	USA	42° 30' N	72° 10' W	300
22	Valea Risnoavei	Romania	45° 28' N	25° 29' E	1035
23	Manistee Mich.	USA	44° 16' N	85° 57' W	200—300
24	Ostego N.Y.	USA	42° 42' N	74° 42' W	579
25	Geneva N.Y.	USA	43° 00' N	77° 00' W	100—200

is referred to and therefore for some sites more recent measurements are considerd. This concerns Ruotsinkyla in Finland, Belle Étoile in Belgium, two of the tree Swedish sites (Bornsjön and Södra Bäcksjö) and two of the Czechoslovak sites (Horni Mohelnice and Dobra). For the third Czechoslovak site, Kobzok, earlier data is given (age 11) since from the measurement at age 20 only an average of all three sites was published (Vincent and Vincent 1964) and used by Lines (1974). Also an additional site is included, which is not among the official planting sites, namely Geneva N.Y., USA, where the material was also grown and measured only when 12 years old (Baldwin 1973). Where there were replicates an average value per provenance is shown in *Table 1*. Under provenance Val di Fiemme 14 data is included also from the supplementary seed source marked 14a or 40. Where this grows besides the standard provenance 14 an average value for two is shown.

The data presented in *Table 1* was normalized, *i.e.* converted to units of standard deviation from the site averages, and plotted onto a map of the planting sites, separately for each provenance (Figs. 3—9). The planting sites are identified in *Table 2* and *Fig. 1*. That figure shows also the asterisk indicating location of a provenance and the magnitude of a + 1 and —1 standard deviations for *Figs. 3—9*. In those figures a black circle indicates that the deviation is less than ½ the diameter of the circle (below ±0.3 of a standard deviation). The 36 provenances of the experiment

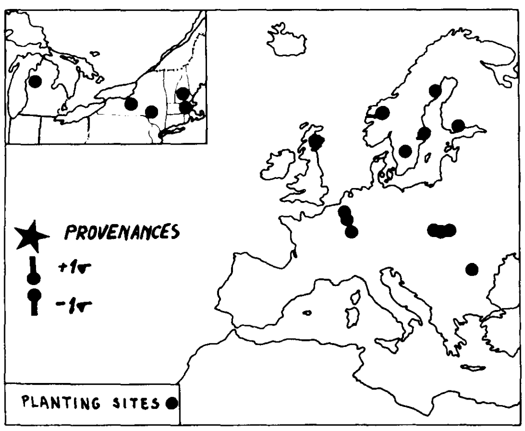


Fig. 1. — The location of planting sites and a legend for figs. 3—9. The asterisk indicates location of a provenance and the ideograms show the designation for a +1 and a −1 standard deviation from a site average.

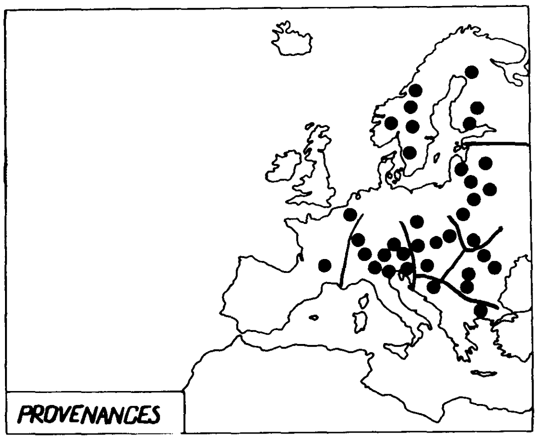


Fig. 2. — Location of seed collection sites with a split up into regions with provenances characterized by similar performance patterns.

are given in *Table 3* and *Fig. 2*. In *Fig. 2* the provenances are split up into groups as was done for presentation in *Figs. 3—9*.

Results

Fig. 3 presents the results for the Scandinavian provenances. There is a striking agreement between the provenances in spite of the fact that some (1, 23, 24) have been little tested in the experiments. Only the most southerly Swedish provenance (Drängsered) is around or slightly above average in performance. The remainder are growing below average on all except the most notherly sites where local provenances are among the better performers. Also at the most elevated site (1035 m) in Romania two of the northern provenances (2 and 4) have satisfactory growth.

The high elevation Alpine provenances *(Fig. 4)* are even more consistently useless. The two from elevations below 1000 m (13 and 31) show around average performance on most sites but the remainder are definitively inferior. The most southern Italian provenance (14) gave relatively tall trees in the high elevation Romanian experiment.

The two southernmost provenances (19 and 22) from Yougoslavia and Bulgaria *(Fig. 5)* are also inferior on all sites, however they have not been tested anywhere near the site of their origin nor in similar climates of N. America,

Table 3. — Data on Norway spruce provenances from the IUFRO 1938 experiment.

IUFRO no.	Provenance	Lat. N	Long. E	Alt. in m.	Notes
1.	Finland, Rovaniemi	66° 25'	26° 36'	250	From few trees only
2.	Finland, Vilppula	62° 04'	24° 30'	120	
3.	Norway, Tyldal	62° 09'	10° 49'	550	From few trees only
4.	Norway, Nesbyen	60° 30'	9° 10'	200—400	From few trees only
5.	Norway, Fallafoss	63° 59'	11° 05'	60—100	From few trees only
6.	Sweden, Drängsered	57° 00'	13° 00'	165	
7.	Latvian SSR, Vecmoka	57° 05'	23° 07'	80	
8.	Poland, Pförten (Brody)	51° 47'	14° 46'	70	
9.	Bielorussian SSR, Stolpce	53° 28'	26° 43'	160—180	
10.	Poland, Istebna	49° 35'	18° 58'	600—640	
11.	Belgium, Bullange	50° 25'	6° 15'	530—555	Cultivated
12.	France, Murat	45° 05'	2° 53'	900	Cultivated
13.	Switzerland, Winterthur	47° 31'	8° 43'	500	
14.	Italy, Val di Fiemme	46° 15'	11° 30'	1000—1200	
15.	Czechoslovakia, Plaňice	49° 20'	13° 30'	600—700	
16.	Austria, Lankowitz	47° 05'	15° 05'	530	From few trees only
17.	Austria, Obervellach H.	46° 55'	13° 10'	1800	From few trees only
18.	Austria, Obervellach L.	46° 55'	13° 10'	800—1150	From few trees only
19.	Yougoslavia, Sarajevo	43° 50'	18° 25'	1200	From few trees only
20.	Romania, Crucea	47° 21'	25° 40'	720	
21.	Romania, Vadul-Rau	45° 05'	22° 15'	917	
22.	Bulgaria, Peštera	42° 00'	24° 20'	1000	
23.	Finland, Bromarv	59° 58'	23° 06'	15	
24.	Norway, Åsnes	60° 40'	12° 00'	230	
25.	Latvian SSR, Griva	55° 50'	26° 25'	120	
26.	Switzerland, Engadin, Scanfs	46° 37'	9° 58'	1700	
27.	Czechoslovakia, Svinosice	49° 20'	16° 30'	300—400	
28.	Yougoslavia, Pokljuka	46° 20'	14° 00'	1200	
29.	Romania, Muntele	46° 21'	25° 50'	1100	
30.	Romania, Valea Bistrei	46° 25'	23° 10'	900—1000	
31.	West Germany, Garmisch	47° 30'	11° 10'	750	
32.	West Germany, St. Blasien	47° 45'	8° 10'	1000	
33.	Lithuanian SSR, Wilno	54° 40'	25° 15'	140—180	
34.	Poland, Białowieża	52° 42'	23° 52'	180	
35.	Poland, Radom (Garbatka)*	51° 30'	21° 37'	140—170	*
36	Ukrainian, SSR, Dolina	48° 55'	24° 05'	400—600	

* I have been informed by Prof. Dr. S. Tyszkiewicz who collected seed from this provenance that the collection was made in Forest District Garbatka (Radom being the nearest major town) in a pure spruce stand. In that region spruce occurs naturally as only a supplemental species and therefore the stand was obviously planted. For this reason it has been referred to as "cultivated". There is no reason to assume that foreign seed was used any more than for all the other provenances in regions long under managed forestry. Thus it should not be treated in the same way as the obviously introduced provenances Murat (12) and Bullange (11).

thus it is not certain whether they would not prove useful in the Balkans or in similar conditions.

The four Romanian (South Carpathian) provenances *(Fig. 6)* have done surprisingly well on most sites, even in northern Scandinavia. They are perhaps less satisfactory in N. America than in Europe but even there they generally have an above average height growth. They have not been tested in Romania but they do seem to be reliable over a very wide range of conditions. Another Romanian provenance, Sinaia, included in the Valea Risnoavei site gave a below average performance.

Fig. 7 presents the eastern provenances. Dolina 36 is included here even though it could just as easily be considered together with the Romanian ones since it comes from the eastern Carpathians from the geographically continuous range of spruce along the mountain range. In fact this whole group of provenances could be linked up with *Fig. 6*. All provenances from Latvia to Romania grow satisfactorily in northern Europe and N. America.

The Central European provenances are shown in *Fig. 8*. Lankowitz 16 is included here since it is the most easterly of the Austrian provenances and comes from a low elevation site. Judgeing by its performance it does not appear to belong to the Alpine group. In fact it fits in well the Central European group. These provenances are among the best on all sites except those in Romania and northern Scandinavia. Of the group Istebna 10 and Švinosice 27 gave tallest trees.

Finally in *Fig. 9* the performance of the two provenances cultivated outside the range of spruce is shown. Bullange 11 is possibly a Central European provenance since it grows well in Belgium and southern Scandinavia, but poorly in northern Sweden and Romania. Murat 12 is more difficult to identify. It could be a lowland Alpine population. Radom 35 is not included in *Fig. 9* for reasons explained in subscript to *Table 3*.

Discussion

The method of data presentation shown in *Figs. 3—9* does not change the basic conclusions relative to those drawn from the study earlier, it does however make them more obvious. Indeed the most striking result is the consistency of relative performance irrespective of the planting site. One might add here that the results obtained in the Austrian experimental area at Mürzzuschlag (Lat. 47° 36', Long. 15° 40', Alt. 850 m), which have not been published, but supplied by Günzl as a personal communication to R. Lines (1974) follow this general pattern. Best were provenances Valea Bistrei 30, Radom 35, Istebna 10, Lankowitz 16 and Planice 15 among 18 others including 3 Alpine ones. This indicates that in the Alpine conditions a similar ranking of the provenances is to be expected as elsewhere.

The species is obviously very adaptable and each race

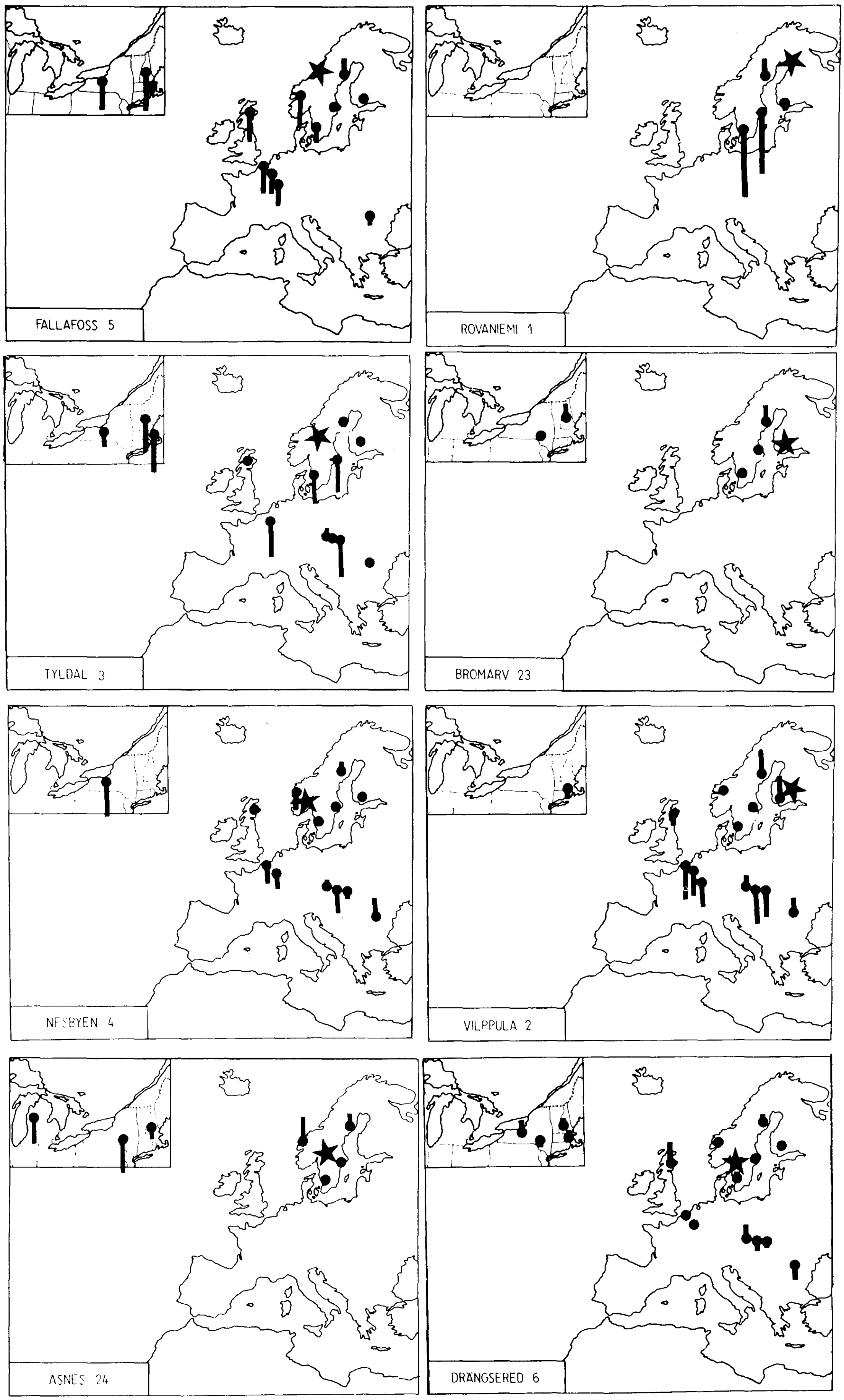


Fig. 3. — Height growth performance patterns of 8 Scandinavian provenances on various sites (see legend fig. 1).

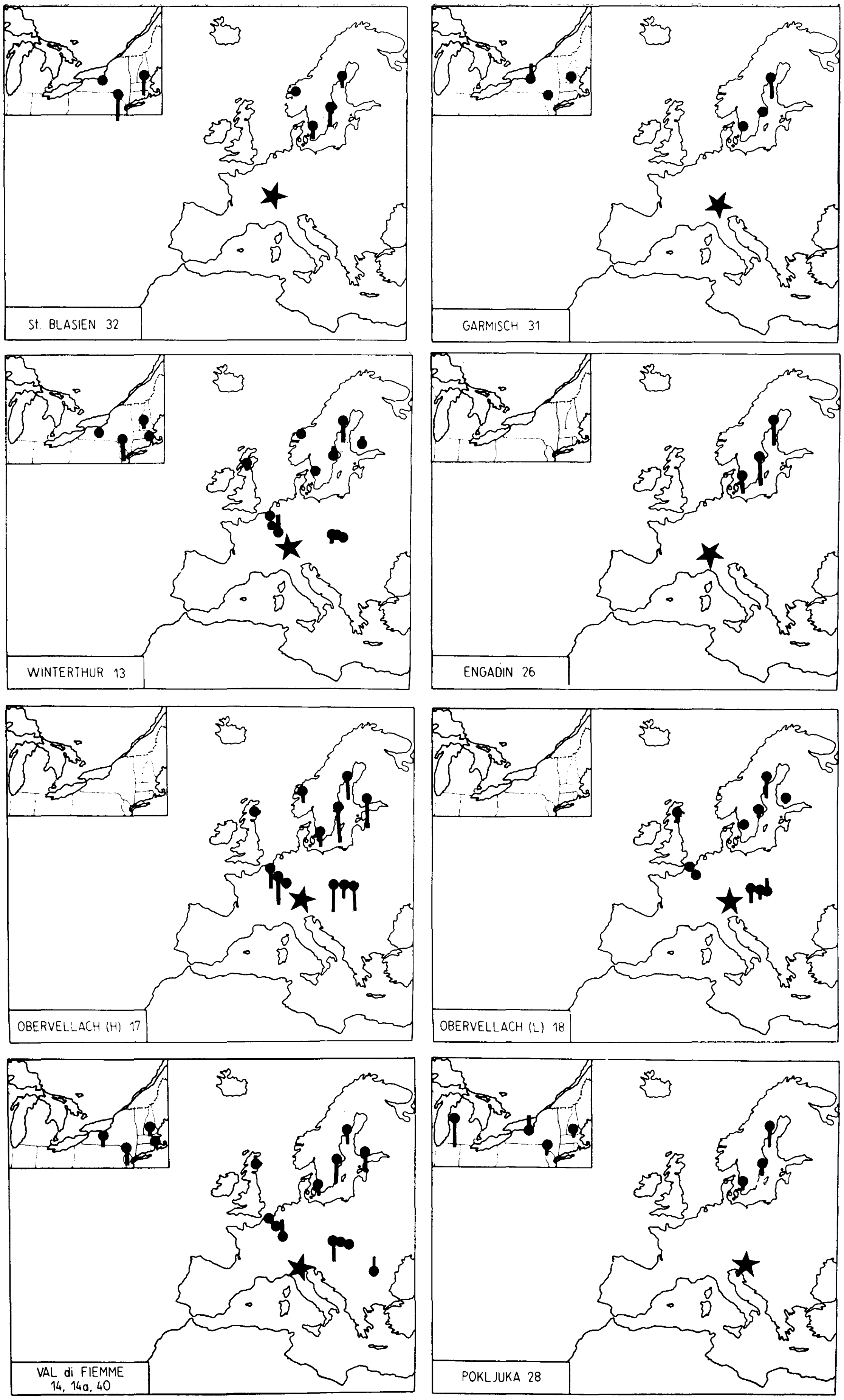


Fig. 4. — Height growth performance patterns of 8 Alpine provenances on various sites (see legend fig. 1).

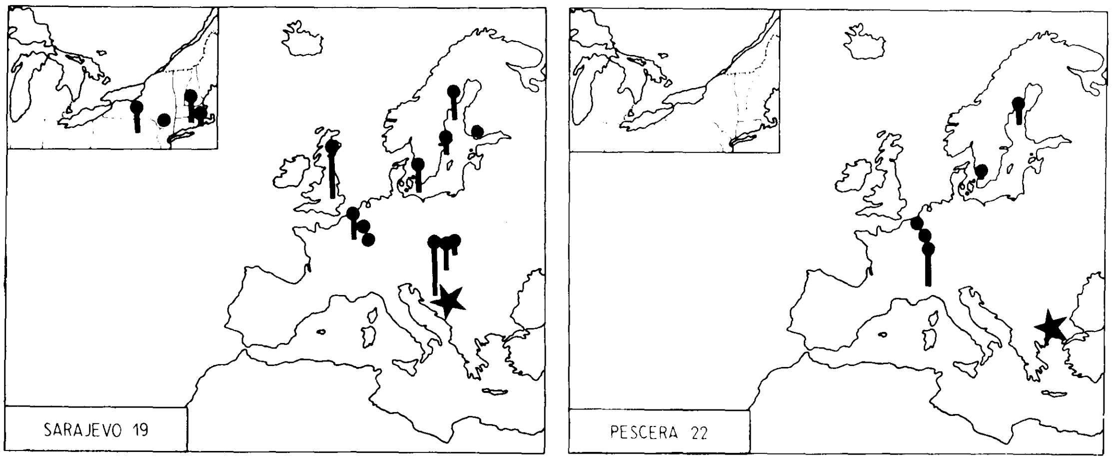


Fig. 5. — Height growth performance patterns of 2 Balkan provenances on various sites (see legend fig. 1).

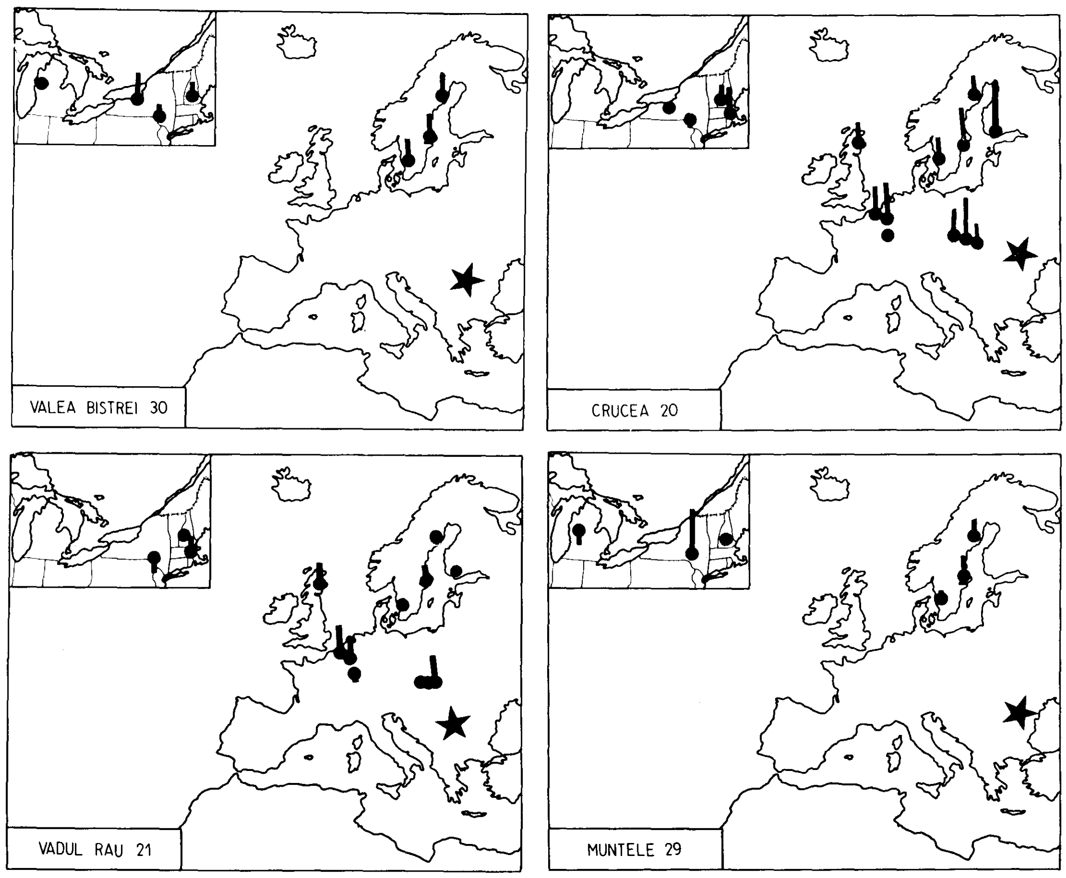
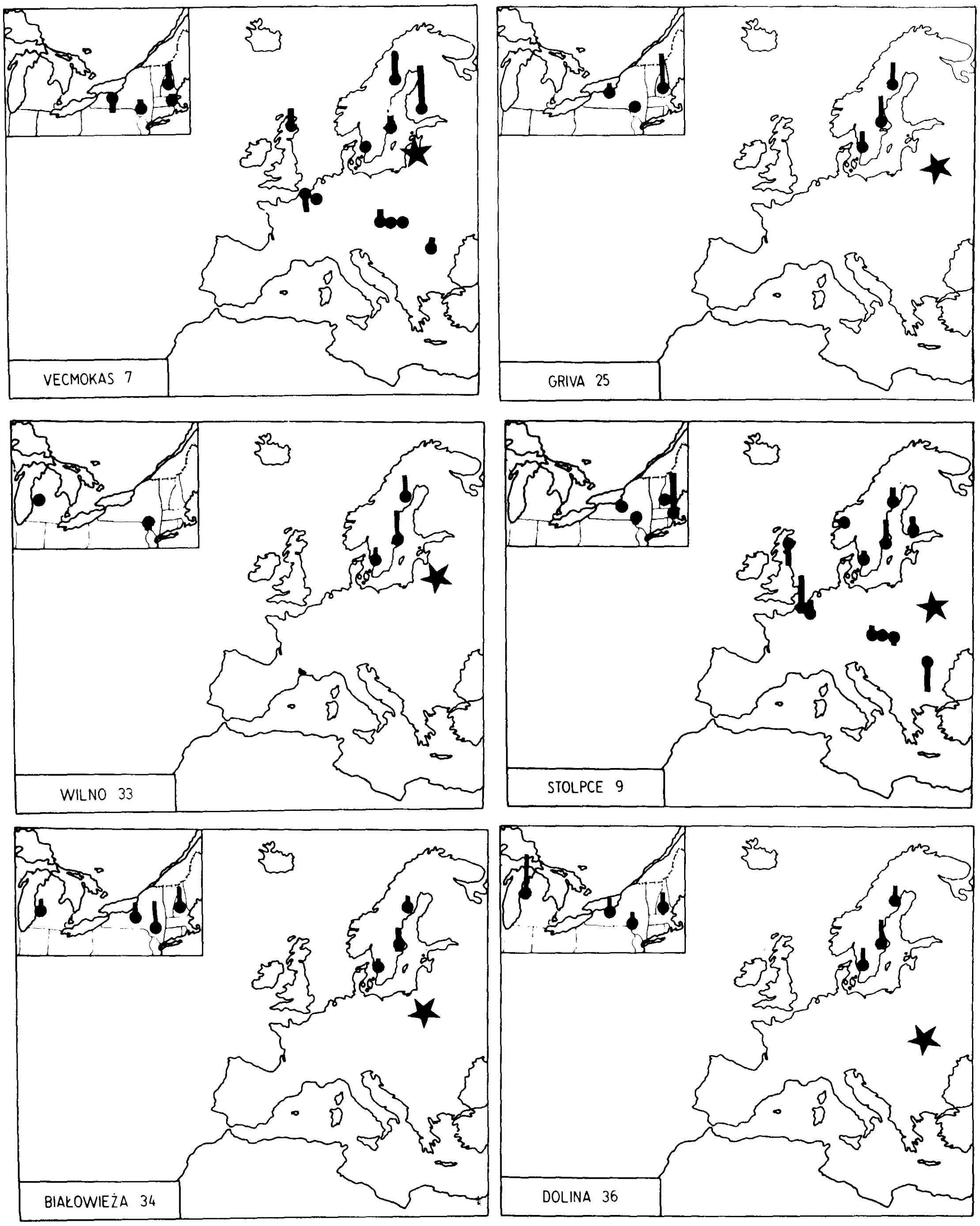


Fig. 6. — Height growth performance patterns of 4 South Carpathian (Romanian) provenances on various sites (see legend fig. 1)

manifests its quality in a similar manner over a very wide range of conditions. This is certainly true for the provenances shown in *Figs. 4—7.* However it cannot be said that there is no provenance × site interaction. In fact the Scandinavian provenances *(Fig. 3)* are generally consistently slow growers, except in northern Sweden and sometimes also in Finland (prov. 2) and Norway (prov. 24) where they are among the better provenances. Conversely the Central European provenances *(Fig. 8)* give tall plants on all sites except northern Sweden and sometimes also Finland (prov. 15 and 8). This indicates that in the far north the conditions are too extreme for the Central European provenances and as a result the local ones do relatively better. The adaptability of the Central European provenances proved less than that of the eastern *(Fig. 7)* and Romanian *(Fig. 6)* provenances which sustain well the conditions of the far north.

Another source of the provenance × site interaction is the Romanian experiment. This is the most southerly site in Europe and at the same time the most elevated one. The poor performance there of such provenances as Drängsered 6, Istebna 10 or Stolpce 9 and good growth of spruce from Val di Fiemme 14 could be explained by the general inadequacy of southward transfers, and by the high elevation conditions, but the good performance of provenances Nesbyen 4 and Vilppula 2 is more difficult to accept. Pos-



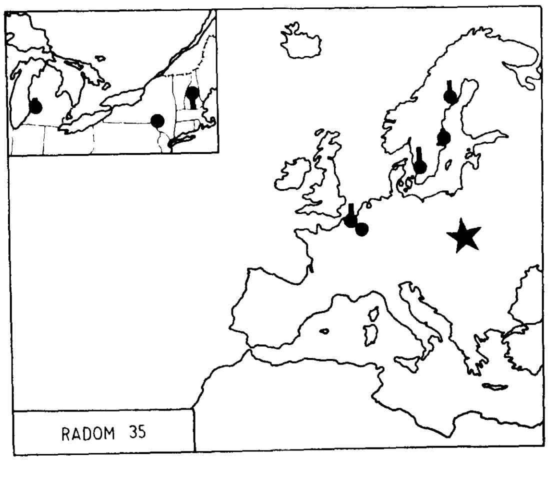
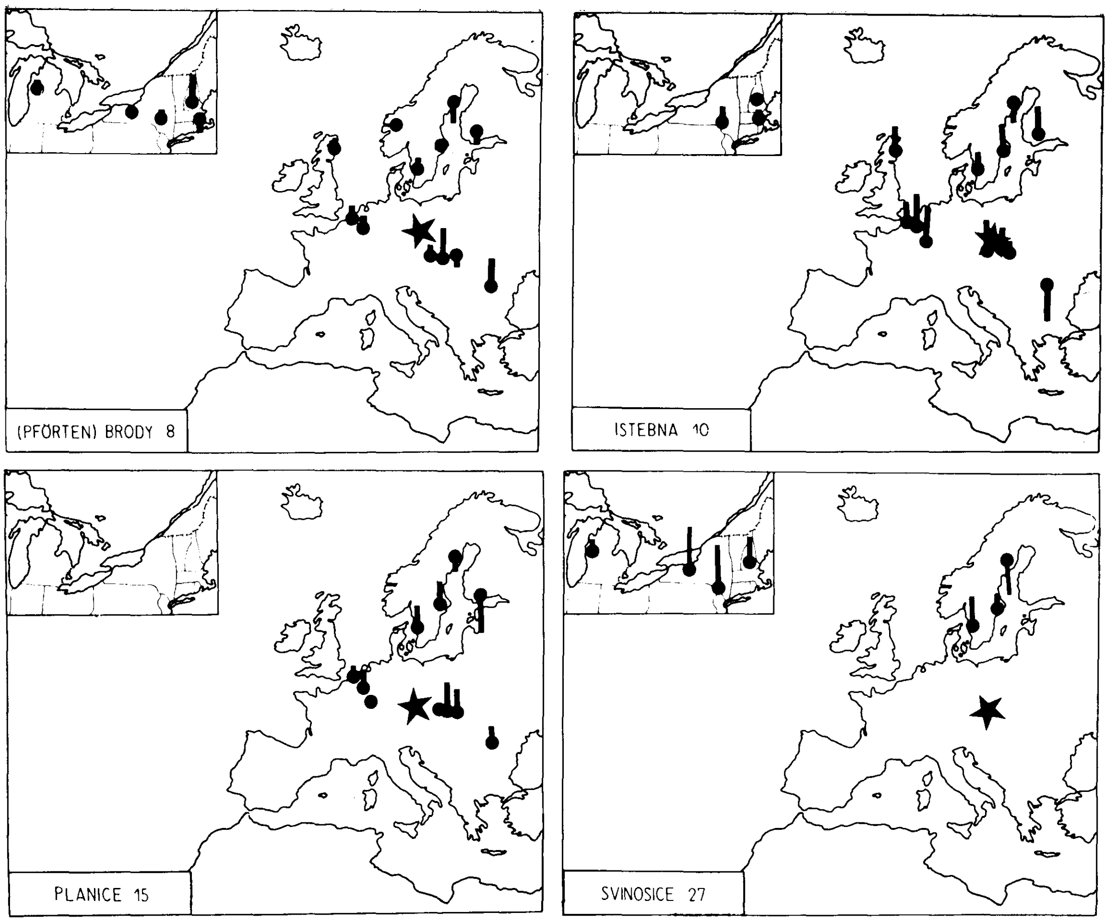


Fig. 7. — Height growth performance patterns of 7 East European provenances on various sites (see legend fig. 1).



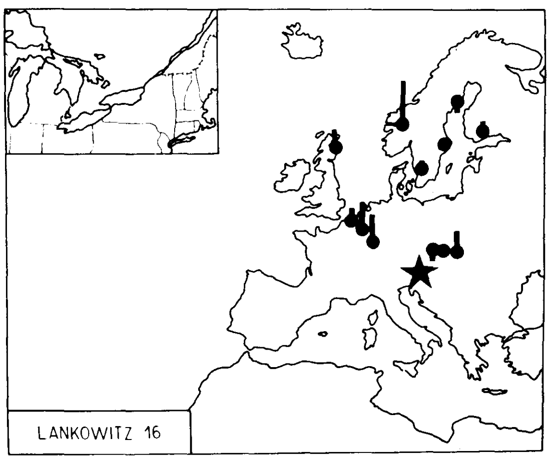


Fig. 8. — Height growth performance patterns of 5 Central Europaean provenances on various sites (see legend fig. 1).

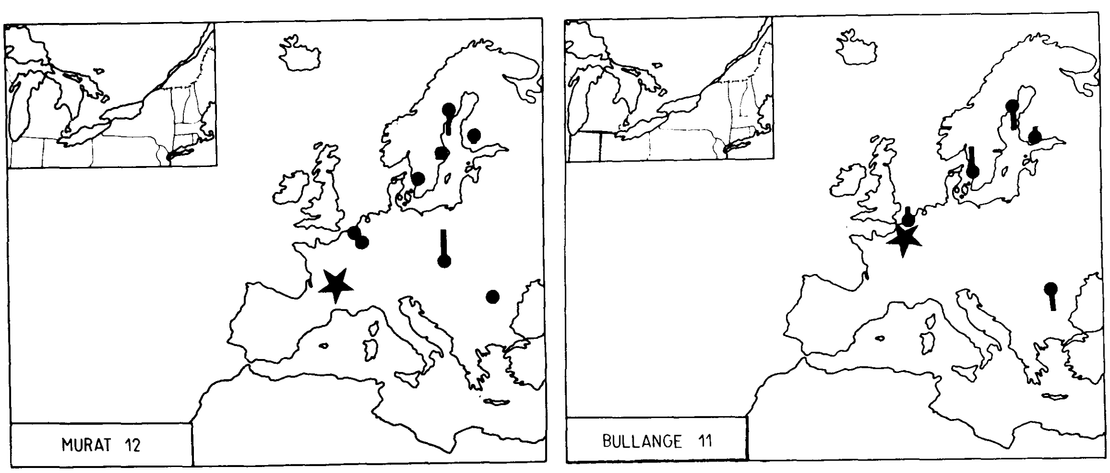


Fig. 9. — Height growth performance patterns of 2 non indiginous provenances on various sites (see legend fig. 1)

sibly the conditions in Valea Risnoavei are similar as in Södra Bäksjö in some climatic parameters which are important for those provenances. GØHRN 1966 and LINES 1974 prefer to doubt the validity of the Romanian experiment due to wide disagreement with other reports. In particular the poor performance of the local Sinaia provenance included in the study would tend to support the doubts.

In Czechoslovakia the northeastern provenances (Prov. 7 and 9, *Fig. 7)* are not very good and in Romania even inferior (9), however those from the south (prov. 21, 20 — *Fig. 6)* are not so bad in Czechoslovakia indicating that in this general region from Latvia to Romania only a northward transfer is justified, and there appears to be no limit in the scale of the transfer since all these provenances do well even on the most northerly sites. The conclusions of VINCENT and VINCENT (1964) about the importance of latitude in transfers originates primarily from this observation. The failure of Alpine provenances wherever tested, usually in more northern latitudes, does not fit with the theory about the significance of latitude in transfers.

All introductions to North America were southward transfers and yet the same pattern of good and bad provenances is observed as in Europe and the overall average performance for a given age is about the same as in Europe. Thus photoperiod seems to be of little significance here. The obvious success of the northward transfer (from Central and Eastern Europe to Scandinavia) seems therefore to be primarily a manifestation of differences in genetic growth potential and not a response to longer daily photosynthetic activity during the growing season. In fact the quality of a population appears to be dependent on its genetic and evolutionary history more than on an adaptation to the presently existing climatic conditions.

The relatively good performance of provenance Drängsered 6, more akin to the pattern for continental spruces, could possibly be the result of this being an introduced population. In that part of Sweden there has been much planting of trees from continental stock.

It was already mentioned above that prov. Bullange 11 is possibly a Central European provenance. It appears that the pattern of response over different sites is a new character to be watched in provenance research since it may prove very useful in identifying introduced or unknown provenances. In the case of this study it also seems to show that generally speaking there are no obvious misfits in the pattern of performance. This would tend to suggest that in general truly indiginous material was used. Radom 35 comes from the west of the Vistula river *i.e.* south of the disjunction usually drawn in the range of spruce. However as it has been shown earlier (GIERTYCH 1973) spruce from that region appears to be genetically more akin to the spruce from NE Poland than to the Hercyno-Carpathian races. The data in *Fig.* 7 seems to confirm this and therefore the provenance is shown together with the northeastern ones.

This new character of the pattern of performance on several sites helped to group provenances into major regions as is shown in *Fig. 2* and as was done in splitting up the data into *Figs. 3—9*. It may prove very useful in regionalization of the spruce range for the purpose of seed collections and transfers since it incorporates both the performance and adaptability.

It is obvious that we cannot hope to use the maternal stand of a selected provenance as a seed source, and therefore more general data on major spruce regions is needed. We need such populations which are good performers over a range of site conditions including those in which we plan to plant spruce. The data presented in *Figs. 3—9* should prove useful in this respect.

The comparative analysis of results presented above was possible because the authors have published the basic data from their experimental areas. Presently various provenance studies are being increasingly frequently written up with a discussion of statistical results (variance analyses, correlations between characters, correlations with climatic data etc.), sometimes with averages for groups of provenances, but without giving the basic data. I would strongly recommend that all reports on provenance experiments give the basic average results for each provenance and character to permit comparative evaluations of data from various sources.

Summary

The data on height growth published to date from the IUFRO 1938 provenance experiment on Norway spruce (*Picea abies* (L.) KARST.) is evaluated jointly. For each experimental site the latest published height measurements are converted to units of standard deviation from the site mean. These deviations are plotted separately for each provenance onto a map of all the experimental sites. In this way it is possible to see simultaneously the relative performance of each provenance on all the sites where it was tested. Alpine provenances and those from the southern Balkans are consistently inferior. So are the Scandinavian provenances except for the extreme north where local provenances are among the better ones. Central European provenances are among the top performers on all sites except the most northern ones. East European provenances from Latvia in the north to Romania in the south are consistently the best performers and transfers even to northern Scandinavia are possible. The pattern of performance over several sites is a useful character indicative of genetic affinities, identifying non indigenous populations and showing the range of adaptability of a given provenance.

Key words: Picea abies (L.) KARST.; provenance; adaptability; indigenity; provenance × site interactions.

Zusammenfassung

Die bisher veröffentlichten Ergebnisse aus den Baumhöhenmessungen des IUFRO Fichtenprovenienzversuchs von 1938 wurden zusammengefaßt. Hierbei wurden die auf den Versuchsflächen zuletzt erhaltenen Werte in Einheiten der Standardabweichung vom Versuchsflächenmittel ausgedrückt und getrennt für jede Provenienz in eine Landkarte eingezeichnet, die alle Versuchsorte umfaßt. Auf diese Weise wurde es möglich, die relative Wachstumsleistung jeder Fichtenherkunft auf allen Versuchsflächen, auf denen diese vorkommt, gleichzeitig zu beurteilen. Dabei stellte sich heraus, daß die alpinen und die aus dem südlichen Balkan stammenden Provenienzen die niedrigsten Werte aufweisen. Das gleiche trifft auf die skandinavischen Herkünfte mit Ausnahme der lokalen nördlichsten, die dort zu den besseren gehören, zu.

Die Wachstumsleistung der mitteleuropäischen Herkünfte läßt diese, mit Ausnahme der nördlichst gelegenen, in der Spitzengruppe erscheinen. Osteuropäische Herkünfte von Lettland bis Rumänien liegen überall an der Spitze, was deren Anbau sogar in Nordskandinavien eröffnet.

Aus dem Gesamteindruck, der durch die Wachstumsleistung auf den verschiedenen Versuchsflächen vermittelt wird, läßt sich der Bereich der Anpassungsfähigkeit einer bestimmten Fichtenherkunft charakterisieren. Desgleichen lassen sich unbekannte Herkünfte identifizieren.

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The Role of the Dendrology Course in the Teaching of Genetics*)

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Introduction

Most professional groups have at least two concerns in common, namely to perpetuate themselves by the recruitment of new members, and to have their views accepted by other members of society. Forest geneticists are no different. In fact, if these two activities were struck from the repertoire of legitimate professional conduct, some of us would have to look for a new livelihood.

Genetics is a young science — in the context of forestry, even younger — but despite its youth, it has, over the past twenty years, assumed a central position in the domain of biology. Its emerging significance may be attributed to the fact that it has provided both empirical evidence and a theoretical framework, to explain the two most perplexing and seemingly paradoxical phenomena that confront us in all life forms, namely continuity on the one hand, and change on the other. Furthermore, its basic three questions, *i.e.*, what genes are, how they act, and how they are transmitted, are relevant to an understanding of life processes at virtually every level of organization, from the molecule to the population. More importantly, perhaps, while it is a young science, it has addressed itself to such age-old phenomena as the resemblance among parents and progenies, such timeless questions as the origin of species, and such hotly debated, if moot, issues as the nature-vs.-nurture controversy.

Not surprisingly then, the teaching of genetics has become an integral part of any college curriculum in the life sciences. Forestry, among the applied fields, has perhaps, lagged behind in this development for a variety of reasons, some of which may have to do with a certain reluctance many foresters have in accepting a genetic point of view. Instituting special forest-genetics courses has been the most direct effort aimed at a remedy. It is my contention, however, that such specialty courses meet only part of the need, and that other courses may in fact be far more suitable to convey genetic concepts and an appreciation for genetics and evolution to the full spectrum of forestry students. One such course is dendrology.

In this article I will discuss the inherent merits of approaching dendrology in this manner. Hopefully, the article makes some constructive contribution to the perennial debate on curricular reform in forestry education. Furthermore, it may also stimulate discussion among those involved in the increasing number of workshops and short courses aimed at updating practicing foresters in such subjects as genetics, ecology, and silviculture.

Common counter-genetic biases in Forestry

Few of us like to go to the dentist. Memories creep up of some white-coated sadist trying to fragment your jaw with a jackhammer while searching for the last live wire of your central nervous system. Yet, our children seem to be much less reluctant to have their teeth examined. Apparently, the systematic effort by the dental profession to change its image is paying dividends. The modern dentist is your friend in shirtsleeves having an animated chat with you while seemingly getting his work done unbeknown to your novocained nerves, all taking place in a private little art gallery with soft background music.

The analogy may be less frivolous than it seems. Indeed, we may learn from the dentists a trick or two in how to make genetics more appealing and how to deliver the ge-

* I dedicate this article to WOLFGANG LANGNER whose writings (LANGNER, 1958) stimulated my early interest in forest genetics and whose generous hospitality during my 1969—70 visit at Schmalenbeck was much appreciated. The support from the Alexander von Humboldt Foundation is gratefully acknowledged.