In the present study, a comparison was made between the karyotypes of Douglas-fir and Formosan Douglas-fir (P. *wilsoniana)*. The basic chromosome number of the Formosan Douglas-fir was found to be 12, unlike Douglas-fir, which has a number of 13. (The basic number for bigcone Douglas-fir is 12, as reported by CHRISTIANSEN in 1962.) The study confirms work of BARNER and CHRISTIANSEN in 1962 on the chromosome morphology of Douglas-fir. Of the 13 chromosomes of Douglas-fir, five have been found to have median centromeres; six, subterminal centromeres; and two, terminal or nearly terminal centromeres. Formosan Douglas-fir was found to have six chromosomes with median centromeres and six with subterminal centromeres.

Literature Cited

BARNER, H., and CHRISTIANSEN, H.: The formation of pollen, the pollination mechanism, and the determination of the most favorable time for controlled pollination in Pseudotsuga mcnziesii. Silvae Genetica 11: 89–102 (1962). — CHING, K. K.: Hybridization between Douglas-fir and bigcone Douglas-fir. Forest Sci. 5: 246–254 (1959). — CHRISTIANSEN, H.: On the chromosomes of Pseudotsuga macrocarpa and Pseudotsuga mcnziesii. Silvae Genetica 12: 124–127 (1963). — DALLIMORE, W., and JACKSON, A. B.: A handbook of Conijerae including Ginkgoaceae. 3d ed. London, Edward Arnold and Company, 570 pp. (1948). — DARLINGTON, C. D.: Recent advances in cytology. 2d ed. Philadelphia, P. Blakiston's Son and Co. 671 pp. (1937). — DURRIEU-VABRE, ANDREE: Chromosomes de Pseudotsuga douglasii CARRIÉRE. Comptes Rendus de l'Académie des Sciences (Paris) 246: 3660—3663 (1958). — GERASSIMOVA, HELEN: Chromosome alterations as a factor of divergence of forms. I. New experimentally produced strains of C. tectorum which are physiologically isolated from the original forms owing to reciprocal translocation. Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS 25: 148–154 (1939). — GÖHRE, K. (Ed.): Die Douglasie und ihr Holz. Berlin, Akademie-Verlag, xiii + 595 pp. (1958). — LI, HUILIN: Present distribution and habitats of the conifers and taxads. Evolution 7: 245–261 (1953). — MCCLINTOCK, BARBARA: A correlation cf ringshaped chromosome: with variegation in *Zea* mays. Proc. Nat. Acad. Sci. 18: 677—681 (1932). — RHOADES, M. M.: Studies of a telocentric chromosome in maize with reference to the stability of its centromere. Genetics 25: 483–520 (1940). — SAX, K., and SAX, HALLY: Chromosome number and morphology in the conifers. Jour Arnold Arbor. 14: 356–375 (1933). — SAYLOR, L. C.: A karyotypic analysis of selected species of Pinus. Silvae Genetica 10: 77–84 (1961). — SIMAK, M.: Karyotype analysis of Larix decidua MILL. from different provenances. Medd. SkogsforsknInst., Stockh. 51: 1–21 (1962). — STEBBINS, G. L.: Variation and evolution in plants. 3d ed. New York, Columbia University Press, xix + 643 pp. (1957). — SWANSON, C. P.: Cytology and cytogenetics. Englewood Cliffs, N. J., Prentice-Hall, Inc., x + 596 pp. (1964). — WHITE, M. J. D.: Animal cytology and evolution. Cambridge, Cambridge University Press, 375 pp. (1945). — ZENKE, URSULA: Untersuchungen über den Ablauf der Meiosis bei *Pseudotsuga* taxijolia Britton. Zeitschr. Forstgenet. 2: 96–102 (1953).

Early Growth of Douglas-Fir from Various Altitudes and Aspects in Southern Oregon

By RICHARD K. HERMANN and DENIS P. LAVENDER[1])

(Received for publication May 22, 1967)

High mortality of planted Douglas-fir in the southern Cascade Mountains of Oregon is of great concern to public and private forest owners. To provide a basis for production of planting stock with increased survival potential, a study was initiated in 1961 to determine whether or not topography and altitude had affected genetic differentiation of Douglas-fir in these mountains.

In 1964, plants raised from 14 lots of seed collected along an altitudinal transect were used to establish reciprocal out-plantings in the vicinity of the transect for future study. The present paper reports on investigations of growth of these trees in the nursery and in growth chambers.

Studies of genetic variation in Douglas-fir (Pseudotsuga menziesii [MIRB.] FRANCO), recent reviews of which have been made by WRIGHT (11), SCHOBER (7), and SWEET (10), have included in the Pacific Northwest both local differences (4, 6, 8) and differences between widely separated provenances (2, 3).

None of these studies was done in the southern Cascade Mountains of Oregon, where Douglas-fir appears to change markedly with altitude and there are pronounced differences between adjacent north- and south-facing slopes.

Seeds

Collection

Cones were collected from August 20 to September 10, 1961, on a 15- by 10-mile transect on the western slope of the Cascades in southern Oregon. The transect covered an area between 42° 40' and 42° 52' N latitude, and 122° 37' and 122° 49' W longitude. Collections were made at intervals of 500 ft in elevation, from altitudes of 1,500 to 5,000 ft, on north- and south-facing slopes (Figure 1). Distances between the two slopes at each elevation varied from 2 to 6 miles. With exception of the three lowest elevations, points of collection were on opposite sides of the same ridge. Open-pollinated cones were obtained from 2 to 4 trees growing in stands at each site of collection. Distance between sampled trees ranged from 200 to 400 ft. Ages of trees from which cones were taken ranged from 30 to 40 years.

Cones from all trees harvested at each site of collection were treated as a single lot and processed together. To have equal representation of parents in each lot, 5 fresh cones were cut and full seeds counted. The quantity of cones from each tree for the bulked sample was then adjusted to yield about the same amount of seeds. After extracting arid cleaning, about 95 percent of each lot was full seeds. Cleaned seeds were stored at 2° C until sowing.

Enough seeds for the study were obtained from each site except at the 2,000 ft elevation, where cones were heavily infested by insects and yielded so few seeds that they were omitted from the investigation.

Weight

Ten samples of 100 seeds from each lot were weighed after they had been stored over 40 percent H_2SO_4 at 20° C for 4 days.

Weight of seeds decreased from low to medium elevations and increased slightly again at high elevations *(Figure 2)*. Up to 3,000 ft, sead from north-facing aspects was heavier than seed from south-facing exposures; above 3,000 ft the trend reversed.

[1]) Forest Ecologist and Forest Physiologist, respectively, Forest Research Laboratory, School of Forestry, Oregon State University, Corvallis, Oregon.

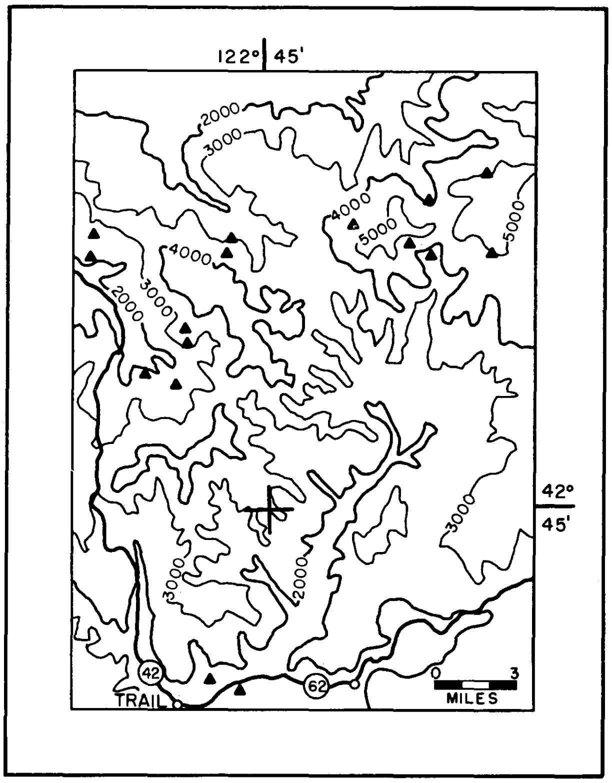

Figure 1. — Map of area where cones were collected in Jackson County, Oregon. Contours shown are 1,000 ft apart. Note pairing of locations chosen to test effects of aspect; most paired spots were on opposite sides of a ridge.

Increase in weight of seeds above 3,000 ft was thought perhaps to be caused by development of thick seed coats at high elevations. To test this possibility, endosperms and embryos were separated from seed coats in 100 seeds of each of the 14 sources. Weighings were made to determine whether or not the lots differed in proportion of weight of seed coats to weight of embryos and endosperms. The nonsignificant differences found ranged from a percentage of 42.9 for weight of seed coats for the source with the lightest seeds to 43.6 for the source with the heaviest seeds.

Germination

Viability of seeds was tested by placing 1,000 seeds of each source on moist filter paper in petri dishes after 3 weeks of naked stratification at 2° C. The petri dishes were kept for 8 hours at 32° C and 95 percent relative humidity, then for 16 hours at 21° C and 65 percent relative humidity. Germinated seeds after 4 weeks of daily alternation between the two conditions of temperature and humidity ranged from 85 to 91 percent of seeds tested, but did not differ significantly among the 14 lots of seed.

Nursery Study

Two nurseries, one in northern and one in southern Oregon, were selected for simultaneous raising of seedlings to investigate whether or not the nursery location influenced initial growth and, if such an effect was found, to determine whether or not nursery effects would carry over into growth of trees in plantations.

Methods

Seeds were stratified for 3 weeks before sowing by soaking individual lots of seed in plastic bags for 48 hours and then, after draining off the water, storing the bags at 2° C.

Seeds were sown in the last week of April, 1962, at the former Oregon State Nursery at Corvallis (44° 30' N lat., 123° 40' W long., elevation 300 ft) and at a nursery maintained by E. T. Tepper at Shady Cove (42° 38' N lat., 122° 50' W long., elevation 1,500 ft). Soils at the two nurseries differed both in texture and in their parent material. At Corvallis, the soil was a clay loam developed from colluvial material consisting of basaltic rocks, and the soil at Shady Cove was a fine loamy sand developed from river terrace deposits.

At each nursery, a 200 ft bed extending east and west was divided into 4 blocks. The 14 lots of seed were randomly assigned to plots in each block. Adjacent plots were separated by 1-ft strips of bare soil. A specially designed frame permitted accurate placement of 40 seeds per square ft for a total of 240 seeds in each plot.

High germination resulted in 30—36 seedlings per square ft; a thinning reduced this number to 25 seedlings about equally spaced on a square ft. One square ft in each plot was randomly selected, and the seedlings were marked for future measurements.

Watering schedules were kept the same at both nurseries. Beds were not fertilized the first year, but ammonium nitrate was applied at 40 pounds an acre before the beginning of the second growing season.

Growth the first year was measured from the cotyledon scar to the base of the terminal bud. Growth the second year was measured from the base of the second year's shoot to the tip of the terminal bud.

Time of bursting and setting of terminal buds for seedlings from each source was investigated in the second growing season at both nurseries. Observations were made at weekly intervals on the seedlings selected for measurement of height growth. Bud burst was considered to have occurred when the last papery scale of the bud ruptured and tips of the needles were exposed. Bud set was recorded when the final terminal bud — some seedlings flushed repeatedly — became visible, even though the bud was still green.

For the statistical treatment, the time after 8 percent of buds had burst until 92 percent of the buds had burst was considered as the period of bud burst. The period of bud set was defined similarly. Mean growth period was defined

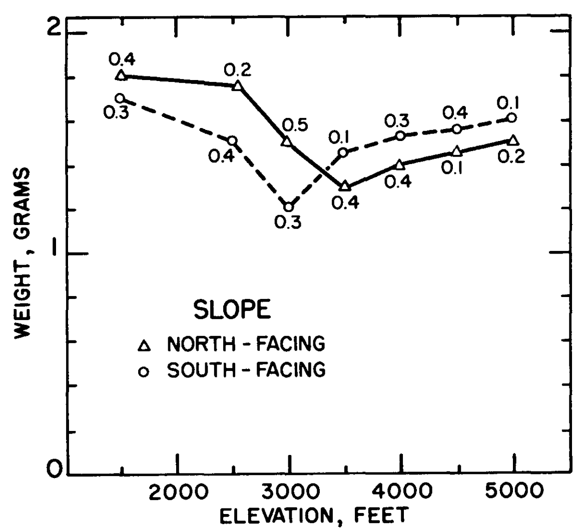

Figure 2. — Relation of seed weight to elevation and aspect of site of collection. Each value represents the mean of 10 samples of 100 seeds each. Variation among samples is indicated by the standard deviation of mean weight.

as number of days from the time half the seedlings had burst buds to the time half had set buds. These mid-points (50 percent) were also used to characterize differences between seedlings in speed of bud burst and bud set.

In analyzing the results, differences were not reported unless they were evident at the 5 percent level of significance.

Results

Height growth

At the end of the first growing season in 1961, average height of seedlings at Corvallis exceeded that of seedlings at Shady Cove by 4 cm, which was a significant difference at the 1 percent level of probability. Height also varied significantly between blocks in each nursery *(Table 1).* Pooled by nurseries and aspects, height growth of seedlings decreased significantly with increase in elevation of seed source *(Figure 3 C).* Regressions of first-year height on altitude of seed source for aspect and nursery *(Figure 3 A, B)* showed regression slopes steeper for seedlings of seed from south- than from north-facing aspects.

Height increment of seedlings during the second growing season was the same at both nurseries. Height growth was still variable between blocks, although differences were much smaller than for the first year *(Table 2).* Growth of seedlings the second year showed significant correlation of decreasing height increment with increasing altitude of source of seed when pooled by nurseries and aspects *(Figure 4).* Regression of second-year growth on altitude of seed source separate by aspect and nursery was significant, however, only for seedlings of seed from south-facing slopes raised at Shady Cove. Seedlings of seed from north-facing slopes grew more than seedlings of seed from south-facing slopes. Means of height growth in the second growing season were 7.6 cm for north aspects and 6.7 cm for south aspects pooled over nurseries. The least significant difference between means for aspect at the 5 percent level was 0.5 and at the 1 percent level was 0.7.

Bud burst

Buds began to open sooner in the nursery at Corvallis than at Shady Cove. Half of the observed seedlings at Corvallis had burst buds on the 109th day of the year, compared with day 115 for 50 percent at Shady Cove.

The relation of bud burst to origin of seedlings was similar at both nurseries. Opening of buds showed a significant trend of delay with increase in elevation of source of seed *(Figure 5 C).* Correlation between earliness of buds bursting

Table 1. — Height in cm of seedlings from 14 sources at the end of the first growing season[1]).

Nursery	Block I	Block II	Block III	Block IV	Mean all blocks
Corvallis	6.2	7.4	7.1	7.0	6.9
Shady Cove	1.8	2.7	3.3	3.6	2.9

[1]) Each value represents the mean of 350 measurements. Least significant difference was 0.7 at the 5 percent level of significance, and 0.9 at the 1 percent level.

Table 2. — Centimeters of growth of seedlings from 14 sources in the second growing season[1]).

Nursery	Block I	Block II	Block III	Block IV	Mean all blocks
Corvallis	7.5	6.8	7.1	7.9	7.3
Shady Cove	6.9	7.2	7.7	5.8	6.9

[1]) Each value represents the mean of 350 measurements. Least significant difference was 1.1 at the 5 percent level of significance.

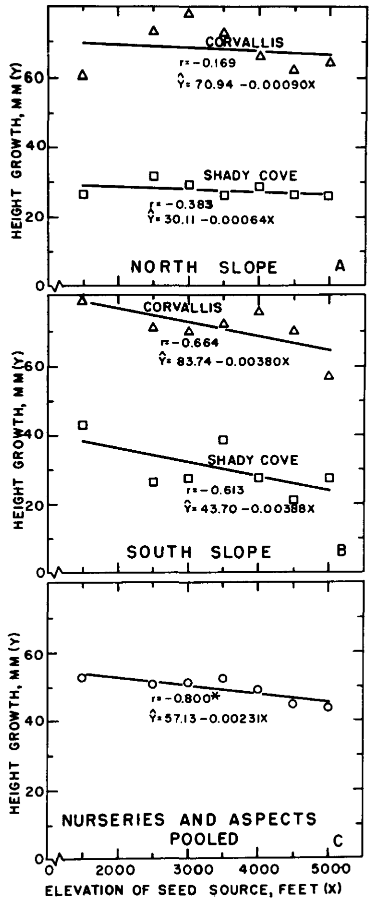

Figure 3. — Regressions of first-year growth in two nurseries on altitude of seed sources from *(A)* north-facing slopes, from *(B)* south-facing slopes, and *(C)* pooled by aspects and nurseries. * Different at the 5 percent level of probabilitiy.

and altitude of seed source was higher for seedlings of seed from north-facing than from south-facing slopes *(Figure 5 A, B).* Length of entire period of bud burst was affected neither by elevation nor aspect of origin of seed.

Bud set

Formation of terminal buds started earlier at Corvallis than at Shady Cove. Half of the observed seedlings at Corvallis had set terminal buds on the 194th day of the year, compared with day 199 at Shady Cove.

Time of formation of terminal buds was related to origin of seed at both nurseries. Buds set first in seedlings from seed of the high elevations and last in seedlings from low altitudes. Most regressions of days until bud set on altitude of seed source were significant when aspects were pooled *(Figure 6 C)* or examined separately *(Figure 6 A, B);* seedlings of seeds from south-facing aspects raised at Shady Cove did not show a strong correlation of bud set with altitude of seed source.

Aspect influenced the date buds set. At both nurseries, seedlings of seed from south-facing aspects set buds earlier than seedlings of seed from north-facing aspects.

Length of the entire period of bud set was not influenced by elevation of origin of seed. Aspect of source of seed affected length of the entire period of bud set at Shady Cove but not at Corvallis. At Shady Cove, seedlings of seed from south-facing aspects completed setting buds more rapidly than did those of seed from north-facing aspects.

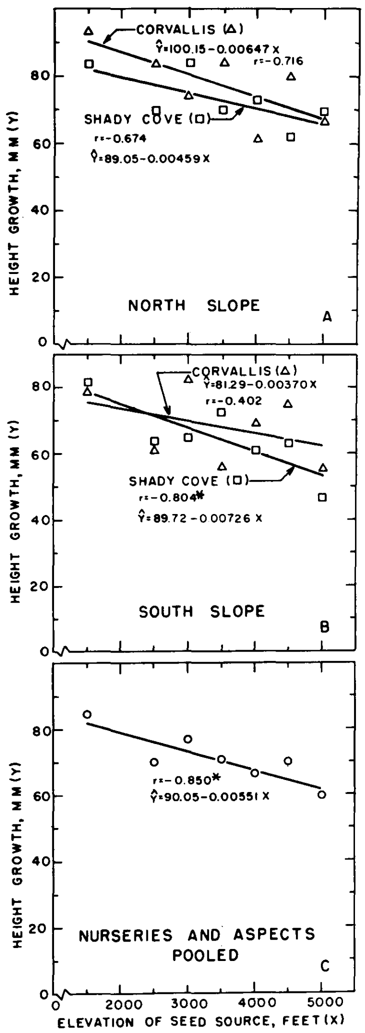

Figure 4. — Regressions of second-year growth in two nurseries on altitude of seed sources from *(A)* north-facing slopes, *(B)* from south-facing slopes, and *(C)* pooled by aspect and nursery. * Different at the 5 percent level of probability.

Mean growth period

For the average of all seedlings observed, the mean growth period was almost the same at both nurseries: 85 days at Corvallis and 84 days at Shady Cove. At Corvallis, however, the mean growth period began and ended about a week earlier than at Shady Cove.

Length of this period for seedlings from the various sources was influenced by altitude of origin of seed. Length of the mean growth period shortened with increase in elevation *(Figure 7 A, B, C)*. Seedlings of seed from south-facing aspects showed a trend toward a shorter mean growth period than those of seed from north-facing aspects, although they were not statistically different.

Growth Room Study

A supplementary study was made in rooms that allowed control of thermoperiod and photoperiod. Because of limited space, seeds from only six of the sources — 1,500 ft north and south, 3,000 ft north and south, and 5,000 ft north and south — were used.

Methods

Seeds were stratified as for the nursery study during the first part of April, 1963, and were planted in 24 flats when radicles protruded from 1 to 2½ cm from seed coats. Flats were 25 wide by 50 long by 15 cm deep and contained one row of 10 seedlings of each of the selected seed sources in each half of a flat. The sequence of seed sources from the end to the center of the flat was random to eliminate position effects.

Flats were kept in a greenhouse under natural day-length and a diurnal fluctuation of temperature from 25° to 15° C until they were transferred to growth rooms in the first week of June. Four flats were randomly assigned in the growth rooms to each of six combinations of temperature and light. Thermoperiods were 25° C for 15 hours and 20° C, 10° C, or 5° C for 9 hours in a 24-hour cycle. Photoperiods were either 15 or 9 hours while the temperature was 25° C. Light intensity was about 8,500 lux at crown height of the seedlings. Flats were watered to about field capacity each week.

Crown elongation of seedlings, measured by the distance from cotyledon scar to growing tip of shoot, and presence of terminal buds were recorded weekly until October. At that time, seedlings in 2 of the 4 flats for each treatment were harvested, and oven-dry weight of shoots, roots, entire plants, and ratios of shoot to root were determined.

Results

Initiation of dormancy

Two criteria were established to measure the time of initiation of dormancy: the appearance of the initial stage of a resting terminal bud, and the attainment of a crown

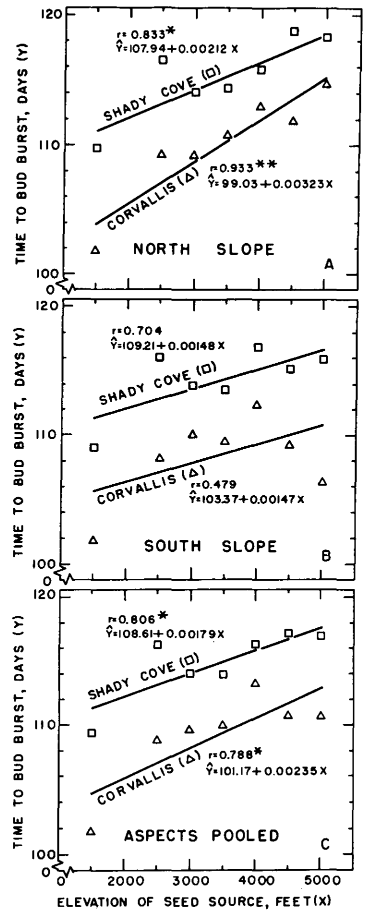

Figure 5. — Regressions of days from beginning of year to bud burst at two nurseries for 50 percent of seedlings of 7 altitudinal origins *(A)* from north-facing aspects, *(B)* from south-facing aspects, and *(C)* for aspects pooled. * Different at the 5 percent level of probability.

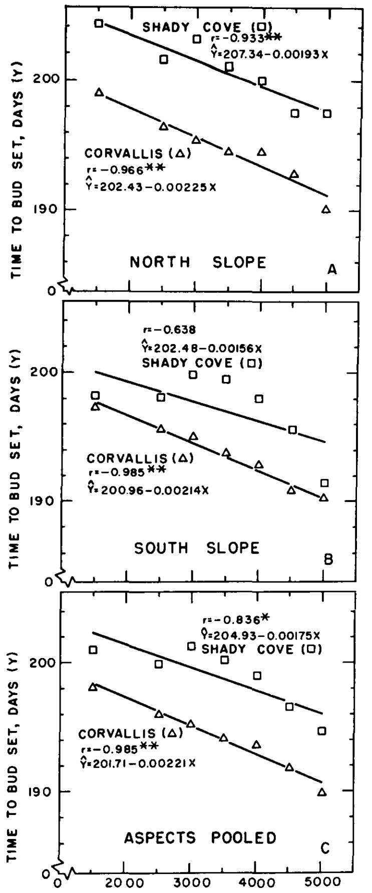

Figure 6. — Regressions of days from beginning of year to bud set for 50 percent of seedlings of 7 altitudinal origins *(A)* from north-facing aspects, *(B)* from south-facing aspects, and *(C)* for aspects pooled. * ** Different at the 5 and 1 percent level of probability.

length within 3 mm of the crown length at the termination of the experiment. Although it proved difficult to define exactly the appearance of the initial stages of the terminal bud, both methods provided essentially the same measure of the onset of dormancy. *Figure 8* illustrates the effects of elevation and aspect of seed source and of growth room environments upon initiation of dormancy. Results of the analysis of variance are shown in *Table 3*.

The mean length of the growing period was 10.9, 6.3, and 7.3 weeks for seedlings grown under night temperatures of 20° C, 10° C, and 5° C, irrespective of photoperiod. The least significant difference between means of weeks to onset of dormancy was 1.2 at the 5 percent level and 1.6 at the 1 percent level. There was a significant interaction of thermoperiod with photoperiod. With cool nights (5° C) seedlings went dormant later under long days, with warm nights (20° C) they went dormant later under short days, and with intermediate nights (10° C) day-length apparently had little effect on duration of growth.

The regression of weeks until dormancy on altitude of seed source was linear and showed that the growing period shortened with increasing elevation of seed source. The correlation coefficient, *r*, was —0.995, which was significant at the 0.1 percent level with 90 degrees of freedom.

Seedlings of seed from north slopes had a longer growing period than those from south-slope sources. Mean values for weeks until dormancy were 8.6 for seedlings of seed from north aspects and 7.8 for seedlings of seed from south aspects. The least significant difference between means for aspect was 0.5 at the 1 percent level.

Crown elongation

The effect of seed source and the various combinations of thermoperiod and photoperiod on crown elongation *(Figure 9, Table 3)* appeared to parallel that on initiation of dormancy. Mean elongation for nights at 20° C, 10° C, and 5° C for photoperiods pooled was 73 mm, 31 mm, and 33 mm. The least significant difference between means was 15 mm on the 1 percent level. There was a significant interaction of thermoperiod and photoperiod. Exposed to 20° C at night, trees grew taller under short than long days; exposed to 5° C at night, this pattern of crown elongation under long and short days was reversed.

The regression of crown elongation on altitude of seed source was linear and indicated that elongation decreased with increasing altitude of origin of seed. The correlation coefficient, *r*, was —0.998, which was significant at the 0.1 percent level with 90 degrees of freedom.

Seedlings of seed from north aspects grew taller than those of seed from south aspects. Mean crown lengths were 49 mm for progenies of trees on north slopes and 42 mm for progenies of trees on south slopes. The least significant difference between means for aspect was 4.3 at the 1 percent level.

Dry weight

Both photoperiod and thermoperiod had a significant effect on production of dry matter *(Table 3)*. Dry weight of

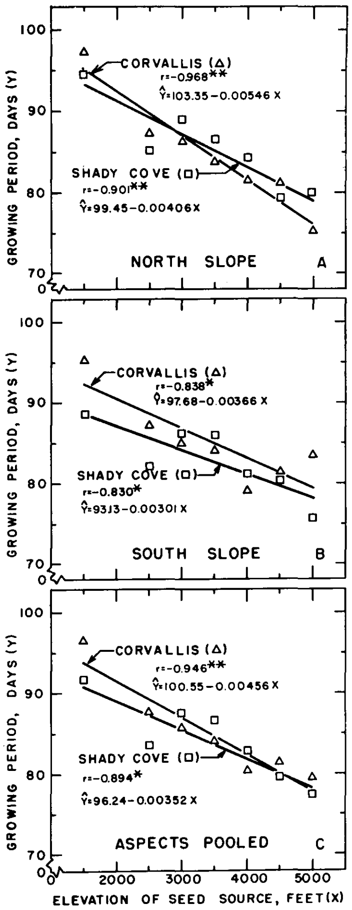

Figure 7. — Regressions of length of mean growing period for seedlings of 7 altitudinal origins *(A)* from north-facing aspects, *(B)* from south-facing aspects, and *(C)* for aspects pooled. The growing period was measured from when half the seedlings had burst buds to the time when half had set buds. * ** Different at the 5 and 1 percent level of probability.

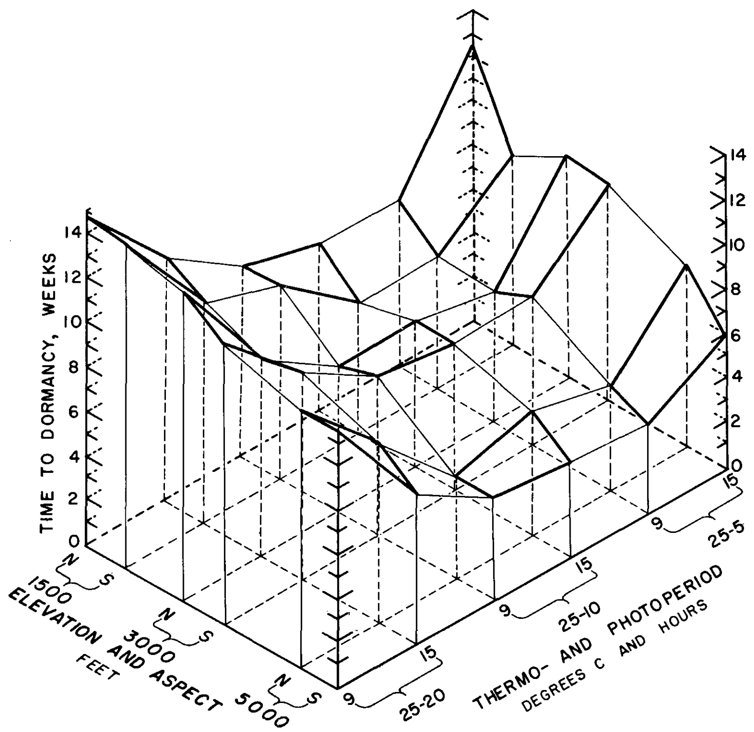

Figure 8. — Weeks until initiation of dormancy for seedlings from 6 different seed sources grown under 6 combinations of thermoperiod and photoperiod. Each point represents mean of 48 observations.

entire seedlings grown under long days was nearly double that of seedlings grown under short days (*Figure 10 A*). Production of dry matter was less the cooler the nights were. Mean dry weights of seedlings kept under 20^0 C, 10^0 C, and 5^0 C at night were 0.36, 0.29, and 0.27 g. The least significant difference between means for night temperatures was 0.03 at the 5 percent level and 0.05 at the 1 percent level.

The regression of dry weight of seedlings on altitude of seed source was linear and indicated less production of dry matter with increasing elevation of origin of seed. The correlation coefficient, r, was —0.952, which was significant at the 1.0 percent level with 30 degrees of freedom. Mean weights for seedlings of seed from north and south aspects were 0.33 and 0.28 g. The least significant difference between means for aspect was 0.03 at the 1 percent level.

Determination of dry weight separately for shoots and roots indicated a strong photoperiodic, but no thermoperiodic effect on accumulation of dry matter in roots (*Figure 10 B*). Production of dry matter in shoots (*Figure 10 C*) was influenced significantly by both thermoperiod and photoperiod (*Table 3*). The regressions of dry weight of shoots and roots on altitude of seed source were linear and showed a decrease in production of dry matter with increasing elevation of origin of seed. The values for r, the respective correlation coefficients, were -0.977 and -0.910, both of which were significant at the 0.1 percent level with 30 degrees of freedom each.

Table 3. — Results of analyses of variance for 6 characteristics of seedlings grown under 6 combinations of 3 thermoperiods and 2 photoperiods[1]).

Source of variation	Degrees freedom	Weeks to dormancy	Crown elongation	Degrees freedom	Oven-dry weight			
					Shoots	Roots	Entire seedlings	Shoot/Root
Thermoperiod (T)	2	***	***	2	**		**	**
Photoperiod (P)	1			1	*	***	***	**
T × P	2	***	***	2				*
Error a	18			6				
Elevation (E)	2	***	***	2	***	***	***	***
Aspect (A)	1	***	***	1	**	*	**	***
E × A	2	*	**	2		**	*	
E × T	4		***	4	*			
E × P	2		**	2		*		
A × T	2			2				
A × P	1	*		1		**	*	
E × A × T	4			4				
E × A × P	2			2				
E × T × P	4		*	4				
A × T × P	2			2				*
E × A × T × P	4			4				
Error b	90			30				
	143			71				

[1]) *, **, ***; different at the 5, 1, and 0.1 percent level of significance. A table of mean squares is available on request from the Forest Research Laboratory.

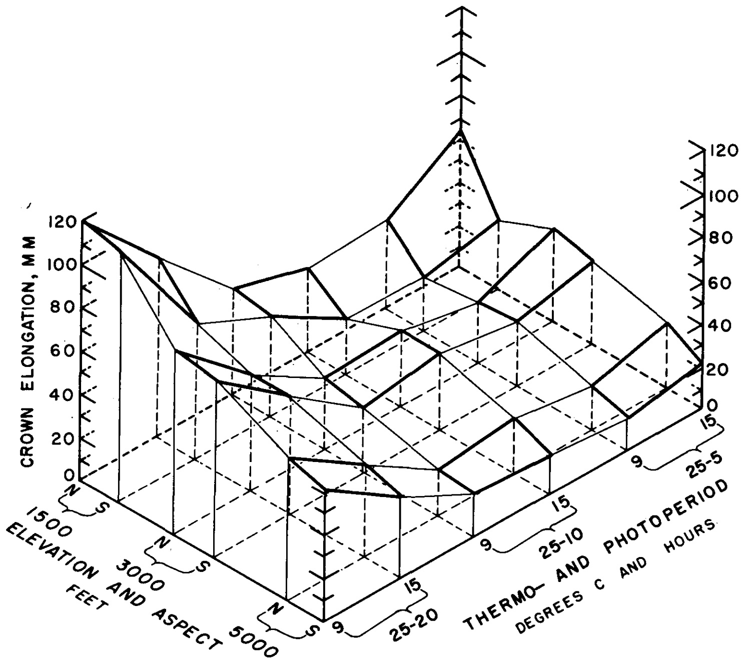

Figure 9. — Crown elongation of seedlings from 6 different seed sources grown under 6 combinations of thermoperiod and photoperiod. Each point represents mean of 48 observations.

Mean dry weights of shoots and roots of seedlings from north-aspect parents were significantly higher than of those from south-aspect parents. However, aspect differences of dry weight became less, and more so for roots than for shoots, the higher the elevation of origin of seed.

Ratios of shoots-to-root dry matter for all combinations of seed sources and environments in the growth room study are presented in *Figure 11*. They demonstrate that warm nights favored growth of shoots, while cool nights stimulated growth of roots. The mean ratios for 20° C, 10° C, and 5° C nights were 1.37, 0.75, and 0.86. The least significant difference between means for night temperatures was 0.22 at the 5 percent level, and 0.34 at the 1 percent level. Short-day seedlings developed larger shoots and long-day seedlings larger roots. The mean ratios of shoot-to-root dry matter were 1.21 for 9 hour days, and 0.77 for 15 hour days. The least significant difference between means for day length was 0.28 at the 1 percent level.

The regression of ratio of shoot-to-root dry matter on elevation of seed source was linear and showed that the proportion of shoot-to-root dry matter decreased with increasing elevation of seed source. The correlation coefficient, r, was —0.863, which was significant at the 0.1 percent level with 30 degrees of freedom.

Seedlings from parents on north-facing slopes formed larger shoots in relation to their roots than did seedlings from parents on south-facing slopes. Mean ratios were 1.03 and 0.95 for progenies of north- and south-aspect parents. The least significant difference between means for aspect was 0.06 at the 1 percent level.

Discussion

The tests at the nurseries and in the growth rooms indicated altitudinal differentiation of Douglas-fir in southern Oregon similar to that reported at Placerville, California, for ponderosa pine (1,5). Growth diminished with increasing altitude of source of seed in all environments tested. In addition, topographic differentiation was evidenced by the difference in growth characteristics between seedlings of seed from north-facing and south-facing slopes.

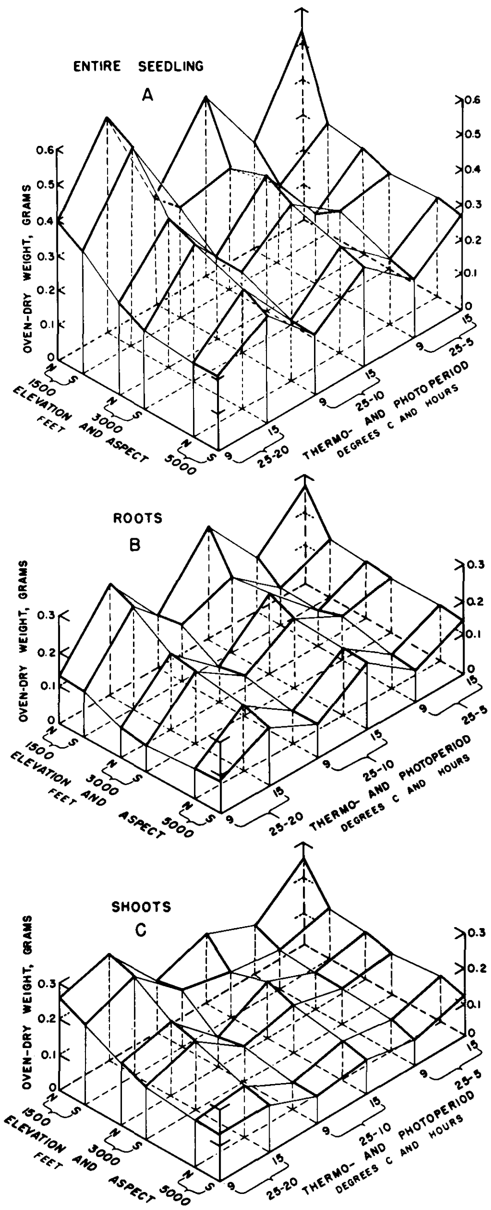

Figure 10. — Oven-dry weight of whole plants, roots, and shoots of seedlings from 6 different seed sources grown under 6 combinations of thermoperiod and photoperiod. Each point represents mean of 24 observations.

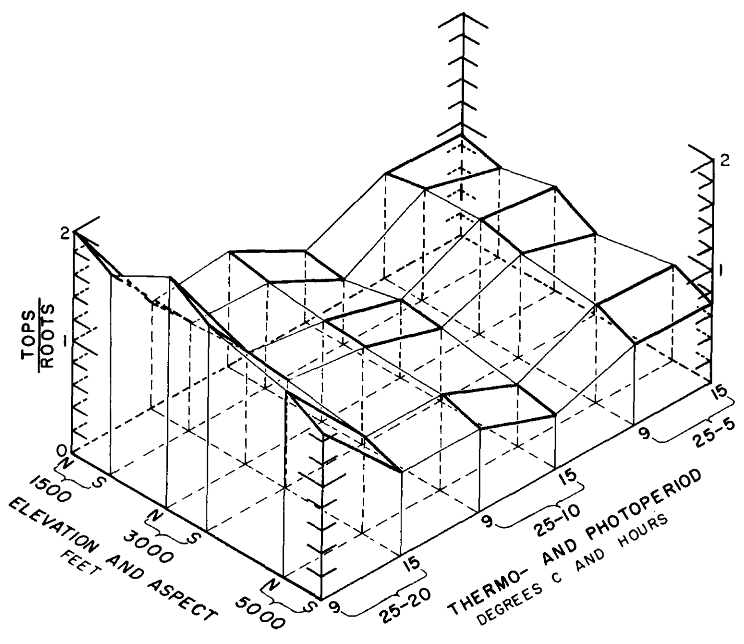

Figure 11. — Ratios of shoot-to-root dry matter of seedlings from 6 seed sources grown under 6 different combinations of thermoperiod and photoperiod. Each point represents mean of 24 observations.

Effect of origin of seed on growth of seedlings was brought out most clearly in the controlled environment of the growth chambers. The results suggested a gradual change along the transect, although seed lots investigated in growth rooms represented only the lowest, middle, and highest locations of collection. The decrease of growth with increasing elevation of seed source probably reflected adaptation to the shorter growing seasons at higher altitudes. The shorter growth period of progeny of trees from south-facing aspects may be a result of natural selection for early cessation of growth in habitats that are particularly dry in summer. Formation of larger roots in relation to their tops on seedlings from parents on south- than on north-facing slopes may be another indication of such selection.

Differentation related to altitude and topography was not so well defined among seedlings grown in the nurseries. Apparently, nursery environments obscured to some extent the influence of seed origin. Variation in height growth the first year could be attributed to nurseries and blocks in nurseries but not to origin of seed. The striking difference between first-year height growth at the two nurseries was probably caused by low content of nitrogen in the soil at Shady Cove. Tissue analyses showed that foliage at Corvallis contained an average of 0.23 mg of nitrogen per seedling compared with 0.05 mg of nitrogen at Shady Cove. Fertilization with ammonium nitrate before the second growing season eliminated the disparity in nitrogen levels between soils at the two nurseries. Height growth the second season was the same at both nurseries, although total height of seedlings at Shady Cove remained less because of poor growth the first year.

The greater variation of height growth within seed sources than between seed sources at the end of the first year further showed that beds were not homogenous at either nursery. Reduction of variation between blocks subsequent to application of fertilizer indicated that at least part of the variation may be attributed to fertility differences within beds at each nursery.

The phenological observation also provided evidence that nursery environment masked genetic differences. Bud set at Corvallis showed a perfect clinal pattern with elevation of seed collection, but at Shady Cove, sources from the lower part of the transect did not differ significantly from each other. Nursery influence seemed further expressed by greater variation in mean growth period between sources at Shady Cove than Corvallis. These differences between the two nurseries probably reflected greater heterogeneity of moisture-holding capacity and nutritional properties of the soil in the Shady Cove nursery. The warm climate of Shady Cove (mean monthly maxima are from 4^0 C to 7^0 C higher than at Corvallis during the growing season) may have further accentuated effects of the soil's heterogeneity.

The findings reported in this paper suggest the existence of "aspect races" in Douglas-fir. Further tests of progenies from parents on opposite slopes in other parts of the Douglas-fir region will be needed, however, to confirm genetic variation of this kind. Squillace and Bingham (9) presented evidence of racial variation in *Pinus monticola* over distances as short as half a mile in the mountains of northern Idaho and western Montana. They hypothesized that such variation occurs where topography is highly variable and summer drought prevails. Under these circumstances, selection pressures such as seedling establishment and growth rate discriminate against infiltration of genes from trees adapted to sites that are radically different although adjacent. Because of the similarities in climate and topography, this hypothesis seems also applicable to Douglas-fir in southern Oregon. The fact that the pair of samples at 1,500 ft, which was the closest at about one mile apart, was perhaps the most strikingly different, especially in its reaction to the long-day cold-night regime, may be worth noting here.

Occurrence of „aspect races" may have great practical significance in southern Oregon. Conceivably, collecting seed separately by aspect and altitude may permit raising seedlings better adapted to survival on their prospective planting sites.

Literature Cited

(1) Callaham, R. Z., and Liddicoet, A. R.: Altitudinal variation at 20 years in ponderosa and Jeffrey pines. J. Forestry 59, 814—820 (1961). — (2) Ching, K. K., and Bever, D.: Provenance study of Douglas fir in the Pacific Northwest region. I. Nursery performance. Silvae Genetica 9, 11—17 (1960). — (3) Ching, K. K.: Early growth of Douglas-fir in a reciprocal planting. Oreg. State Univ.,

For. Res. Lab. Res. Pap. 3. (1965). — (4) IRGENS-MOLLER, H.: Ecotypic response to temperature and photoperiod in Douglas fir. Forest Sci. 3, 79—83 (1957). — (5) MIROV, N. I., DUFFIELD, J. W., and LIDDICOFT, A. R.: Altitudinal races of *Pinus ponderosa* — a 12-year progress report. J. Forestry 50, 825—831 (1952). — (6) MUNGER, T. T., and MORRIS, W. G.: Growth of Douglas fir trees of known seed sources. U. S. Dept. Agric. Tech. Bull. 537. (1936). — (7) SCHOBER, R.: Experiences with the Douglas-fir in Europe. Proc. World Consult. on Forest Genetics and Tree Improvement, Stockholm, Sweden, 1963. F. A. O., Vol. I, Sect. 4/5, viii, 13 pp. (1963). — (8) SILEN, R. R.: Regeneration aspects of the 50-year-old Douglas-fir heredity study. Proc. 1964 Annual Meet. West. Ref. Coord. Comm., Spokane, Wash., pp. 35—39 (1964). — (9) SQUILLACE, A. E., and BINGHAM, R. T.: Localized ecotypic variation in western white pine. Forest Sci. 4, 20—34 (1958). — (10) SWEET, G. B.: Provenance differences in Pacific Coast Douglas-fir. Silvae Genetica 14, 46—56 (1965). — (11) WRIGHT, J. W.: Genetics of forest tree improvement. F. A. O., Rome, 399 pp. (1962).

Buchbesprechungen

Die Wurzeln der Waldbäume. Untersuchungen zur Morphologie der Waldbäume in Mitteleuropa. Von JOSEF NIKOLAUS KÖSTLER, ERNST BRÜCKNER und HANS BIBELRIETHER, München. 1968. 284 Seiten mit 135 Abb. und 20 Tab. Verlag Paul Parey, Hamburg und Berlin. Ganzleinen DM 64,—.

Für die Probleme der Waldbaumbewurzelung hat man sich schon sehr lange interessiert. Doch haben Schwierigkeiten bei der Untersuchungstechnik bislang eine zusammenfassende Darstellung verhindert. Nur in wenigen Literatur-Sammelreferaten waren Ansätze hierzu vorhanden. — Das Münchener Waldbauinstitut widmete sich in den letzten 12 Jahren intensiv diesem Problemkreis. Es führte viele eigene Untersuchungen durch und sichtete die vorhandene Spezialliteratur. Ergebnisse dieser Arbeiten fanden ihren Niederschlag in dem nun vorliegenden Buche, das z. B. ein Literaturverzeichnis von 830 Titeln enthält. — Nach einer Einleitung (p. 11—23), in der u. a. die Methoden der Wurzelgrabungen beschrieben werden, gliedern Verff. den Stoff in 3 Teile: A. Allgemeines über Baumwurzeln (p. 24—106); B. Die Bewurzelung der Baumarten (p. 107—206); C. Die Wurzelpflege im Waldbau (p. 207—265). — In diesen 3 übersichtlich gegliederten Teilen des Werkes erfährt auch der Forstpflanzenzüchter alles, was er von der Morphologie und vieles, was er von der Physiologie der Wurzeln seiner Objekte und, soweit bekannt, auch ihrer Symbionten wissen muß. Es erübrigt sich, Einzelheiten besonders herauszustellen; man sollte schon das gesamte Buch lesen und es in den einschlägigen Bibliotheken als Nachschlagewerk verfügbar haben. Es ist sicherlich eine außerordentlich wertvolle Stoffsammlung über ein wichtiges Spezialgebiet der Forstwissenschaft. SEITZ

Paplid Eesti NSV's. (Die Pappel in der Estnischen SSR.) Von M. MARGUS und Ü. TAMM. Herausgegeben von der Estnischen Akad. d. Wissenschaften, Sektion Botanik, Tallinn. 1967. 219 Seiten mit 77 Abb. *(Text estnisch, Zsfg. russisch und deutsch.)* Verlag „Valgus", Tallinn.

Die Einführung von Pappeln nach Estland begann schon im 18. Jahrhundert. Die ältesten importierten Arten waren *Populus nigra* und *P. alba*, denen wahrscheinlich bald andere gefolgt sind. Heute gibt es in Estland etwa 20 Pappelarten und -sorten, von denen als Waldbaum nur die Aspe, *P. tremula*, bekannt ist. Die meisten Pappeln finden sich vielmehr einzeln oder truppweise in Parks, Anlagen, um Bauernhöfe, in Forstkulturen und Eisenbahn-Schutzpflanzungen. — Die in Estland häufig auftretenden Arten und Bastarde werden im vorliegenden Buche morphologisch eingehend beschrieben, weil die älteren, aus der ausländischen Literatur stammenden Angaben den Gegebenheiten des Landes nicht immer entsprechen. Bei seltener vorkommenden Formen werden nur die wichtigsten Fundorte genannt. Die Mehrzahl der Pappelkulturen in Estland wurde nach dem 2. Weltkrieg, insbes. 1948—1952, angelegt. — Über die Technik der Anzucht von Sämlingen, von bewurzelten Stecklingen und über Sortenversuche wird berichtet. Krankheiten und Schädlinge der Pappeln werden besprochen. Am häufigsten kommen vor: *Cytospora nivea* und *Saperda carcharias*. MAX ONNO

Referate

SCHEINBERG, E.: **An approach to data processing in selection for genetic gain using high speed computers.** Canad. J. Genet. Cytol. 9, 857—873 (1967).

Vf. beschreibt die Nützlichkeit und Notwendigkeit der Anwendung schneller elektronischer Rechenanlagen bei Problemen der quantitativen Genetik — besonders in Selektionsexperimenten bei der Berechnung des genetischen Selektionsgewinns und der Parameteränderungen unter verschiedenen Selektionsverfahren. — Am Beispiel von Selektionsexperimenten demonstriert er das vorgeschlagene Verfahren der simultanen Analyse genetischer Daten bei der Berechnung der interessierenden statistischen und genetischen Maßzahlen. — Das in Fortran IV geschriebene Programm wird angegeben. HÜHN

SCHMIDT-VOGT, H.: **Zur Anerkennung von Fichtenbeständen.** Allg. Forstztschr. 23, 123—127 (1968).

In der Bundesrepublik Deutschland ist die wirtschaftliche Leistung eines Waldbestandes das Hauptmerkmal, nach dem Samenbestände zugelassen werden. Bei der Fichte ist entscheidend für die wirtschaftliche Leistung eines Bestandes sein Massenertrag. Dieser jedoch ist in erster Linie abhängig von der Güte des Standortes. — In Deutschland wird die Fichte seit langem künstlich angebaut. Autochthone Bestände sind deshalb sehr selten. Am Beispiel eines von ihm mit Hilfe von Nachkommenschaftsprüfungen untersuchten Fichtenvorkommens im Bayerischen Wald konnte der Verf. zeigen, daß zwischen den Nachkommenschaften der Bestände im jungen Alter Höhen- und Wuchsunterschiede zwischen 114 und 83% des gemeinsamen Mittels vorlagen. Dieses Vorkommen bildet einen Teil einer sog. „Sonderherkunft". Diese Unterschiede liegen im Rahmen der Ertragsstreuung innerhalb einer bestimmten Standortseinheit. Daraus kann geschlossen werden, daß hohe Massenleistungen eines Fichtenbestandes in erster Linie auf die Standorte und nicht auf die Auswirkung der genetischen Veranlagung zurückzuführen ist. Auch durch Zur-Hilfe-Nahme von Massenaufnahmen kann man den Massenertrag nicht als Maßstab wählen, weil kein Standort über eine größere Fläche so einheitlich ist, daß eine Abweichung im Rahmen von ± 10% vom Durchschnitt mit Sicherheit als genetisch bedingt erkannt werden könnte. Phänotypische Auslese nach Massenleistung ist also innerhalb eines bestimmten Wuchsgebietes betrieben wirkungslos. Es bleibt nichts anderes übrig als sie durch Nachkommenschaftsprüfungen festzustellen. — Andere Merkmale, die über Anerkennungswürdigkeit von Fichtenbeständen entscheiden, sind Feinastigkeit, Astreinheit, Resistenz gegenüber Rotfäule, Verhalten gegenüber Spätfrösten, Resistenz in schneebruchgefährdeten Berglagen und Resistenz gegen Eisanhang. Man darf annehmen, daß hinsichtlich der Klimaresistenz autochthone Herkünfte überlegen sind und über Erhaltungs-Samenplantagen vermehrt werden sollten. Die Spätfrostresistenz kann durch einfache Frühtests in der Baumschule ermittelt werden. Resistenzunterschiede gegenüber Rotfäule mögen zwischen verschiedenen Herkünften bestehen, aber es ist vorläufig noch nicht möglich, sie bei der Anerkennung im Gelände zu erkennen. Auch Feinastigkeit und Astreinheit können ohne Nachkommenschaftsprüfung nicht erkannt werden, da sie in hohem Maße vom Dichtstand beeinflußt werden. — Für die Zukunft wird vorgeschlagen, die Anerkennung von Fichtenbeständen mehr und mehr an Hand von Frühtests und Nachkommenschaftsprüfungen vorzunehmen. STERN

SCHRÖCK, O.: **Herkunftsbedingte Variabilität des individuellen Wachstumsganges bei Pinus silvestris.** DAL, Tagungsberichte Nr. 75, Eberswalde, 145—149 (1965).