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EARLY HEIGHT GROWTH OF PONDEROSA PINE forecasts dominance in plantations

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Foresters in California are planning initial thinnings in thousands of acres of planted ponderosa pine (*Pinus ponderosa* Laws.). These thinnings, usually precommercial, often precede inter-tree competition. Precommercial thinning is cheaper in saplings than in pole-size stands. And sapling stands often yield Christmas trees which help offset the cost of thinning.

What marking criteria should be used for these thinnings? Should relative height be as important in marking young plantations as crown class in older stands?

As part of a larger study of competitive influences on the development of ponderosa pine plantations, we obtained information on early expression of crown dominance. The wide range of site qualities sampled provide new data on the number of growing seasons dominant trees take to reach breast height (4.5 feet). These data are valuable when using conventional site index curves based on total age.

METHODS

Ten ponderosa pine plantations on the westside Sierra Nevada, southern Cascade Range, and Warner Mountains of northeastern California were sampled. The plantations were pole-size and larger, had well-differentiated crown classes, and were experiencing inter-tree competition. Ages ranged from 16 to 50 years from planting. And spacings ranged from 3 by 3 feet to 12 by 12 feet.

Site index was determined from curves developed by Dunning and Reineke¹ and ranged from 30 to 120 feet at 50 years. Preliminary results from a separate study² suggested that these curves more accurately describe height growth in stands less than 50 years old than curves more frequently used.

Abstract: Future crown class may be determined well in advance of inter-tree competition in plantation-grown ponderosa pine. Regardless of site quality, dominant trees in 10 California plantations reached breast height 1/2 year sooner than codominants and 1-1/2 years sooner than intermediates. Dominant trees on poor sites reached breast height several years earlier than has been reported for natural stands. Failure to recognize this rapid early growth will result in underestimating site index in plantations. Relative height is recommended as a guide in marking thinnings or Christmas tree cuttings.

Oxford: 174.7 *Pinus ponderosa*-228.7:228.125:242.
Retrieval Terms: *Pinus ponderosa*; plantation stands; crown class prediction; pre-commercial thinning.

We chose to study 31 groups of at least 10 trees each in portions of plantations with high survival. The current crown class³ and breast-height age were determined for each tree, and site index was determined from the dominant trees in each group. Site indices were grouped into five site classes for certain comparisons.

RESULTS

Early Expression of Dominance

Future crown classes could be recognized by the time plantation trees reached breast height (*table 1*). We found that throughout the range of site indices, pre-dominants (trees now classified dominants) reached breast height about one-half growing season before pre-codominants (trees now classified codominants). Pre-intermediates (trees now classified intermediates) took about 1-1/2 growing seasons longer than pre-dominants.

Differences in height between future crown classes were small in the sapling stage. But small differences became progressively larger as the stands developed. We compared the current mean height of codominant and intermediate crown class trees with that of dominant trees for all plots, regardless of site quality. The relationships were. . .

Mean height of codominant trees = $-1.009 + 0.929$

H_D

Mean height of intermediate trees = $-1.433 + 0.848$

H_D

in which H_D = mean height of dominant trees.

Correlation coefficients for both equations exceeded 0.98. The equations were tested by covariance analyses and found to be significantly different at the 1 percent level.

An example of how far behind intermediate crown classes can fall in the height-growth race can be found in the oldest plantation we studied. In this 50-year-old plantation on Site Class I land, the average pre-intermediate was only 0.5 feet shorter than the average pre-dominant when the plantation was about 4.5 feet tall (*fig. 1*). Forty-three years later, this height difference had stretched to 15 feet, placing the intermediates well below the canopy.

Shifts in crown class between trees as stands develop are well documented.^{4,5} They probably contributed to variation in our results. But there is little chance that shorter trees in a sapling-size plantation will develop into dominants. Shifts in crown classes are usually downward.

Table 1—Growing seasons to reach breast height for plantation-grown ponderosa pine, by crown class and site index, in California

Site index class (base: 50 yrs.)	When crown class is. . .			Basis: number of trees
	Dominant	Codominant	Intermediate	
	<i>Mean number of seasons</i> ¹			
108-117	4.6	5.0	5.4	60
88-107	6.5	7.5	8.4	30
68-87	6.6	7.3	7.7	138
48-67	8.3	8.8	9.8	50
28-47	11.4	11.8	13.2	40

¹Statistical differences between crown class means tested by Duncan's Multiple Range Test and coded as follows: (a) Means not joined by lines are significantly different at the 5 percent level. (b) Means joined by broken lines are significantly different at the 10 percent level. (c) Means joined by solid lines are not significantly different.

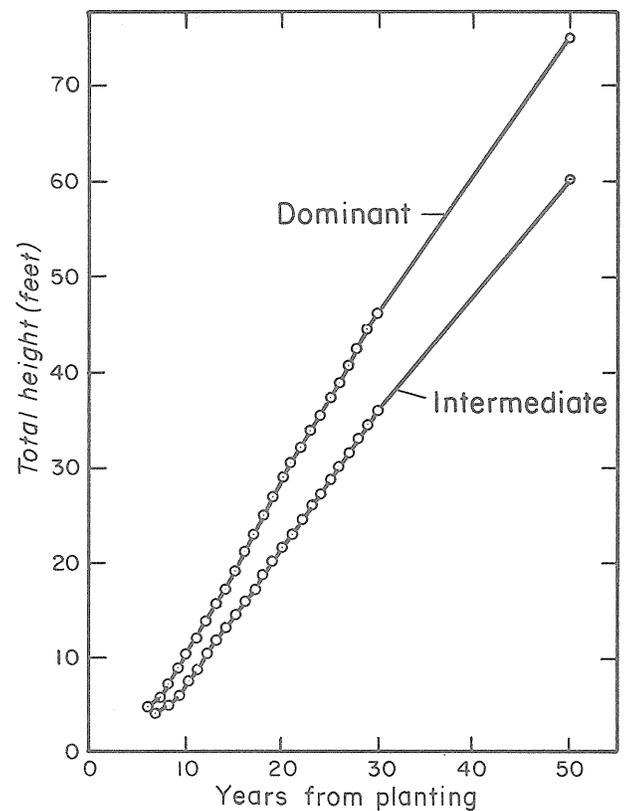


Figure 1—Mean height growth of dominant and intermediate crown class trees in a 50-year-old pine plantation. Basis: stem analysis of seven trees in each class.

Years to Reach Breast Height

Site had a profound effect on time to reach breast height—much more so than did future crown class. Pre-dominant trees took an average of 13.2 years to reach breast height on the poorest sites measured—site index 30 feet at 50 years (*fig. 2*). The number of years dropped sharply to 8.5 on medium sites—site index 50 feet at 50 years. From site index 50 to site index 100, the number of years to reach breast height decreased more gradually to 6.5 years. Then, the years to reach breast height decreased sharply again to 4.4 years on the very best sites—site index 120 feet at 50 years. When site index values were grouped into five site classes, each class was found to be significantly different from every other class at the 1 percent level.

These data suggest that on poorer sites, plantation-grown ponderosa pine in California reaches breast height at a younger age than trees in natural stands (*table 2*). Since we measured age from planting, not age from seed, planted trees might be expected to reach breast height sooner than trees in natural stands. But observations elsewhere indicate that this initial height advantage is negligible by the time trees reach breast height.⁶ More likely, our

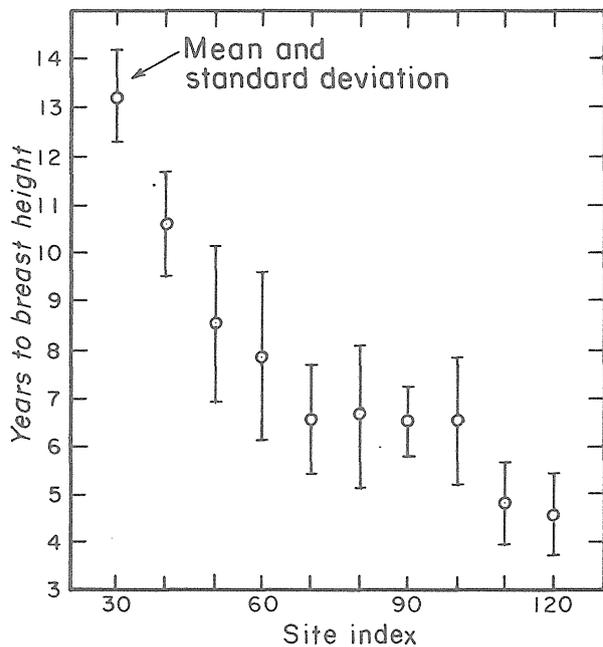


Figure 2—Years to reach breast height for dominant ponderosa pine in plantations, by site index (base: 50 years).

Table 2—Growing seasons for dominant ponderosa pine to reach 4.5 feet tall when growing in natural stands and plantations in California

Site index class (base: 50 yrs.)	Natural Stands ¹	Plantations
120	6	5
100	6	6
80	8	7
60	12	8
40	16	11

¹Revised for dominant trees only and a base age of 50 years from: Meyer, Walter H. *Yield of even-aged stands of ponderosa pine*. U.S. Dep. Agr. Tech. Bull. 630, 59 p. Rev. 1961.

²Measured from planting.

plantation results differ from those reported for natural stands for another reason: the data for natural stands were gathered throughout the range of the species. Highly productive sites and the Pacific Coast form of ponderosa pine were relatively under-sampled.

Both site index and future crown class affected time to reach breast height, but no interaction between the two was found. Differences in time to reach breast height between pre-dominants and pre-intermediates were about the same and statistically significant at the 10 percent level for all site indices (*table 1*). Furthermore, differences between pre-dominants and either pre-dominants or pre-intermediates were about the same within all site classes. But these differences often were not statistically significant.

At first thought, interaction between potential crown class and site quality would be expected. Crown class differentiation is accelerated by inter-tree competition, and is more active on good sites than on poor ones.⁷ But inter-tree competition is not yet a factor in plantations 4.5 feet tall.

CONCLUSIONS

Trees fall behind in the height-growth race for many reasons. We did not attempt to determine them. But regardless of the reasons, if during the first few years plantation trees do fall behind in height growth, chances are slim that they will catch up. Therefore, in thinnings and Christmas tree cuttings in ponderosa pine plantations, the forest manager

should favor leaving the taller trees. These trees will grow to form the dominant crown classes.

Many older site index curves are based on total age rather than breast-height age. A correction for time to reach breast height is necessary. Since site markedly influences breast-height age of plantation-grown ponderosa pine, applying the same correction for all sites is wrong. Furthermore, applying the published estimates based on natural stands (*table 2*) will underestimate site index by as much as 20 feet at 50 years on poor sites.

NOTES

¹Dunning, Duncan, and L. H. Reineke. *Preliminary yield tables for second-growth stands in the California pine region*. U.S. Dep. Agr. Tech. Bull. 354, 23 p. 1933.

²Manuscript in preparation by Robert F. Powers, Pacific SW. Forest & Range Exp. Sta., Redding, Calif.

³Society of American Foresters. *Forestry terminology*. 3rd Ed. Washington, D.C., 97 p. Rev. 1958.

⁴Guillebaud, W. H., and F. C. Hummel. *A note on the movement of tree classes*. *Forestry* 23: 1-14. 1949.

⁵Warrack, George. *Comparative observations of the changes in classes in a thinned and natural stand of immature Douglas-fir*. *Forestry Chron.* 28:46-56. 1952.

⁶Unpublished data by Philip M. McDonald on file at the Pacific SW. Forest & Range Exp. Sta., Redding, Calif.

⁷Deen, J. Lee. *Some aspects of an early expression of dominance in white pine (*Pinus strobus* L.)*. Yale Univ. Sch. Forestry Bull. 36, 34 p. 1933.

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