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Analysis of results from a 59-years-old provenance experiment with Scots pine (*Pinus sylvestris* L.) in Lubień, Poland

Abstract: In 1992 and 1997 there measurements were made on an experimental area which is a part of an international provenance experiment with Scots pine (*Pinus sylvestris* L.), established by IUFRO in 1938. This paper presents results obtained in these measurements. It is shown that best provenances are from Baltic countries and Central Europe. The most productive provenances had the most crooked stems. Scandinavian provenances had straight trees but low survival and productivity.

Additional key words: IUFRO 1938, productivity, survival, straightness

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Introduction

In 1938 IUFRO (International Union of Forest Research Organizations) established its second international provenance experiment with Scots pine (*Pinus sylvestris* L.). The whole experiment was described in an earlier paper (Giertych and Oleksyn 1992). There is only one experimental area in Poland, established during World War II in 1940 in Lubień. First results from this area were published by Przybylski and Sztuka (1968). Data regarding height growth of trees in 1977 were mentioned by Giertych (1979). The latest published results concern measurements from 1984 including survival, height growth, diameter (DBH), basal area, productivity and qualitative traits such as stem straightness, self – prunning, branchiness and branch angle (Giertych 1986).

This paper presents results of recent measurements which were done in 1992 and 1997.

Methods

There are 18 European provenances of Scots pine included in this trial (Fig. 1, Table 1). An exact description and plan of the experimental area was published by Przybylski and Sztuka (1968) and Giertych (1986).

In 1992 height and diameters of trees were measured and qualitative traits were estimated. In 1997 only diameters were measured and also some qualitative traits were estimated. Estimation of stem straightness, branch thickness, branch length, branch angle, self-prunning and foliage density were done on a three point scale from 1 – poor to 3 – good.

All evaluation were based on the measurements and observations of 1997 except for tree height and volume production where 1992 measurements were considered.

Average stem diameters were calculated from the formula which is given in Giertych's paper (1986):

$$\bar{d} \quad \sqrt{\frac{\sum d^2}{N}}$$

where
$\bar{d}$ = average stem diameter
$\sum d^2$ = sum squares of diameters on the given plot
N = number of trees on the given plot.

Number of trees per hectar, basal area and volume production per hectar were calculated. This traits were obtained considering plot size.

The experimental area can be conventionaly divided into two blocks (Giertych 1986). Provenances with numbers 1, 2, 3, 4, 6, 7, 11, 17 and 18 have two replicates, provenances 53, 54 and 55 have three replicates and the other provenances (nos. 19, 20, 21, 22, 23 and 24) have no replication. Provenances with three replicates have plots which are situated near each other thus they form one big plot and plots with provenances 23 and 24 have a smaller area than the others.

An analysis of variance (Table 2A and B) was used for provenances which have two replications (in two blocks). Populations were grouped by the Duncan test (Table 3 and 4) on the basis of average trait values. According to the method described by Giertych (1986) results of unreplicated plots were corrected depending on the relation between block means and overall average of traits. The corrected values are shown in brackets in Tables 3 and 4.

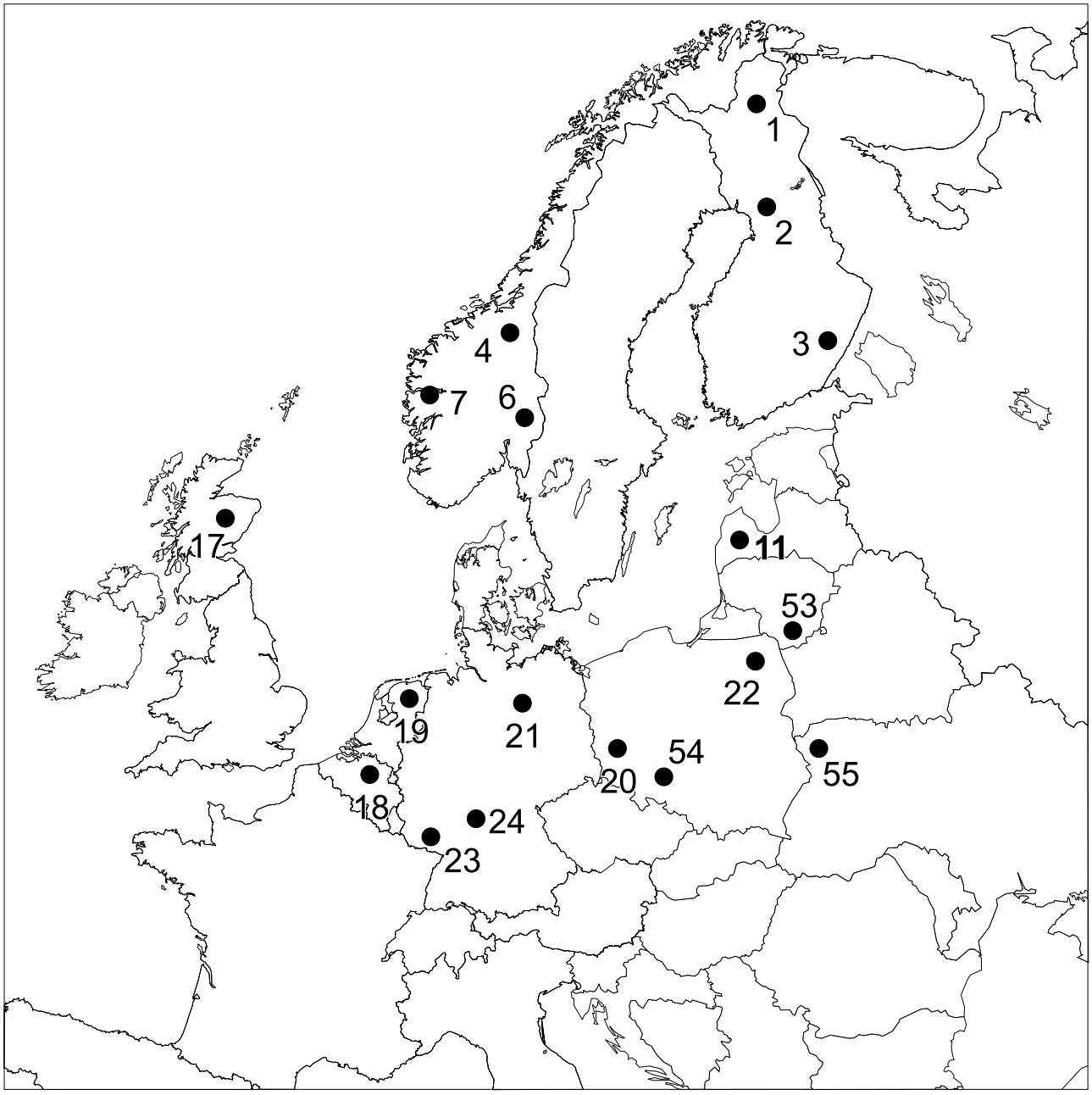

Fig. 1. Location of seed origin of Scots pine used in IUFRO 1938 provenance experiment in Lubień. Provenance names are shown in T7able 1.

Data for respective traits were normalized (transformed to units of standard deviation from the average) and showed ideographically on a map for stem straightness and volume production per hectar (Fig. 2 and 3), according to the method described by Giertych (1976).

Results

Analysis of variance has shown statistically significant differences among provenances as regards stem diameters, tree height, branch thickness and branch length. Significant differences were also shown be-

Table 1. Geographical data on Scots pine provenances used in the experimental area in Lubień

Number	Provenance	Country	Latitude	Longitude
1	Inari	Finland	68°40' N	27°37' E
2	Rovaniemi	Finland	66°25' N	26°36' E
3	Sääminki	Finland	61°40' N	28°55' E
4	Tonset	Norway	62°22' N	10°48' E
6	Åsnes, Hamar	Norway	60°32' N	12°11' E
7	Svanøy	Norway	61°30' N	5°07' E
11	Vecmokas	Latvia	57°03' N	23°10' E
17	Glen Garry	Scotland	57°04' N	4°55' W
18	Herselt	Belgium	51°03' N	4°56' E
19	Diever	Netherlands	52°51' N	6°21' E
20	Brody	Poland	51°47' N	14°46' E
21	Göddenstedt	Germany	52°59' N	10°50' E
22	Ruciane	Poland	53°41' N	21°26' E
23	Elmstein	Germany	49°20' N	7°57' E
24	Zellhausen	Germany	50°01' N	9°00' E
53	Mustejki	Lithuania	54°08' N	24°25' E
54	Rychtal	Poland	51°12' N	17°55' E
55	Luboml	Ukraine	51°15' N	24°05' E

Table 2. Results of variance analyses. F values
quantitative characters

Sources of variance	Degrees of freedom	Number of trees/ha 1997 [1)]	DBH 1997 [2)]	Height growth 1992 [3)]	Basal area 1997 [1)]	Volume production 1992 [1)]
Provenances	8	5.96*	3.44**	22.23**	2.11	2.53
Blocks	1	0.36	5.08*	26.95**	0.03	0.84
Provenances × blocks	8	*ni*	1.94	9.30**	*ni*	*ni*

qualitative characters

Sources of variance	Degrees of freedom	Straightness 1997 [2)]	Branch thickness 1997 [2)]	Branch length 1997 [2)]	Branch angle 1997 [2)]	Self – prunning 1997 [2)]	Foliage density 1997 [2)]
Provenances	8	1.29	3.53**	3.71**	0.97	1.91	0.47
Blocks	1	57.8**	1.18	7.27**	6.36*	77.91**	0.63
Provenances × blocks	8	4.0**	1.16	1.44	3.77**	4.0**	0.43

For provenances and interaction (tree traits) $F_{0.05} = 1.97^*$ $F_{0.01} = 2.57^{**}$
For blocks (tree traits) $F_{0.05} = 3.87^*$ $F_{0.01} = 6.72^{**}$
For provenances (plot traits) $F_{0.05} = 3.44^*$ $F_{0.01} = 6.03^{**}$
For blocks (plot traits) $F_{0.05} = 3.32^*$ $F_{0.01} = 11.30^{**}$
Degrees of freedom for error : [1)]8; [2)]378; [3)]412
ni – no interaction was evaluated

Table 3. Averages for quantitative traits. Values corrected according to block means are shown in brackets. The same letters indicate no significant differences between provenances on the 0,05 level

Provenance	Number of replications	Number of trees per ha	Tree height [m] 1992	DBH [cm] 1997	Basal area [m^2/ha] 1997	Volume [m^3/ha/year] 1992
1	2	618 ab	18.63 cd	23.46 ab	26.59 a	2.61 b
2	2	765 ab	16.03 b	21.86 ab	28.72 a	2.55 b
3	2	603 ab	18.30 c	22.58 ab	23.01 a	1.99 ab
4	2	471a	17.64 c	24.76 b	22.26 a	2.34 ab
6	2	676 ab	16.39 b	20.00 a	21.41 a	2.00 ab
7	2	368 a	13.85 a	23.47 ab	16.37 a	1.25 a
11	2	1132 b	19.44 d	20.16 a	36.40 a	3.97 c
17	2	324 a	17.80 c	22.76 ab	13.31 a	1.30 a
18	2	868 ab	16.07 b	21.01 a	29.61 a	2.94 b
19	1	765 (835)	16.76 (16.45)	21.01 (20.37)	26.50 (27.31)	2.68 (2.98)
20	1	941 (1027)	22.83 (22.41)	21.18 (20.53)	33.13 (34.14)	5.51 (6.14)
21	1	853 (931)	16.63 (16.33)	20.60 (19.97)	28.42 (29.29)	2.99 (3.34)
22	1	912 (995)	16.17 (15.87)	20.47 (19.84)	30.00 (30.92)	2.76 (3.07)
23	1	1303 (1184)	19.11 (19.47)	20.09 (20.71)	41.31 (40.04)	4.87 (4.80)
24	1	1116 (1014)	19.86 (20.24)	22.69 (23.39)	45.13 (43.74)	5.24 (5.17)
53	3	988	20.83	20.65	33.19	3.98
54	3	1029	19.64	20.18	32.91	4.09
55	3	1047	16.40	20.31	34.0	3.63
Mean		821	17.87	21.44	29.07	3.23

Table 4. Averages for qualitative traits. Values corrected according to block means are shown in brackets. The same letters indicate no significant differences between provenances on the 0,05 level

Provenance	Number of replications	Straightness 1997	Branch thickness 1997	Branch length 1997	Branch angle 1997	Self – prunning 1997	Foliage density 1997
1	2	2.40 a	2.03 ab	1.84 a	1.80 a	1.47 a	2.29 a
2	2	2.18 a	2.00 ab	1.93 a	2.04 a	1.50 a	2.11 a
3	2	2.32 a	2.04 ab	1.92 a	2.02 a	1.68 a	2.24 a
4	2	2.57 a	1.69 a	1.76 a	1.87 a	1.35 a	2.34 a
6	2	2.23 a	2.04 ab	2.00 a	2.09 a	1.63 a	2.07 a
7	2	2.21 a	1.71 a	1.78 a	2.17 a	1.48 a	2.33 a
11	2	2.59 a	2.34 b	2.35 b	2.14 a	1.72 a	2.21 a
17	2	2.50 a	1.82 a	1.73 a	1.95 a	1.55 a	2.23 a
18	2	2.21 a	2.01 ab	1.92 a	1.78 a	1.54 a	2.17 a
19	1	2.04 (2.27)	2.04 (2.01)	1.77 (1.87)	1.62 (1.51)	1.50 (1.25)	2.04 (2.01)
20	1	1.94 (2.16)	2.16 (2.12)	2.00 (2.11)	1.81 (1.69)	1.84 (1.53)	2.16 (2.13)
21	1	2.17 (2.41)	2.17 (2.13)	2.00 (2.11)	2.31 (2.15)	2.14 (1.78)	2.34 (2.31)
22	1	2.48 (2.76)	1.94 (1.91)	1.90 (2.01)	2.00 (1.87)	1.90 (1.58)	2.19 (2.16)
23	1	1.83 (1.62)	1.83 (1.85)	1.83 (1.75)	1.50 (1.60)	1.17 (1.36)	2.25 (2.28)
24	1	1.71 (1.51)	2.0 (2.02)	1.71 (1.61)	1.71 (1.83)	1.29 (1.5)	2.14 (2.16)
53	3	2.37	2.02	2.08	2.07	1.84	2.13
54	3	2.62	2.11	2.15	1.76	1.45	2.20
55	3	2.47	2.03	2.05	1.80	1.23	2.20
Mean		2.30	1.99	1.94	1.89	1.52	2.19

Fig. 2. Volume production per hectar per year shown in units of standard deviation from the average of the experimental area. Dots indicate origin of provenance, columns up or down indicate their value. Deviations from – 0,15 to +0,15 are contained in the diameter of dot

tween blocks as regards the same traits and in addition for stem straightness, self – prunning and branch angle (Table 2 A and B). Results of measurements of quantitative traits and estimation of qualitative traits are shown in Tables 3 and 4, respectively.

As can be seen from Table 3, the best survival was noticed in populations from Germany (23 and 24), Latvia (11), Ukraine (55), Poland (54) and Lithuania (53). The highest mortality was observed in northern provenances from Scotland (17), Norway (7 and 4) and Finland (3 and 1).

Tallest trees were from provenances of Poland (20 and 54), Lithuania (53), Germany (24) and Latvia (11) and the smallest ones originated from Norway (7), Poland (22), Finland (2) and Belgium (18) (Table 3).

The most important trait is the calculated volume production per hectar (Fig. 2) which was highest for provenances from Poland (20 and 54) and Germany (23 and 24). Highly productive were also Lithuanian (53) and Latvian (11) pines. Norwegian (7, 6, 4) and Scotch (17) populations had lowest volume (Table 3, Fig. 2). The three most productive provenances had the most crooked stems. As regards stem straightness the best were trees from Polish (22 and 54), Latvian (11) and Norwegian (4) provenances (Tab. 4, Fig. 3).

Good in self – prunning of stems were provenances with trees of thin and short branches: German (21) and Latvian (11) and also those with a mean branch thickness – Lithuanian (53), Finnish (3) and Norwegian (6). The poorest in this trait were pines from Ukraine (55), Netherlands (19), Norway (4) and Germany (23) (Table 4).

As regards branch angle and foliage density no significant diferences among provenances were observed (Table 2). Provenances from Norway (6 and 7), Germany (21) and Latvia (11) have a branch angle close to 90 degrees. Polish (20 and 54), German (23) and Belgian (19) provenances have trees with an acute branch angle. Northern provenances have both good (1, 4, 7) and sparse (2 and 6) foliage density (Table 4).

Discussion

The results indicated remarkable provenances which have high productivity as well as good quality traits. The best is Latvian provenance Vecmokas (11), known earlier as "Riga pine" (Wright and Bull 1963). Also good are Lithuanian Mustejki (53), Polish Rychtal (54) and Ukrainian Luboml (55). They grow well and have good quality and only the latter two populations have poor self-prunning.

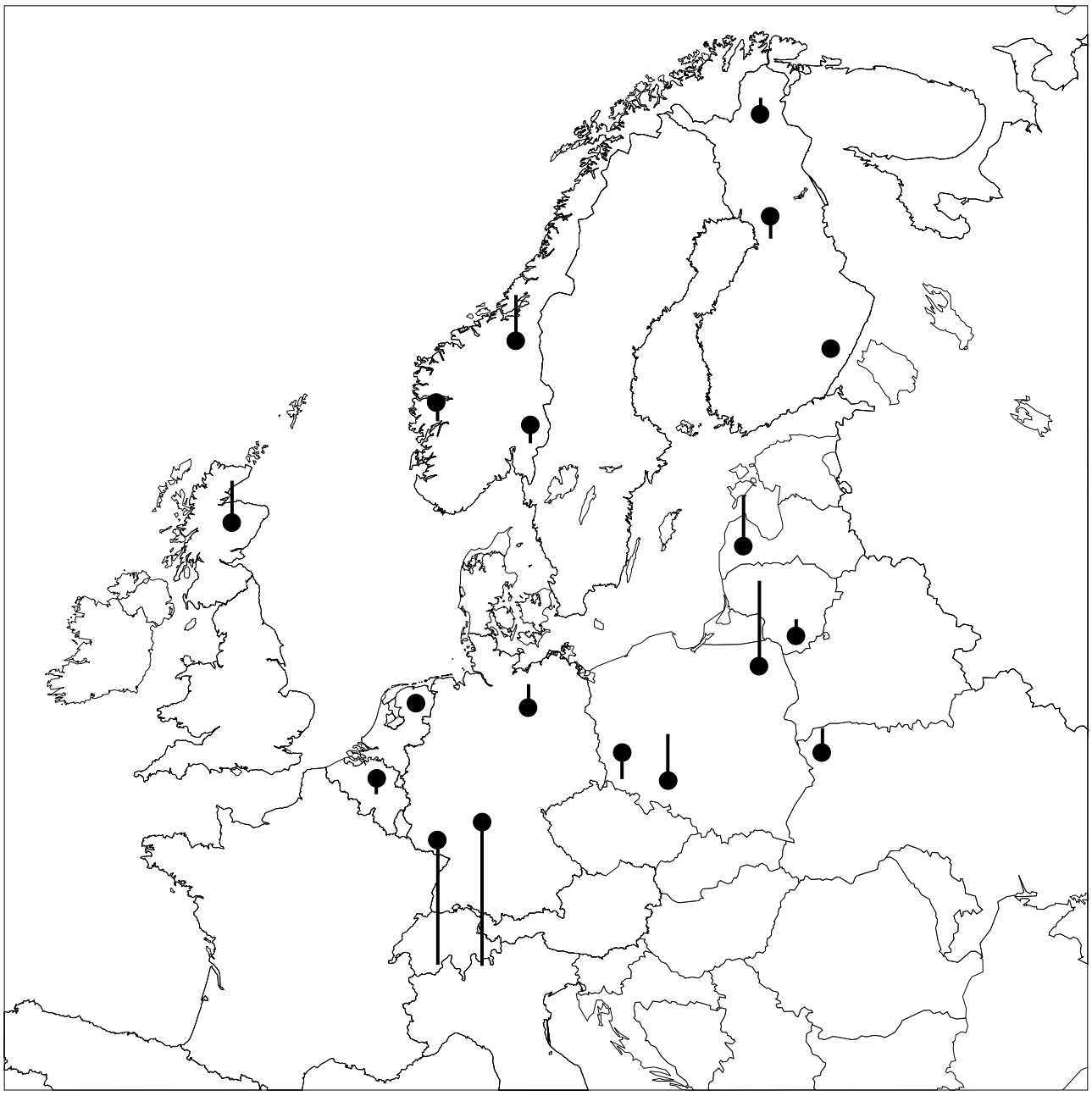

Fig. 3. Estimation of stem straightness shown in units of standard deviation from the average of the experimental area. Dots indicate origin of provenance, columns up or down indicate their value. Deviations from – 0,15 to +0,15 are contained in the diameter of dot

Trees of Polish provenance Ruciane (22) are very straight but other traits are on average level; pines from German provenance Göddenstedt (21) are very similar.

There is no confirmation of high value for the Dutch provenance Diever (19), which was described earlier as very good by Przybylski and Sztuka (1968). Also Belgian provenance Herselt (18) has not confirmed its good results obtained in other trials (Wright at al. 1966). They are rather average in this trial.

It appears that very different provenances of Scots pine can be found in a not very extensive area, e.g. provenances from western Poland-Brody (20) and Rychtal (54) are distant only about 200 km each from other and they are highly productive but differed with respect to quality.

These results are in agreement with results attained in other provenance experiments with Scots pine. They confirm the high value of pines from the Baltic countries and Central Europe (Giertych 1979, Giertych and Oleksyn 1992).

Based on 1992 and 1997 evaluations there is no recommendation for breeding in Poland for provenances Elmstein and Zellhausen (23 and 24 respectively) from western Germany. They have good productivity but also many crooks and thick branches. Polish provenance Brody (20) is very similar regarding productivity and shape of stem. Northern populations from Scotland, Norway and Finland are also not recommended. They have low productivity and high mortality confirmed also in other international experiments. Therefore the breeding value of these provenances is limited.

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Analiza wyników 59-letniego doświadczenia proweniencyjnego z sosną zwyczajną (*Pinus sylvestris* L.) w Lubieniu w Polsce

Streszczenie

W 1992 i 1997 przeprowadzono kolejne pomiary na jednej z powierzchni badawczych doświadczenia proweniencyjnego z sosną zwyczajną, założonej z inicjatywy Międzynarodowej Unii Leśnych Placówek Badawczych (IUFRO) w 1938 roku w Polsce. Dane przedstawione w tej pracy wskazują, że sosny środkowoeuropejskie i z krajów bałtyckich dają duży przyrost masy w połączeniu z dobrą jakością. Najbardziej produktywne są proweniencje z Niemiec i południowo-zachodniej Polski, ale jakość drzew jest niska. Proweniencje skandynawskie mają natomiast proste drzewa, lecz niską przeżywalność i produktywność. Obie grupy pochodzeń nie powinny być rozprzestrzeniane w Polsce.