Effects of Elevation and Seed Source on Tracheid Length in Young Ponderosa Pine

R. M. ECHOLS

Made in the United States of America
Reprinted from FOREST SCIENCE
Vol. 19, No. 1, March 1973
pp. 46–49

Effects of Elevation and Seed Source on Tracheid Length in Young Ponderosa Pine

Note by R. M. Echols

Abstract. Tracheid lengths in 30-year-old ponderosa pine progeny test plantations in the central Sierra Nevada of California were analyzed for effects of (a) elevation of seed parents and (b) elevation and location of test sites. The influence of elevation of seed parents on progeny tracheid length was not significant. Plantation location was significant, but interaction between progeny and location was not. The regression of tracheid length on dbh was negative. Regardless of elevation of parent source, high-elevation plantings produced larger diameters and shorter tracheids than lower elevation plantings. ***Forest Science 19:46–49.***

Additional key words. Wood quality, Ampliscope.

In 1938, the Institute of Forest Genetics at Placerville, Calif., began a study of the growth performance of ponderosa pine (*Pinus ponderosa* Laws.) progenies at different elevations. Three plantations were established in the central Sierra Nevada at elevations of 960 (Low), 2730 (Mid), and 5650 (High) ft. They contained open-pollinated offspring of parents selected along an east-west transect from the Sacramento valley to the high Sierra. Echols and Conkle (1971) found that wood specific gravity in the plantations decreased as elevation of seed parents increased. This note reports another phase of the study—effect of elevation of seed sources or plantation sites on tracheid lengths of the progeny.

Materials and Method. Seed used were from (a) groups of 4 to 12 wind-pollinated trees in seven elevational zones defined by 1,000-ft intervals, and (b) six individual trees from the 1000, 3000, 5000, and 7000-ft zones. The mixed-parentage plots were designated Zonal;

The author is Research Forester, Pacific Southwest Forest and Range Expt. Sta., USDA Forest Service, Box 245, Berkeley, Calif. 94701. Manuscript received March 16, 1972.

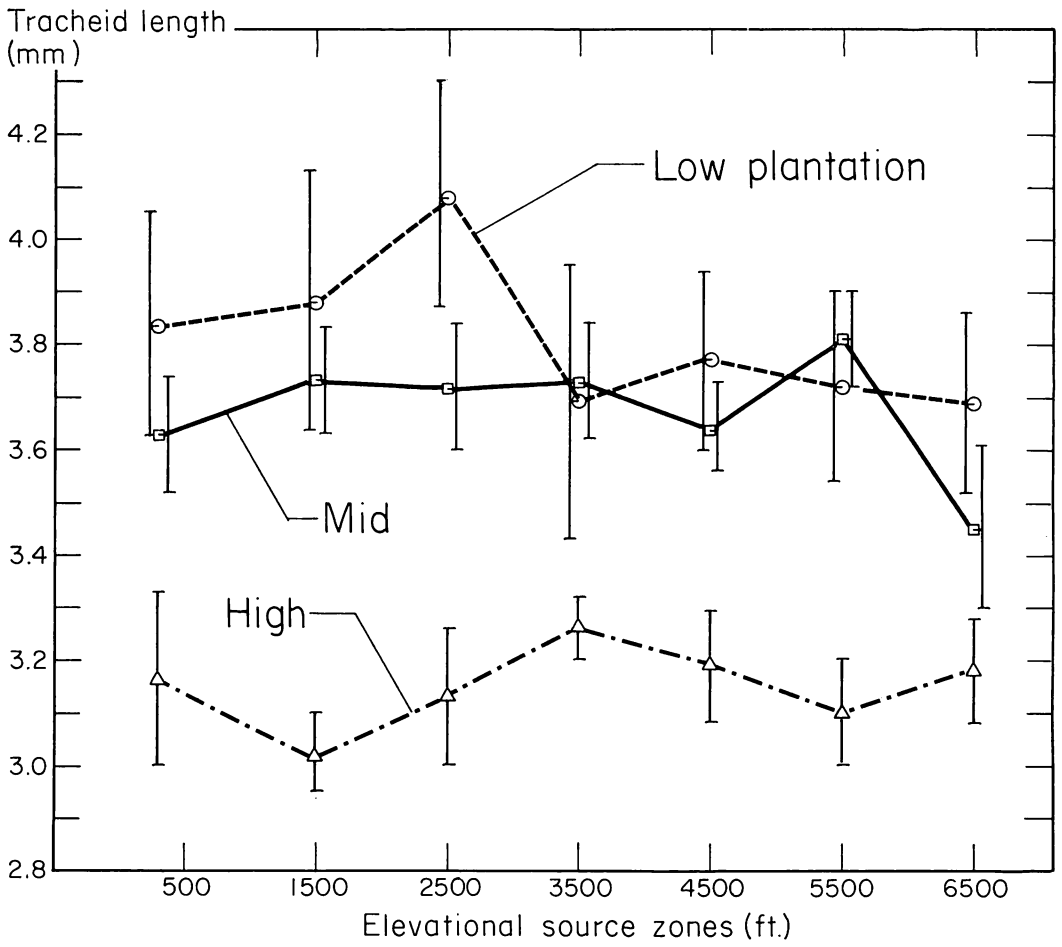

FIGURE 1. *Tracheid length means, taken at breast height, for mixed-parent zonal plots in three plantations in the central Sierra Nevada. The Low plantation is at 960 ft, Mid at 2730 ft, and High at 5650 ft elevation, near Placerville, Calif. Vertical lines represent 95 percent confidence limits on means.*

those made up of progenies all from one tree were labeled Single-Parent plots. The progenies were raised in nurseries next to the planting sites and outplanted in randomized blocks, replicated four times in each plantation.

In 1967, when the trees averaged about 9 inches dbh, I extracted 12-mm-diameter increment cores across complete diameters in the stems at breast height from all 1,248 trees in the 156 plots. The cores were then separated at the pith, yielding pairs of wood samples. They were labeled, dipped in a 2-percent Chlorox-water solution to prevent fungus buildup, and sealed in polyethylene bags.

Latewood from the outermost two growth rings of each sample pair was combined, macerated, and the tracheids were mounted on microscope slides. The 2,496 slides provided two sample points per tree from opposite sides. Tracheids were measured at 40× magnification on an Ampliscope.

Two primary variables were examined for effects on tracheid length: (1) Elevation of seed parents, and (2) location and elevation of plantation sites. After analyzing gross results, I separated out the mixed-parentage Zonal plots and the Single-Parent plots.

Results. The influence of elevation of seed parents on tracheid length of the progeny was not significant, whether related to Zonal plots, Single-Parent plots, or all plots combined (Table 1). Plantation location was signifi-

TABLE 1. Tracheid length of 30-year-old ponderosa pine progenies in three plantations, by seed source and elevation.

(In millimeters)

Elevation of source (ft)	Plantation			
	Low	Mid	High	Mean
	ZONAL PLOTS			
500	3.84	3.62	3.16	3.54
1500	3.88	3.73	3.02	3.54
2500	4.08	3.72	3.13	3.64
3500	3.69	3.72	3.26	3.56
4500	3.77	3.65	3.18	3.53
5500	3.72	3.81	3.10	3.54
6500	3.69	3.45	3.18	3.44
Mean	3.81	3.67	3.15	3.54
	SINGLE-PARENT TREES			
1000	3.79	3.46	3.11	3.45
1000	4.13	3.70	3.11	3.65
3000	3.81	3.85	3.20	3.62
4000	3.70	3.63	3.20	3.51
6000	3.70	3.61	3.08	3.46
6000	3.75	3.41	3.22	3.46
Mean	3.81	3.61	3.15	3.52

cant, but interaction between progeny and location was not.

No statistically significant difference (5-percent level) in tracheid length was found by *t*-test between the Low and Mid plantations with either Zonal or Single-Parent plot means. The difference between the Mid and High plantations was significant for both Zonal plots (Fig. 1) and Single-Parent plots (Table 1). Tracheid lengths averaged 3.8 mm for the Low plantation, 3.7 and 3.6 mm for the Mid, and 3.1 mm for the High.

Discussion. Plantation effects on tracheid lengths found in this study can be explained by the soil moisture and temperature relationships. Rainfall amounts and seasonal distribution affect tree growth (Zahner 1968). The Low and Mid plantations receive 25 in. and 45 in., all in late fall, winter, and early spring. The High site receives about 55 in., mostly in winter but with some in spring, summer, and fall. In Arizona, supplemental irrigation of ponderosa pine during summer doubled the growth (Mace and Wagle 1964), and in eastern Washington it added up to 40 percent more latewood to 100-year-old trees (Howe 1968). Optimum air temperature for diameter growth in the Arizona plots was around

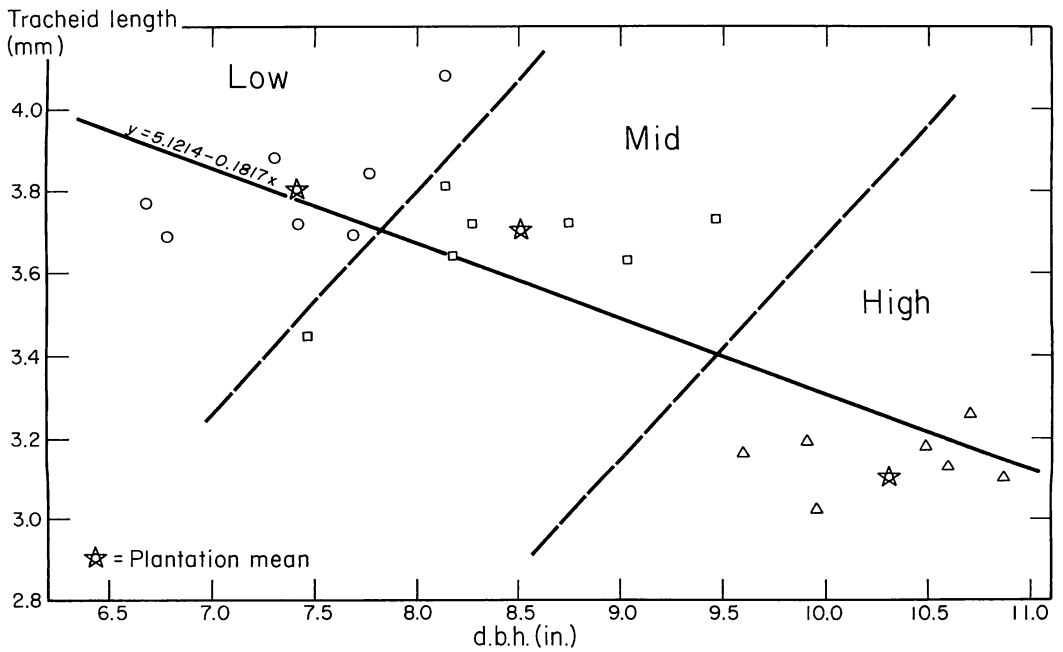

FIGURE 2. *Tracheid length—tree diameter relationships for mixed parent zonal plots in Low, Mid, and High plantations. See Fig. 1 for definition of plantations.*

70° F., and growth inhibition was associated with higher temperatures. In the High-elevation plots temperatures are seldom above the 70's, while at the Mid and Low sites the summer daytime temperatures often exceed 90° F.

As early as 1951 Bisset *et al.* (1951) found a relation between tracheid length and rate of radial growth of *Pinus* stems. They stated that, in general, within any one stem a wide growth ring had a low average tracheid length and a narrow growth ring a high average tracheid length. Bannan (1964) observed that the relative rate of xylem cell divisions is slower in wider rings, and there was an inverse or negative relationship between cell length and rate of pseudotransverse division. He reported lodgepole pine tracheids were shorter in samples taken at higher elevations in Colorado and Wyoming and related the size to division rate. In our High plantation the mean tree diameter was 10.3 in., compared to 8.5 in. for the Mid and 7.4 in. for the low plantations. A regression analysis showed a significant negative correlation between dbh and tracheid length: $r^2 = 0.61$ (Fig. 2).

Conclusion. For ponderosa pine in the western Sierra Nevada, regardless of elevation of parent source, a high elevation planting produces trees with shorter tracheids than at either middle or low elevations. Tree diameters are larger and height equal or greater, resulting in a combination of higher volume, shorter fibered wood. The same sources produce trees with longer tracheids when grown at medium or low elevations. Although genetic differences were not obvious in this study, the occurrence of individual trees with longer tracheids at all three sites suggests selection possibilities.

Literature Cited

BANNAN, M. W. 1964. Tracheid size and anticlinal divisions in the cambium of lodgepole pine. Can J Bot 42:1105–1118.

BISSET, I. J. W., H. E. DADSWELL, and A. B. WARDROP. 1951. Factors influencing tracheid length in conifer stems. Australian Forest 15(1):17–30.

ECHOLS, R. M., and M. T. CONKLE. 1971. The influence of plantation and seed-source elevation on wood specific gravity of 29-year-old ponderosa pines. Forest Sci 17:388–394.

HOWE, J. P. 1968. Influence of irrigation on ponderosa pine. Forest Prod J 18:84–93.

MACE, A. C., JR., and R. F. WAGLE. 1964. A measure of the effect of soil and atmospheric moisture on the growth of ponderosa pine. Forest Sci 10:454–460.

ZAHNER, R. 1968. Water deficits and growth of trees. *In* Water Deficits and Plant Growth, Vol. II, pp 191–254, ed by T. T. Kozlowski. Academic Press, N Y.