

bb) Inconvénients:

- 1) Dégâts importants sur les pousses isolées.
- 2) Obstacle aux échanges gazeux (manque de gaz carbonique; imperméabilité à la vapeur d'eau).
- 3) Dans la plupart des cas, abaissement de température très marqué.
- 4) L'eau de condensation se collecte, alourdit les sacs et augmente le risque de cassure des branches.
- 5) Taux de mortalité élevé des fleurs isolées et des organes végétatifs.

b) Sacs en tissu

aa) Avantages:

- 1) Les dommages aux pousses sont plus faibles.
- 2) Les dimensions des pores du tissu peuvent être choisies en fonction de celles du pollen.
- 3) Faible variation de température.
- 4) Échanges gazeux suffisants.
- 5) Le développement des fleurs peut être observé par une fenêtre en polyéthylène ajustée sur le sac.

bb) Inconvénients:

- 1) Prix d'achat relativement élevé.
- 2) Augmentation de poids en période de pluie jusqu'à 3 fois le poids sec.

c) Sacs en "pergamine"

aa) Avantages:

- 1) Faible prix d'achat.

bb) Inconvénients:

- 1) Dommages aux pousses très élevés.
- 2) Aucune possibilité d'observer le développement des fleurs.
- 3) Les plus fortes variations de température.
- 4) Pas d'échange gazeux
- 5) Petites dimensions.

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A Cline or not a Cline - a Question of Scots Pine

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In a paper published in this Journal, WRIGHT and BALDWIN (1957) reported certain results of a provenance test for Scots pine (*Pinus silvestris*) conducted at Hillsboro, New Hampshire, U.S.A. The test embraced mainly provenances used in the 1938 international provenance test, of which Professor WERNER SCHMIDT, then at Eberswalde, was the initiator. He was at the time Chairman of a Sub-Committee for Forest Seed and Forest Tree Races set up by the International Union of Forest Research Organizations (which committee was unfortunately dissolved when the Union was linked to the F.A.O. after the War). In the tests with pine and spruce, the seed material was complemented in Stockholm, with the intent to avoid incomplete sampling and distributed from there by the Secretary-General of the Union at the time, Professor PETRINI, and the Author. The larch provenances were collected wholly by Professor SCHMIDT.

The results of the test in New Hampshire are of great interest for two reasons, firstly because in comparison with European conditions, the test is located in a very southerly latitude, 43° N., and secondly because it comprises a very large number of the provenances which were the objects of the international test, viz.: 46 out of a total of 52.

WRIGHT and BALDWIN (ibid.) report the average height of the trees, which is given for the different provenances in each block separately, whereas, in the few cases where replications occur, it is not given for the individual plots in each block. The results in regard to needle length,

number of living and dead trees, stem and branch diameters, different kinds of crook, fructification and damages by porcupine, have been presented only as means for the provenances as grouped into ecotypes or corresponding regions by WRIGHT and BALDWIN. This makes a detailed study of the test results impossible, except so far as the height measurements are concerned.

The study of the height measurements can hardly be said to have been facilitated by the consistent use by WRIGHT and BALDWIN of an order of sequence for the provenances which is dictated neither by their numbers, their alphabetical sequence, their latitude, nor by their measured heights. This applies equally to Table 1, containing data on the origin of the seedlots, and Table 3, giving a summary of the heights (ibid. pp. 3 and 6).

In Table 1, all the pine provenances used in the 1938 international test have been reported. They are given in numerical sequence, with latitudes, longitudes and altitudes. In some cases the data available at present regarding the origin of the provenances differ from those reported by WRIGHT and BALDWIN. This is partly due to the fact that they have taken their data from VEEN (1952). Hence the error in the latitude of Nos. 37 and 38, Suprasl, which has been given as "51° 13'" instead of 53° 13'. No. 8 was already in the first List of data, issued from Eberswalde, called "Voxana" instead of *Voxna*. Due presumably to a misprint, the latitude of No. 2 Rovaniemi is also incorrect. It should be 68° 30' instead of "66° 30'". This location is however in the correct place on their map (ibid. Fig. 1).

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Table 1. — Data on the origin of seedlots used in the international Scots pine provenance test of 1938, percentage of dry matter content in the needles of 2—4-year seedlings in the late fall in Stockholm and the average 17 year height in New Hampshire, U.S.A.

Italics = not native stands.

Provenances		North lat.	East long.	Altitude m	Number of days with average temperature $\geq + 6^{\circ}\text{C}$	Length of first day in spring with temp. $\geq + 6^{\circ}\text{C}$ hours min.	Dry matter content in the needles %	Average 17 year height ¹⁾ feet
No.	Locality							
1	Inari (Kyrö)	68°40'	27°37'	140	102	24 00	40,3	5,0
2	Rovaniemi (Kivalo)	66°25'	26°36'	250	111	21 14	39,4	6,4 ⁴⁾
3	Sääminki (Niittylahti)	61°44'	28°55'	85	148	17 08	37,7	12,8
4	Tönset	62°22'	10°48'	550	120	18 25	38,4	9,3
5	Målselv (Björkli)	69°06'	18°50'	75	113	24 00	40,0	5,8 ⁴⁾
6	Åsnes	60°32'	12°11'	230	149	16 30	37,1	13,6
7	Svanöy	61°30'	5°07'	50	184	15 53	36,7	12,5
8	Voxna	61°20'	15°31'	200	143	17 02	37,3	13,4
9	Tönnersjöheden	56°40'	13°08'	100	177	15 01	36,0	15,3 ²⁾
10	Böda	57°18'	17°01'	5	178	15 24	36,0	17,2 ²⁾
11	Vecmokas	57°03'	23°10'	80	176	15 03	36,1	17,6
12	Susk (B)	50°50'	26°00'	185	194	13 31	34,5	⁷⁾
13	Presov	49°00'	21°15'	500	204	13 17	34,3	⁷⁾
14	Talmacel	45°40'	24°08'	600	211	12 59	34,4	17,1
17	Glen Garry	57°04'	4°55' W	150	199	14 03	35,7	14,5 ²⁾
18	Hersselt (cult.)	51°03'	4°56'	20	231	12 21	34,0	22,2
19	Diever (Smilde) (cult.)	52°51'	6°21'	10	214	13 12	35,1	18,1 ⁴⁾
20	Pförten	51°47'	14°46'	85	210	13 13	34,5	19,5
21	Göddenstedt (Jg. 80)	52°59'	10°50'	75	206	13 33	34,6	18,8
22	Cruttinen (Jg. 240a ²⁾)	53°41'	21°26'	120	186	14 13	34,8	19,0
23	Elmstein (Erfenstein)	49°20'	7°57'	325	211	13 03	33,5	19,0
24	Zellhausen (Jg. 27)	50°01'	9°00'	140	218	12 51	33,9	19,0 ²⁾
25	Lenti	46°38'	16°33'	250	226	12 26	33,2	19,0
26	Ambert	45°33'	3°45'	700	214	13 02	34,8	⁷⁾
27	Millau (Causse Noir)	44°10'	3°22'	825	215	13 03	34,8	⁷⁾
28	Les Angles (Forêt de la Matte)	42°36'	2°07'	1570	170	14 12	35,0	⁷⁾
29	Bromarv (Solböle)	60°03'	23°06'	15	162	16 25	37,4	15,6 ²⁾
30	Modum	60°04'	10°00'	300	145	16 34	37,0	14,9
31	Val di Fiemme - Fleimstal	46°18'	11°20'	1100	199	13 24	34,4	17,2 ⁴⁾
32	Griva	55°58'	26°15'	160	179	14 48	35,7	18,7
33	Breda (Mastbosch) (cult.)	51°34'	4°46'	10	231	12 26	34,3	⁷⁾
34	Tinoava	47°24'	25°22'	910	165	14 18	35,7	16,2
35	Langensteinbach (VII 11)	48°55'	8°30'	260	216	12 49	33,9	19,5 ⁴⁾
36	Langenbrand (IV 51, 52, 53)	48°47'	8°40'	525	200	13 24	34,7	19,5 ²⁾
37	Suprasl (A)	53°13'	23°22'	160	187	13 59	35,2	19,4 ²⁾
38	Suprasl (B)						35,2	19,7
39	Bolevice (A)	52°24'	16°10'	90	200	13 35	35,0	19,6
40	Bolevice (B)						34,8	19,7
41	Susk (A)	50°50'	26°00'	185	194	13 31	34,3	19,6 ⁴⁾
42	Kuřivody	50°36'	14°43'	300	197	13 33	34,9	19,7
43	Tišnov	49°21'	16°24'	375	201	13 22	34,4	19,4 ²⁾
44	Třebon — Wittingau	49°00'	14°45'	450	208	13 03	34,6	20,7
45	High Tatra - Vysoké Tatry	49°09'	20°13'	650	190	13 43	34,8	18,9
46	Vindeln (Kulbäcksliden)	64°11'	19°35'	270	123	19 02	38,3	10,0
47	Brännberg	65°48'	21°16'	100	122	19 59	38,5	9,1
48	Vitsand	60°23'	12°55'	175	148	16 43	36,9	15,4
49	Axamo	57°46'	14°03'	225	159	15 51	36,8	16,0 ⁵⁾
50	Strömsund	63°50'	15°33'	300	127	18 34	38,3	10,0
51	Svenskådalen	64°02'	13°04'	500	118	19 22	38,6	9,3 ⁵⁾
53	Mustejki	54°08'	24°25'	130	187	14 12	35,6	20,2 ³⁾
54	Rychtal	51°12'	17°55'	190	200	13 31	34,4	19,6 ⁴⁾
55	Luboml	51°15'	24°05'	195	204	13 20	34,3	18,1

1) Average of blocks I, II and IV (WRIGHT and BALDWIN, Table 3).

2) Estimated from blocks I, III and IV.

3) Estimated from blocks II, III and IV.

4) Estimated from blocks I and IV.

5) Estimated from blocks II and IV.

6) Estimated from block IV only.

7) Provenance not cultivated in New Hampshire.

8) WRIGHT and BALDWIN (Table 1) point out this provenance as originating from a planted stand, although the stand is characterized as "Old scots Pine" and VEEN (1952, p. 30) too states it to be autochtoneous.

The table also gives the number of days with an average normal temperature of $+6^{\circ}\text{C}$ or higher — representing the vegetation period — and the length of the first day of the year with this temperature. In the last column but one the per cent dry weight of the needles is given, the figures representing the means of 11 determinations per provenance on 2/0 seedlings in the late autumn 1939, and of 10 determinations on 2/2 seedlings in 1941. Each deter-

mination was made on 1 or a few pairs of needles per plant taken from the terminal shoot of a large number of individuals.

The last column gives the average height of the trees, computed on the basis of the data contained in Table 2 in WRIGHT's and BALDWIN's report. In the last-mentioned table the mean heights of the different provenances are given for each block separately. However, no. 4 is the only block

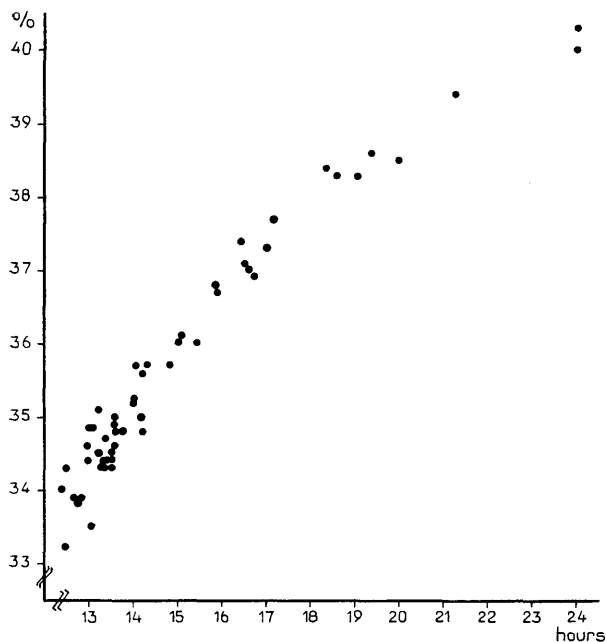


Figure 1. — Relationship between dry matter content and the length of daylight of the first day in the year with an average normal temperature of $+6^{\circ}\text{C}$ at the native habitats of the 52 provenances (Cf. table 1). Correlation coefficient $R > +0.98$.

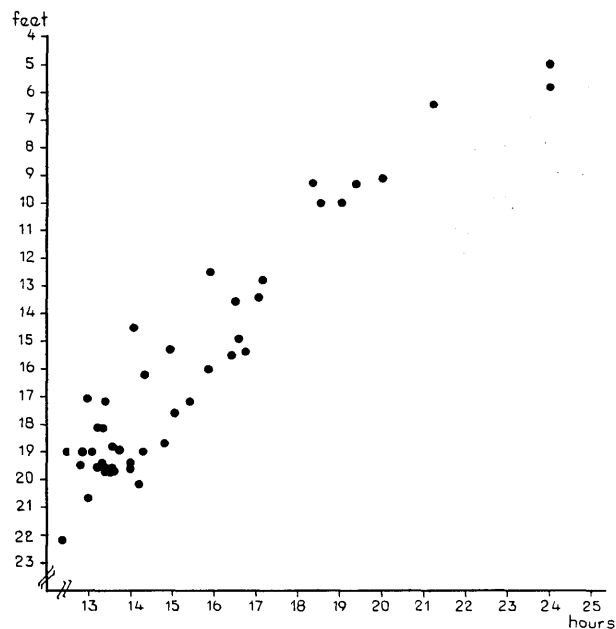


Figure 2. — Relationship between the average 17 year height of the 46 provenances in New Hampshire, U.S.A., and the daylight period as in figure 1.

that is complete. The plots in this block consist of single rows of 15 trees, except in the case of 7 provenances, which have two rows. Four provenances are missing in Block I, 14 in Block II, and 22 in Block III. This due to the experimental design of the outplant. Thirty-six trees have been measured in each of the plots in Blocks I, II and III.

The height data in the last column of Table 1 represent the means of the heights measured in Blocks I, II and IV. In some cases the data for the individual block represents the mean also of 2 plots, or, as in two cases, of 3 plots.

Wherever a provenance has been missing in one of these blocks, I have tried to reconstruct the missing value by means of the other height data given. I have had to do so for no less than 17 of the 46 height measurements. Of these 17 values, however, 7 are based on measurements in 3 different blocks, but 9 of them are based on measurements in only 2 blocks (4 of which are however based on at least 3 plots). One value had to be calculated on the basis of one single plot in Block IV.

Due to the design of the test, the height data presented are thus based on a very unequal number of trees: from 195 (No. 20) down to no more than 15 trees (No. 20). The average number is thus just below 100 trees per provenance. It may consequently be assumed a priori that in many cases, mean heights that are representative of the provenances have not been obtained. The result is that when calculating the relationship between the tree heights and the rest of the provenance data — e.g. the latitudes of their native habitats — the deviations will be greater than would be the case if all the height values were truly representative.

My own studies of the variability of Scots pine have concerned also the dry matter content of the needles at the entrance of dormancy: in the vicinity of Stockholm = October–November. The dry matter content is a very good measure of the plants' readiness for hibernation. It varies parallel with their resistance to frost, their content of reducing substance (sugars), the degree of winter coloration of the needles (depending partly on the chloro-

phyll content), the rapidity of shoot development in the spring, and their resistance to the attack of certain parasites, e. g. *Phacidium infestans* (LANGLET, 1934, 1936).

The dry matter contents thus obtained show a remarkably close relationship with the conditions in the native habitats of the different provenances in respect of latitude and duration of the period of vegetation (expressed as the number of days with an average temperature of $+6^{\circ}\text{C}$ or more). Even more close is the relationship between the dry matter content and the length of the first day of the year with a normal average 24-hour temperature of $+6^{\circ}\text{C}$. This relationship in respect of the 52 pine provenances used in the 1938 international test will be seen in the scatter diagram Fig. 1. The line of regression is curvilinear, and the correlation coefficient (R) exceeds $+0.98$. About 97% of the original variance has thus been removed by eliminating the influence of the day length during the first $+6^{\circ}\text{C}$ day (LANGLET, in print).

One may be justified in drawing certain conclusions from the diagram in Fig. 1. Firstly, the temperature and light conditions that exercise any influence at all on the dry matter content and thus also of the physiological state of the plants which in reveals may be expressed as "the length of the first $+6^{\circ}\text{C}$ day of the year": If it is of this day length that exercises direct influence, then it must be some other factors with which its relationship is practically speaking perfect. Secondly, the dry substance content of the needles shows a condition of the plants which indicates their adaptation to the temperature and day length of the native habitat of the provenance, an inherited ecological adaptation. Thirdly, the variability of the dry matter content, and thus also of the physiological conditions which it illustrates, corresponds to the variability that is characteristic of the changes in temperature and day length from one place to another.

It was established from a material comprising some 600 different pine provenances that the dry matter content of the seedlings varied *continuously* from the mild

regions in the south to the cold northerly regions in Sweden. A material comprising 97 provenances from places scattered over the larger part of the pine range indicated that the same continuity in the variability of the dry matter content applies in principle also to these provenances (LANGLET, 1934, 1936).

Although I have stressed the continuous variability of the dry matter content, I have never, be it well noted, assumed primarily that there must be a continuity in relation to distance, i. e. that the dry matter content would change by a certain per cent upon transfer a certain number of miles north to south or the like, although this may very well occur. What I have assumed is *the continuity in relation to the factors to which the dry matter content is adapted*: "It may be assumed that the characteristics that determine the seedlings' reactions to extraneous influences generally vary continuously accordingly as these influences themselves vary from one place to another" (LANGLET, 1934, p. 107)². *Discontinuity may thus very well occur — where the conditional ecological factors vary discontinuously*.

Such a continuity of the physiological variability is nothing peculiar to Scots pine, and my statement: "This may a priori be expected to characterize any species with a large range which shows evidence of inherited adaptation to the climate or other continuously varying natural conditions" (ibid. p. 109)³, has later on been confirmed (e. g. STEBBINS, 1950).

The same opinion has also been expressed by STEBBINS (1950, p. 44): "It is likely that most species with a continuous range that includes more than one latitudinal or altitudinal climatic belt will be found to possess clines for the "physiological" characteristics adapting them to the conditions prevailing in the different parts of their range."

However, it is not my intention to imply that I am the first investigator to have found in the Scots pine a continuous variability, and a variability that occurs parallel with the changes in continuously varying external factors. Nor has it ever been so, since I have summarized the opinions held by other authors on this subject in an earlier report (LANGLET, 1936). Thus NÄGELI, as early as in 1865, spoke of "Chemisch-physikalische Varietäten", and CIESLAR (1899, p. 115) invented the term "physiologische Varietät", which is still used in forestry literature and which he defined in general as follows:

*"Among the botanical species, and even among the recognised morphological varieties, there are physiological varieties which for their existence have to thank hereditary characteristics acquired under the influence of special environmental conditions during an infinite space of time"*⁴). (Italics are CIESLAR's.)

Two decades later TURESSON introduced into the botanical-genetical discussions the term "ecotype" for the same phenomenon — without being cognizant of CIESLAR's term, which had so far not penetrated beyond forestry litera-

²) „Es ist anzunehmen, daß im allgemeinen die Eigenschaften, die die Reaktion der Pflanzen gegenüber äußeren Einflüssen bedingen, in demselben Maße kontinuierlich variieren, wie diese Einflüsse selbst sich von Gegend zu Gegend ändern.“

³) „Es ist a priori zu erwarten, daß solche Variation jede Art mit größerem Verbreitungsgebiet kennzeichnet, welche erbliche Anpassung an das Klima oder andere kontinuierlich variierende Naturverhältnisse aufweist.“

⁴) „Innerhalb der botanischen Species, ja selbst innerhalb der anerkannten morphologischen Varietäten gibt es physiologische Varietäten, welche der Erblichkeit von im Laufe unendlich langer Zeiträume unter dem Einflusse spezifischer Standortsfaktoren angeeigneter Charaktere ihre Entstehung verdanken.“

ture. TURESSON's definition of the term was in principle the same as CIESLAR's: "The term *ecotype* is proposed here as an ecological unit to cover the product arising as a result of the genotypical response of an ecospecies to a particular habitat" (TURESSON, 1922, p. 112).

SCHOTT (1904, p. 602), it is true, has not used the expression "continuity", but when he says that "we can thus distinguish as many physiological varieties of pine, within its natural range, as there are regions within this range which differ from each other in regard to climate and other factors of importance for the development", and then assumes that "... at the boundaries ... the varieties will transmute into each other", the result is in reality a continuous variability. This is made still more clear when later on he writes (SCHOTT, 1907, p. 271)⁵: "These pine races ... occur in unlimited numbers within the vast range of the pine."⁶

ENGLER (1908, p. 306) was very well aware of the real significance of the variability of the pine: "... The varieties of this species occurring from south to north, and from the lowlands of Central Europe to the upper tree limits in the Alps, form two continuous series that are very similar, and the initial and end sections of which are linked together by a large number of intermediate types. The North German pine can no more be distinguished from the South Swedish pine by any distinct morphological or biological characteristics than the latter can be distinguished from the Lappland pine, just as the Baltic and Livonian pines are nothing but climatic forms of transition between the East Prussian and the Finnish pines. The characteristics of all Scots pine in the different European regions vary always only in quantity. There are no sharply defined borders anywhere."⁷

Thus, half a century ago clear opinions were expressed regarding the connection between the variations in Scots pine from different provenances and between the climatic conditions of their native habitats and those of their new sites. As early as in 1895 CIESLAR assumed that the differences between various provenances (of spruce) were due to the latter's congenital adaptation to the different lengths of the vegetation period.

It was some Swedish investigators, however, — WIBECK (1919), SCHOTTE (1923), and ENEROTH (1926) — who were the first to connect the variability of Scots pine according to its provenance directly with definite temperature data for the native habitats: the mean annual temperature, different monthly mean temperatures, or the mean temperature of the June—September period. Since the mean temperatures vary continuously from south to north, from

⁵) „Wir können mithin soviel physiologische Varietäten der Kiefer innerhalb ihres natürlichen Verbreitungsgebietes aufstellen, wie es in diesem Verbreitungsgebiete Gegenden gibt, die sich durch Klima oder sonstige für den Wuchs wichtige Faktoren voneinander unterscheiden.“

⁶) „Diese Rassen der Kiefer ... sind auf dem ungeheuren Verbreitungsgebiet der Kiefer in unbegrenzter Zahl vorhanden.“

⁷) "... die von Süd nach Nord und von den Tieflagen Mitteleuropas bis zur oberen Waldgrenze der Alpen auftreten, Formen dieser Holzart zwei, einander sehr ähnliche, kontinuierliche Reihen darstellen, deren Anfangs- und Endglieder durch eine große Zahl von Zwischengliedern verbunden sind. Die norddeutsche Föhre läßt sich ebensowenig durch scharfe morphologische und biologische Merkmale von der südschwedischen trennen als diese von der Föhre Laplands, und in gleicher Weise sind die kur- und livländischen Föhren nur klimatische Übergangsformen von der ostpreussischen zur finnischen Föhre. Es handelt sich bei den Föhren der verschiedenen Gebiete Europas immer nur um das Mehr oder Weniger der gleichen Eigenschaften. scharfe Grenzen bestehen nirgends.“

the low coastal areas to the high inland altitudes, the same continuous variability in the pine was a pre-condition for the existence of any such close relationship. They consequently found no cause for discussing this continuity at all, nor did their findings occasion any invention of new "varieties" on their part.

My own studies, which have led to my calculating not with the mean temperatures of certain periods, but instead with an annual periodicity of the temperatures, expressed as the number of days of a certain temperature ($+6^{\circ}$ C. or more, corresponding approximately to the "vegetation period"), and with the daily periodicity of daylight, expressed as the day length (on the first day of the year with an average temperature of $+6^{\circ}$ C.), are thus a direct supplementation of my above-mentioned fellow-countrymen's findings. My own findings confirm the accuracy of CIESLAR's actually quite modern views reflected in his above-mentioned definition of "physiological varieties", for it is of little significance whether he put into "Einfluß spezifischer Standortsfactoren" a Lamarckian view when the same term is now accepted as meaning "selection". The result is in both cases the same, viz.: the "geographical gradient in phenotypic characters" that I have called *continuous variability*, and which later on HUXLEY (1938) called *cline*.

TURESSON, who defines "ecotype" as an "ecological unit", also stresses the general discontinuity between ecotypes of the same species. He points out, however, (TURESSON, 1936) with reference to my preliminary report (LANGLET, 1934), that in principle, a continuous variability is not incompatible with his definition, and that such variability is not inconceivable where pine and certain other species of forest trees are concerned. — This would however make them exceptions to the general rule.

What has caused me to summarize here some earlier statements made in this field of research are the conclusions drawn by WRIGHT and BALDWIN from their findings on the variability of pine.

In discussing these findings they quote by way of introduction WIEDEMANN (1930, p. 818), who writes regarding the results of i. a. the 1907 international provenance test for Scots pine: "According to the conclusions quoted in Section III, there is in general uniformity of growth characters within the various race regions, so that in most cases the results of the International Experiment and other race investigations can be carried over to the races concerned in toto. In these experiments as well as in practice, the susceptibility of the southern pine to needle cast, the crookedness and susceptibility to snow break of the southwest German pine, and the exceedingly straight and narrow form of the East Prussian and Belgian pine are apparent." (WRIGHT and BALDWIN, p. 10.)

It is to be regretted that WRIGHT and BALDWIN did not pay attention also to the next sentence in WIEDEMANN's report: "Despite the general uniformity, one has to reckon on finding within a race region — and particularly those regions where within a small area the differences in climate and site are more pronounced — that certain local races with special characteristics that correspond to the local differences in the site have developed, even though *the general race type need not thereby necessarily have become wholly extinct.*" (WIEDEMANN loc. cit. p. 818. *Italics mine.*)⁹⁾

⁹⁾ „Trotz dieser allgemeinen Übereinstimmungen muß man vor allem in Gegenden, die auf kleinem Raum stärkere Unterschiede von Klima und Boden besitzen, damit rechnen, daß sich innerhalb eines Rassengebietes feinere Lokalrassen entwickeln, die

It should thus be noted that WIEDEMANN, in common with the authors quoted earlier, relates the variability of the pine to the climatic differences in different regions, and that contrary to WRIGHT and BALDWIN, he does not consider the pine to be uniform within large race areas. This is by no means contradicted by WIEDEMANN's statement that pine from East Prussia and Belgium — as opposed to pine from the Baltic, Brandenburg and Pfalz — is not unfavourably affected by transfers involving rather great climatic changes.

If a genetic adaptation has occurred under the influence of the climate, one may of course speak of "race regions", just as one speaks of "climatic regions". But just as a climate in a similar region is not uniform in detail, neither is the mixture of pine biotypes in the same region uniform. From a *purely practical point of view*, a similar grouping into "race regions" is of course possible, but in that case, be it well noted, these regions will be only *administrative regions* that are not separated by natural biological borders other than in exceptional cases.

It will be seen from Fig. 1 that the variability of Scots pine — as reflected in the dry matter content in late autumn — is closely correlated to the day length at the beginning of the vegetation period. If the length of this period were constant in a large region within the same latitude, or, even better, if it were to increase by about 5 days per degree of latitude northwards, then it might be expected that all the pine provenances from this region would be uniform — i. e. that they would have the same dry matter content, the same earliness and winter-colouring, etc. We would then have one step of a "continuous horizontally stepped cline" (HUXLEY, 1939). On the other hand, if certain combinations of vegetation period and day length were not present, then the corresponding pine populations would be absent. According to HUXLEY, we would then have a "discontinuous cline". It is thus quite clear that pine in Scotland, to take an example, would be bound to manifest a certain discontinuity in comparison with all other pine provenances, for the simple reason that the distribution is — accidentally — discontinuous!

When discussing continuous and discontinuous variability in 1934 and later, it was not a discontinuity of the kind mentioned above that I had in mind. Such discontinuity is more or less an exceptional occurrence, and affords pleasure mainly to those taxonomists who find in it an opportunity to indulge their proclivity for introducing "subspecies" and "varieties" (nota bene, with parts of their names attached). The continuity I am referring to is *that continuity of the variability, that is the consequence of a close relationship between the varying characteristics and the continual varying determinative environmental factors.*

If the vegetation period and day length — and other factors concurring with these two variables — change continuously at a geographic dislocation from south to north, or from low to high altitudes, and if a plant species, e. g. Scots pine, occurs scattered over the entire area in question, then I contend that so far as the pine is concerned — and I deem it to be probable also in general (LANGLET, 1934, p. 109) — the species will in certain respects change continuously accordingly as the combination vegetation period/day length changes.

diesen örtlichen Standortunterschieden entsprechend besondere Eigentümlichkeiten besitzen, wenn auch der allgemeine Rassencharakter dadurch nicht völlig verwischt werden muß." (Italics are WIEDEMANN'S.)

Now what do the height measurements reported by WRIGHT and BALDWIN tell us! Fig. 2 shows the correlation between the means as computed by me from their height measurements and the length of the first + 6° C day of the year in the respective native habitats of the provenances (cf. Table 1, above). To permit a comparison with Fig. 1, in which the correlation between the dry matter content and the day length is shown, the height values in Fig. 2 have been arranged so as to comprise a length of the abscissa equal to that of the dry matter contents. To facilitate comparison still further, the height of the shortest tree occurring has been placed at the top and that of the tallest at the bottom.

Considering the relatively small number of trees measured by WRIGHT and BALDWIN, and considering particularly the incompleteness of the blocks, the correlation in Fig. 2 is remarkably close. The correspondence between the scatters in Fig. 1 and Fig. 2 is striking. This correspondence indicates that there is close correlation also between the dry matter content and the height values in Table 1. It will be seen from Fig. 3 that this is also the case: The per cent dry weight is high when the trees are short, and low when the trees are tall. The correlation coefficient is no less than $r = -0.919$, which, since $n = 46$, means that $t = 15$, consequently a significance well below the 0.01 level.

Obviously the above significance need not mean that all deviations must be purely incidental. It is thus very likely that there is some actual reason why the tree heights reported for the maritime provenances No. 7 from the west coast of Norway and No. 17 from Scotland are both low in relation to the dry matter content (Cf. LANGLET, in print). But this applies equally to the continental provenance No. 25 Lenti from western Hungaria. Deviations of this kind are however not incompatible with the principles of continuity: The general cline which appears in Fig. 1 and Fig. 2, i. e. a heat-cold and south-north (or low-high altitude) cline, may be, and most probably is combined with other clines, e. g. a maritime-continental cline, or, in central Europe, a west-east cline at diminishing phototrophy (SCHMIDT, 1943 and earlier). In so far as such different clines are connected with the same physiological features — e. g. the osmotic pressure and all that this implies — we may of course get deviations in a diagram showing only

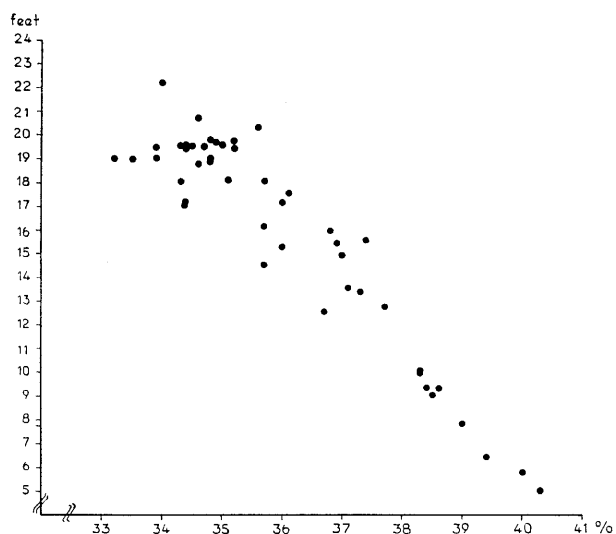


Figure 3. — Relationship between the average 17 year height, as in figure 2, and dry matter content, as in figure 1. Correlation coefficient $r = -0.92$.

one of these clines. This, however, does not indicate a discontinuity occasioned by the occurrence of boundaries between ecotypes as "unities".

There is no sign in Fig. 2 of any discontinuity in the material with regard to tree heights. WRIGHT and BALDWIN have thus enriched provenance research with a very valuable material, which in respect of the juvenile height growth, too, establishes the continuous variability of Scots pine.

With regard to the other characteristics reported by WRIGHT and BALDWIN, these, as I have already pointed out, do not permit analysis in detail. However, this does not preclude the possibility of obtaining from some of their data an elucidation of the question of whether or not there is continuity.

If the mean latitudes of the regions — for which measurements and evaluations are given in their Table 4 — are computed and compared with the mean height and the mean percentages of trees with large crooks of the regions comprising 3 or more provenances given in the same table, the results shown in Fig. 4 will be obtained.

With regard to the tree heights, it will be seen that the relationship in respect of the northerly regions, A, B, C, D, from Scandinavia, F from Latvia, is almost perfect. This was to be expected, since a great deal of the dispersion appearing in Fig. 2 is eliminated through the formation of group means. "Region G from Germany, etc.", comprises a heterogeneous material.

It is more surprising to find that the percentage of trees with large crooks interacts so closely with the tree heights, and that it shows such close correlation with the latitude. As regards the stem and the branch diameters, their correlation with the tree height is always so close that there is no need to elaborate on it here.

WRIGHT and BALDWIN have also referred to data I have presented earlier, for the purpose of proving the non-existence of continuous variability (WRIGHT and BALDWIN, p. 10, Table 8). The truth of this matter will be apparent from Fig. 5. In this figure I have used as a basis the regional grouping as it occurs in their table. The figure shows the relationships of the means of the needle lengths⁹⁾ (ibid., Col. 1) and the proportion of mature needle length observed on June 3rd in a certain year (ibid., Col. 5) to the mean latitudes. As will be seen, the relationships are very clear, although not rectilinear.

I consider that the correlations shown in the diagrams in Fig. 4 and Fig. 5 are continuous, and this opinion is shared by STEBBINS (1950, p. 44): "Among the best examples of clines within plant species are those described by LANGLET (1936) in *Pinus sylvestris* for genetic variation in chlorophyll content, length of mature leaves, hardness and rapidity of shoot development in the spring." But it goes without saying that *however continuous the cline may be in reality, it will always be possible to establish by different methods a seeming discontinuity*. The most simple method is by incomplete sampling (Cf. LANGLET, 1934, p. 109). In many cases this is no doubt the reason (LANGLET, 1933; FAEGERL, 1937; STEBBINS, 1950) for the discontinuity which TURESSON (1936 and earlier) indicates as generally characterizing the climatic ecotypes occurring within a species. Another method is by grouping the material in "regions", calculating the means and standard errors, proving the differences between the groups to be "significant at the

⁹⁾ The needle length in column 1 (ibid.) for the provenance of Karlsholm has been misprinted as 25.4 mm. instead of the correct measure 45.4 mm. (Cf. LANGLET, 1936, table 29).

5 per cent or 1 per cent level" (WRIGHT and BALDWIN, Table 5, p. 7), and then drawing the conclusion that this proves discontinuity with the same significance!

To what extent a correlation of the type shown in Fig. 3 and Fig. 4 is in fact discontinuous — irrespective of the significance of the differences — will be clear from the following calculation:

Let us assume the following number sequence: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. I consider this to be a continuous sequence. We divide it up into two: 1, 2, 3, 4, 5 and 6, 7, 8, 9, 10. We thus obtain 3 and 8 as the means. In each group the deviations from the means are $-2, -1.0, +1, +2$. The deviations squared are 4, 1, 0, 1, 4, and the sum of squares $= 10$. Then for each group $\sigma^2 = \frac{10}{5} = 2$ and $\sigma = \sqrt{2}$. The

standard error of the mean, $\frac{\sigma}{\sqrt{n-1}}$ becomes $\frac{\sqrt{2}}{\sqrt{4}}$ or $\pm \sqrt{0.5}$. The standard error of the difference between the two groups $= \sqrt{(\sqrt{0.5})^2 + (\sqrt{0.5})^2} = \pm \sqrt{1} = \pm 1$. The difference between the two groups with 3 and 8 as the means thus $= 5 \pm 1$. It is thus five times its standard error, and is consequently significant well below the 0.01 level.

Admittedly the number of terms is strictly speaking too small to permit a computation such as the above. If we therefore take instead a sequence 1, 2, 3 . . . 51, and its continuation 52, 53, 54 . . . 102, we obtain as the means of the two groups 26 ± 2.1 and 77 ± 2.1 . The difference in this case $= 51 \pm 3$, or 17 times its own standard error. The significance in this example almost approaches infinity.

If the significance of the difference between the groups in the above examples signifies with almost absolute certainty the presence of discontinuity in the number sequences used, I will readily endorse the conclusions drawn by WRIGHT and BALDWIN from their material. If not, I shall feel in duty bound to call attention to the existence of statistics as alluded to in the phrase: "lies, damned lies and statistics"

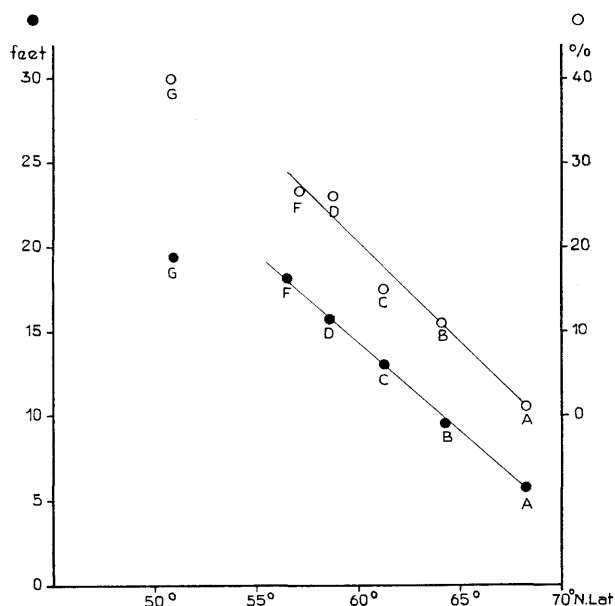


Figure 4. — Average 17 year height (●) and the percentage of trees with large crooks (○) given in table 4 of WRIGHT and BALDWIN (1957) as averages for their regions A, B, C, D, F and G in relation to the average latitudes calculated for the provenances belonging to each of the regions.

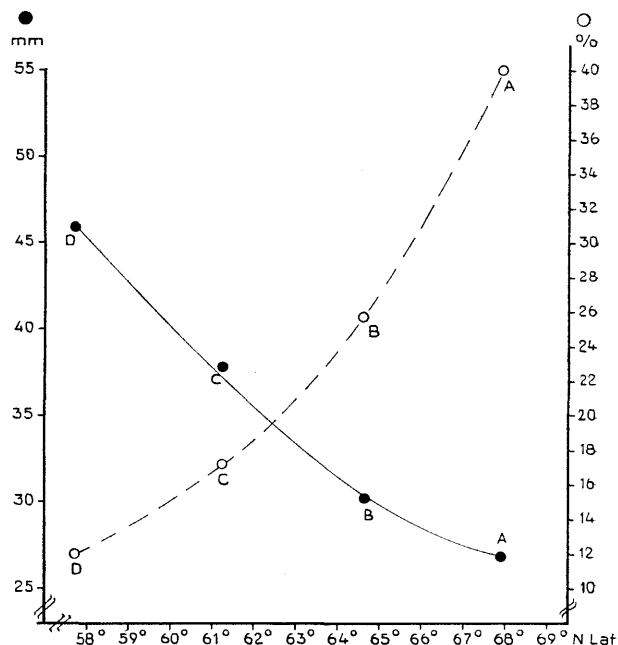


Figure 5. — Needle length (●) and the proportion of mature needle length evident on June 3 in 1935 (○) at Tönnersjöheden (lat. 56°45') in relation to the latitude. Averages for the Scandinavian regions of WRIGHT and BALDWIN (1957), calculated from their table 8, columns 1 and 5 and the latitudes.

Even a brief scrutiny of the regions that correspond to the geographical ecotypes established by WRIGHT and BALDWIN, and reproduced here in Fig. 6¹⁰⁾, will confirm this viewpoint. Region C comprises a narrow belt running from the west coast of Norway over Jotunheimen (Norway) and Hälsingland (Sweden), Satakunta and Savolaks (Finland) towards Ladoga. The boundary where it cuts the south coast of Finland is only roughly outlined, but it makes a peculiar small, sharp bend that definitely separates the provenances No. 6 Åsnes and No. 48 Vitsand, which are only about 60 km (36 miles) distant from each other. Holland and Belgium with contiguous small parts of Germany, each constitute a special region, as do also Scotland and the South Tyrol — all of them represented in the test by only one of the international provenances. Roumania, represented by two provenances, also makes a special region, as do the Baltic Provinces approximately north of the 55th latitude. Contrary to WIEDEMANN'S statement, translated and referred to by WRIGHT and BALDWIN (p. 10) and quoted here, all the rest of central Europe: Germany (east of the Wilhelmshaven—Saarbrücken line), Poland, Czecho-Slovakia, Switzerland, Austria and Hungary, dwell in peace and concord in the same region G, i. e. one and the same "geographic ecotype"!

But this is by no means all. WRIGHT and BALDWIN apparently consider that in common with earlier authors, they have to issue recommendations regarding the transfer of seed based on their own conclusions and intended for practical application. I quote them in full:

¹⁰⁾ Fig. 6 is a reproduction of Fig. 1 in WRIGHT'S and BALDWIN'S report (1957), except that No. 1 Inari has been moved to its correct place on the map, as has also No. 9 Tönnersjöheden and Nos. 37 and 38 Suprasl. Since the authors have grouped together Nos. 3 Sääminki, 8 Voxna, 6 Åsnes and 7 Svanöy into a "Region C", the north boundary of this region has been extended so as to include also No. 3 Sääminki. Further, the pine provenances Nos. 12, 13, 26, 27, 28 and 33 used in the international test, which unfortunately were not available to WRIGHT and BALDWIN, have been marked in.

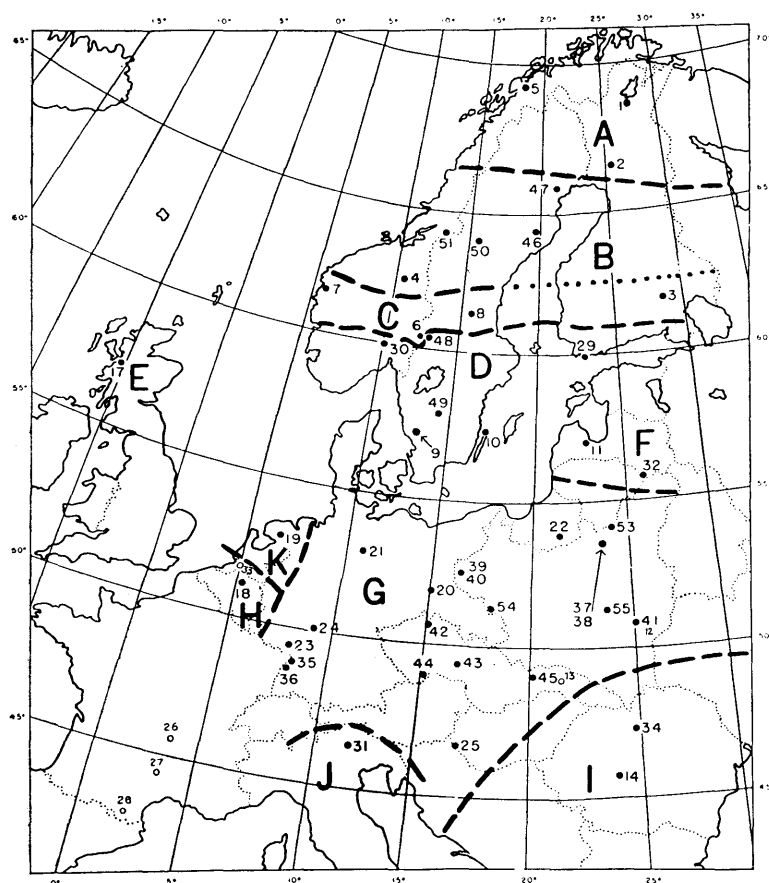


Figure 6. — Geographic distribution of the provenances used in the international Scots pine provenance test of 1938 reproduced from WRIGHT and BALDWIN (1957, figure 1). The origins of the provenances 1, 9, 37 and 38 are corrected. To separate the provenance no. 3 from region B the northern border of region C is prolonged with a dotted line. — The provenances missing in the New Hampshire test, i. e. nos. 12, 13, 26, 27, 28 and 33 have been added (o). — Provenances 18, 19 and 33 are not native.

"Most of the evidence from the Hillsboro study indicates that the variation in Scotch pine is discontinuous. Much of the evidence from other studies supports (or at least does not refute) this hypothesis. Therefore one might well revise the standard seed-collecting recommendations to read: 'Collect seed from within the boundaries of the geographic ecotype best suited to the planting area.' This may permit the safe transfer of seed for several hundred miles or only for a few miles." (WRIGHT and BALDWIN, 1957, p. 11.)

— "This may permit the safe transfer —"! — All right, it *may*, but will it? Although it is a well-known fact that not even pine seed collected at the shores of the western Fjords of Norway can be used on the islands or in the seaward areas only some 40—50 km (20—30 miles) distant (HAGEM, 1926), yet WRIGHT and BALDWIN recommend seed from — eastern Finland. The "safe transfer" would thus also imply that under their guarantee, seed can now apparently be transferred with an equally good result to any place within region G — irrespective of whether it emanates from East Prussia or Pfalz, from the Alps or from Hungary. — Further comments on their "geographical ecotypes" and WRIGHT's and BALDWIN's seed-transferring recommendations in general are superfluous.

Then how can it be that WRIGHT and BALDWIN have arrived at results that are the very opposite of those reported by practically every provenance investigator over more than half a century, and for what reason have they

attempted to group Scots pine into those very ecotypes reproduced in Fig. 6? The explanation will be found in their section: "Taxonomy".

WRIGHT and BALDWIN state that "... it is desirable to identify the geographic ecotypes with previously described taxonomic varieties whenever possible" (p. 11). The result is, of course, that in many cases such identification produces an identity of a kind which inclines me to believe that WRIGHT and BALDWIN must have done the exact opposite and started from the other end, i. e. that they have based themselves on "previously described varieties" in grouping their geographical ecotypes.

In one respect however, WRIGHT and BALDWIN must have been labouring under an unfortunate delusion when they say in their report: "We have made no attempt to describe new varieties from the New Hampshire plantings to cover those segments of the population for which no varietal names have been proposed. To do so would require a comprehensive herbarium and field study of the trees as they occur in their native habitats" (p. 11). Actually the position is just the reverse: It is not necessary to study native habitats and the variability occurring in nature in order to "describe new varieties". In most cases a dried herbarium specimen will suffice for this purpose. But what does of necessity require a "study of the trees as they occur in their native habitats" is any attempt to specify ecotypes, as "ecotype" is *not* a taxonomic but a genecologic term. The distinguishing of ecotypes, and the conclusions arrived at on the basis of the ranges these ecotypes have been given — e. g. recommendations regarding the transfer of seed — obviously calls

for a thorough knowledge of the material and its variability in the respects now discussed. Judging from the results, WRIGHT and BALDWIN do not possess this knowledge.

With regard to the relationship between provenance research, or other genecological studies, and taxonomy, this relationship has been characterized concisely by HUXLEY (1939, pp. 491—492) in terms that are wholly applicable in the present case:

(a) "When gradation exists within a group, the mere conferring of a subspecific or specific name gives a false impression of the geographical homogeneity of the group.

(b) When intergroup gradation exists, mere naming and description of the separate groups not only does nothing to bring out the gradation in their characters, though this relation of connection may be at least as important as their relation of separation with regard to difference of characters, but may even serve to disguise it.

Finally, when an intergroup character-gradient comprises some named (subspecific) groups and others which are unnamed, this disguises the fact that all the groups are of equal importance in regard to the relation of connection. A name confers a false sense of importance on the named groups."

As far as Scots pine is concerned, I have long held the same opinion, viz.: that "any grouping of the pine into subspecies, climatic races, geographic races or ecotypes in

(the sense in which TURESSON (1922) uses the word¹¹⁾ — he lays strong emphasis on the discontinuity of the ecotypes — cannot be done in so far as the object of the grouping is to obtain expressions for the natural conditions" (LANGLET, 1934, p. 109).¹²⁾

The results reported by WRIGHT and BALDWIN of the tests for pine conducted at Hillboro in New Hampshire with provenances used in the 1938 international test do not call for any amendments to my above statement. In so far as their findings throw any light on the question of the occurrence of "Ecotypes, Clines or Geographic Varieties" they constitute a further valuable support for the theory that the physiological variability of Scots pine is clinal.

Summary

On the basis of the results of experiments conducted with 46 out of the 52 Scots pine (*Pinus silvestris*) provenances used in the 1938 international test (Table 1), WRIGHT and BALDWIN (1957) have grouped the pine in large parts of its European range into "geographic ecotypes" (Fig. 6), since they consider they have proved that the variability of the species is discontinuous, which is contrary to what has been established earlier (Cf. ENGLER, 1908, LANGLET, 1934, 1936, etc.).

A study of the data published by WRIGHT and BALDWIN, however, shows that these data only lend further valuable support to the theory that the variability in question is continuous, in the same degree as the determinative environmental factors vary continually. The variability in e. g. the dry matter content of the needles — and judging from WRIGHT's and BALDWIN's measurements, also in the height increment — is thus continuous and closely related to the length of the first day with a normal average temperature of + 6° C in the native habitats of the provenances (Fig. 1 and Fig. 2). It follows from this that there is a close ($r = -0.92$) correlation also between the height increment and the dry matter content (Fig. 3). Similarly, it will easily be seen from the graphs (Fig. 4 and Fig. 5) that continuity exists in those very cases which WRIGHT and BALDWIN have specially indicated as proof of discontinuity.

It is important that the relationships between certain important characteristics (e. g. winter hardiness, growth rate, etc.) of a species and the factors to which adaptation (selection) has occurred, and still occurs, should be estimated. The risk of a seed transfer from a native stand to a site with a different temperature climate and a different day length must be judged in relation to the variability of the species. Taxonomic subgroupings are then not only valueless (LANGLET, 1934) but downright harmful (HUXLEY, 1939), since they suggest a non-existent homogeneity within conventional units which are in reality mere abstractions.

Zusammenfassung

Titel der Arbeit: Ein Kline oder kein Kline — eine Frage der gemeinen Kiefer. —

WRIGHT und BALDWIN (1957) haben auf Grund der Ergebnisse von Versuchen mit 46 der 52 Provenienzen von

¹¹⁾ As mentioned above TURESSON points out later (1936) that a continuous variability is not incompatible with his definition of the term ecotype, and that in some forest tree species a variability of this kind is possible.

¹²⁾ "... eine Einteilung der Kiefer in Unterarten, Klimarassen, geographische Rassen oder Ökotypen in dem Sinne, wie TURESSON (1922) dieses Wort verwendet — er betont kräftig die Diskontinuität innerhalb einer Art — nicht gut vorgenommen werden kann, sofern man durch die Einteilung einen Ausdruck für die Verhältnisse in der Natur erhalten will."

Kiefern (*Pinus silvestris*), die zum internationalen Provenienzversuch von 1938 gehören, die Kiefern umfangreicher Teile ihres europäischen Verbreitungsgebietes in „geographische Ökotypen“ eingeteilt (Abb. 6), da sie nachgewiesen zu haben glauben, daß die Variabilität der Art diskontinuierlich ist, und zwar im Gegensatz zu früheren Ergebnissen (vgl. ENGLER, 1908, LANGLET, 1934, 1936 usw.).

Wie ein Studium der von WRIGHT und BALDWIN vorgelegten Daten zeigt, bilden diese jedoch nur eine weitere, wertvolle Stütze für die Theorie, daß die in Rede stehende Variabilität insoweit kontinuierlich ist, wie die bedingenden Umweltfaktoren kontinuierlich variieren. Die Variabilität des Trockensubstanzgehaltes der Nadeln beispielsweise — und gemäß den Messungen von WRIGHT und BALDWIN auch die Variabilität des Höhenwachstums — sind demnach kontinuierlich und stehen in enger Beziehung zur Länge des ersten Tages im Jahre, an dem die normale Durchschnittstemperatur + 6° C erreicht (Abb. 1 und 2). Hieraus folgt, daß auch zwischen Höhenwachstum und Trockensubstanzgehalt eine enge Beziehung ($r = -0.92$) vorliegt (Abb. 3).

In gleicher Weise geht aus den Schaubildern (Abb. 4 und 5) hervor, daß Kontinuität auch in solchen Fällen besteht, die von WRIGHT und BALDWIN besonders als Beweise der Diskontinuität angeführt wurden.

Von Bedeutung ist die Feststellung der Zusammenhänge zwischen gewissen wichtigen Eigenschaften (z. B. Winterbeständigkeit, Wachstumsgeschwindigkeit usw.) einer Art und denjenigen Faktoren, an die eine Anpassung (Selektion) stattgefunden hat und noch stattfindet. Die Möglichkeit, Samen eines autochthonen Bestandes an einen Platz mit anderem Temperaturklima und anderer Tageslänge zu versetzen, muß im Verhältnis zur Variabilität der Art beurteilt werden. Systematische Einteilungen der Art sind hierbei nicht nur wertlos (LANGLET 1934), sondern geradezu schädlich (HUXLEY 1939), weil sie eine nicht vorhandene Homogenität innerhalb konventioneller Einheiten vortäuschen, die in Wirklichkeit nur Abstraktionen sind.

Résumé

Titre de l'article: Cline ou non — Une question de pin sylvestre. —

Se basant sur les résultats des essais portant sur 46 des 52 provenances de pin sylvestre (*Pinus silvestris*) faisant partie de l'essai de provenance international de 1938, WRIGHT et BALDWIN (1957) ont réparti le pin sylvestre en «écotypes géographiques» (fig. 6) à l'intérieur de vastes régions de son territoire européen, du fait qu'ils estiment avoir démontré que, contrairement à ce qui a été constaté antérieurement, la variabilité de l'espèce est discontinue (Cf. ENGLER, 1908, LANGLET, 1934, 1936 etc.).

Une étude des données présentées par WRIGHT et BALDWIN révèle cependant qu'elles fournissent uniquement une confirmation supplémentaire importante de la théorie selon laquelle la variabilité en question est continue dans la même mesure que les facteurs ambiants varient d'une manière continue. La variabilité du taux de substance sèche des aiguilles, par exemple — de même que la croissance en hauteur, à en juger des mesures effectuées par WRIGHT et BALDWIN — est de ce fait continue et en corrélation étroite avec la longueur du premier jour de l'année dont la température normale moyenne atteint + 6° C (fig. 1 et 2). Il s'ensuit qu'une corrélation étroite ($r = -0.92$) existe également entre la croissance en hauteur et le taux de substance sèche (fig. 3). De la même manière il ressort

des diagrammes (fig. 4 et 5) que la continuité existe même dans les cas spécialement mentionnés par WRIGHT et BALDWIN comme étant de preuves de discontinuité.

Il est important de déterminer la relation existant entre certaines propriétés importantes (par ex. la capacité de supporter l'hiver, la rapidité de croissance, etc.) d'une espèce ainsi que les facteurs ayant provoqué et provoquent encore actuellement une adaptation (sélection). Les risques de transplantation d'une graine d'un peuplement autochtone à un endroit où règnent un climat de température et une longueur de journée différents, doivent être évalués par rapport à la variabilité de l'espèce. *Les répartitions taxonomiques des espèces ne sont donc pas uniquement sans valeur aucune* (LANGLET 1934) *mais même absolument dangereuses* (HUXLEY 1939) *du fait qu'elles suggèrent une homogénéité inexistante au sein d'unités conventionnelles qui ne sont en réalité que des valeurs abstraites.*

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Deep-Freezing Pine Pollen

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Pine pollen, unlike the pollen of most angiosperms, is long-lived and tolerant of wide variation in storage conditions (DUFFIELD, 1954). Even with this latitude some provision is needed in breeding work for long-term storage without loss of viability. Deep-freezing would seem to satisfy this need. The first attempts to freeze pine pollen, reported here, were successful. Deep-freezing probably can be developed as an effective technique for preserving and extending the viability of pine pollen.

Deep-freezing of the pollen of fruit trees has been under study for some time. Initial work at very low thermal levels (-180° C) indicated that the life processes within pollen grains can be practically suspended (BREDEMANN, et al., 1948). More practical work, using thermal levels available in commercial and domestic deep-freeze facilities, has demonstrated the feasibility of deep-freezing fruit tree pollens in conjunction with breeding work (GRIGGS, et al., 1953).

Procedure

A small scale study of the feasibility of deep-freezing pine pollen was started in the spring of 1952. Ripe pine pollen catkins were collected, and the pollen was extracted using the technique of CUMMING and RIGHTER (1948). The

pollen was placed in cotton stoppered glass bottles and was given a preliminary desiccation over anhydrous calcium chloride for 1 week. In July these bottles of pollen were placed on the quick-freezing shelf of a domestic deep freezer (about -23° C). In April of the following year this treated pollen was transferred from the freezer to a commercial reach-in refrigerator (about 5° C). All pollen regularly is stored in this refrigerator at the Institute of Forest Genetics. Where possible, fresh pollen was collected in the spring of 1953 from the same trees that were used for the 1952 collections. The viability of all pollen samples was tested after extraction from the catkins and after deep-freezing. The hanging drop method described by RIGHTER (1939) was used for these tests.

Fresh and treated pollens were used in 1953 in controlled pollinations (CUMMING and RIGHTER, 1948). Both pollens were used separately to pollinate conelets on individual trees of the same species. The seeds produced were collected in the fall of 1954 and were sown in the nursery in the spring of 1955. Time required for the seeds to germinate and height at the end of the first growing season were recorded for each progeny.

Results

Viability of the pollen was not appreciably altered by deep-freezer storage (table 1). Only crude estimates were made of the percent of pollen grains which germinated.

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