Wood properties of immature ponderosa pine after thinning

Donald C. Markstrom
Harry E. Troxell
Charles E. Boldt

Abstract

Trees from growing stock levels of 20, 60, and 100 in sapling and pole stands were sampled at three vertical positions — zero, 25, and 50 percent of total height above the l-foot stump. Wood grown during the 10-year period after initial thinning was compared for growth and wood properties. Wide differences in radial growth, induced by thinning treatments, were not accompanied by significant differences in specific gravity, latewood percentage, tracheid length, nor microfibril angle. However, all properties except microfibril angle were significantly affected by vertical position on the stem.

Accessible ponderosa pine (*Pinus ponderosa* Laws.) forests of the Black Hills of South Dakota and Wyoming have been changed profoundly by human activity. Harvesting has, in little more than a century, practically eliminated the old growth sawtimber. Timely, abundant natural regeneration has reforested most of the cutover area with dense second-growth (5). Most of the second-growth stands, in turn, have been brought under management (2, 11, 16, 17).

Prior research has shown that ponderosa pine responds with increased growth when thinned (2,4,11). Trees now being harvested from older, managed, second-growth stands commonly display a patterned response of diameter growth to thinning — typically an inner core of slowly grown, narrow-ringed wood surrounded by a sheath of rapidly grown, wide-ringed wood following release.

Growers, processors, and users of Black Hills ponderosa pine are concerned about the technical properties of wood from stands which have been intensively managed. This study was conducted to determine whether there are significant differences in wood properties of stemwood from trees grown at different rates under different silvicultural regimes.

Study design

A preliminary investigation compared diameter and volume growth rates and selected physical properties of stemwood in trees from thinned and unthinned portions of a single pole-sized pine stand (3). Results showed that A) trees remaining in the thinned portion of the stand had significantly wider rings at all heights from 0.5 to 28.5 feet; B) there were no significant differences in specific gravity, percent latewood, and percent extractives in wood from the two groups of trees; and C) the unthinned trees had slightly longer tracheids. Limitations of the sample precluded widely applicable conclusions, but the outcome suggested that an expanded investigation would be worthwhile.

During the period 1960-1964, a comprehensive study of growing stock levels (GSL) was planned and installed on the Black Hills Experimental Forest (13).[1] The study was designed to meet the needs of forest planners and managers for reliable information on growth, development, and potential yields of even-aged ponderosa pine stands under intensive management.

[1]The plan for the Black Hills study was subsequently adopted as the prototype for a westwide series of compatible studies in even-aged stands in other ortions of the Interior Ponderosa Pine Type. For more details of the westwide effort, see Myers (13). Growing stock level (GSL) is defined as the residual square feet of basal area when average stand diameter is 10 inches DBH. Basal area retained in a stand with an average diameter of less than 10 inches is less than the designated level (13).

The authors are, respectively, Wood Technologist, USDA Forest Serv., Rocky Mountain Forest and Range Expt. Sta., 240 West Prospect, Fort Collins, CO 80526; Associate Dean, College of Forestry and Natural Sciences, Colorado State Univ.; and Silviculturist, USDA Forest Serv., Rocky Mountain Forest and Range Expt. Sta. This paper was received for publication in August 1982

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A distinctive feature of the study was a provision for replicated tests of six stocking levels that cover the reasonable range of options with levels to be maintained through rethinnings every 10 years. Levels selected for testing in the Black Hills study were GSL 20 through 120, with 20-square-foot intervals. Three replicate plots of each GSL were established in typical stands of two sizes — large saplings and small poles — with initial thinnings to prescribed GSLs completed on all 36 plots during the dormant season of 1963-64. The site index for the plots ranged from 55 to 60. The average site index in the Black Hills ranges from 54 to 58, depending on the geologic area (14).

In 1974, 11 years and one rethinning after the installation of the GSL study, this satellite study of wood properties and growth rate in relation to stand size and stockings was made.

Methods and materials

To keep the overall size of the study within manageable limits, only three of the six GSL classes were sampled - 20, 60, and 100.

A total of 270 wood samples was extracted from 90 randomly selected trees, on 18 plots, representing three replicates of three stocking levels in two stand sizes. Samples were taken at three vertical positions on the stem of each tree: at zero, 25, and 50 percent of total height above a l-foot stump.

The sample at each vertical position consisted of a set of three cores — one extracted at the measured point, one approximately 1 inch above the first, and one approximately 1 inch below it. All nine borings from any tree were roughly inline, vertically, with their position along the circumference of the stem determined by the easiest route for climbing. The cores were extracted with a common 0.175-inch diameter increment borer inserted deeply enough to include at least the outer 11 growth rings. Use of the small borer minimized damage to plot trees. After extraction, the cores were placed immediately in vials of distilled water to maintain the green condition until laboratory processing.

Analysis of the cores was confined to the outer 11 growth rings, representing the growing seasons since first thinning. One of the three cores from each sample point was used to measure specific gravity and radial increment; a second was used to determine latewood percentage; and a third was used to measure tracheid length and fibril angle. The unusually small size of the specimens required use of some uncommon techniques for laboratory analysis.

Specific gravity and radial increment

Each core used for these determinations was severed at the cambium to remove the bark, and between the 11th and 12th growth rings. The wet length of the outer 11 rings was measured to the nearest 0.001 inch with machine calipers. A mean core diameter of 0.178 inch was established for all wet cores by averaging many sample measurements. The cores were ovendried until weights ceased to change, and a final dry weight to the nearest .001 gram recorded for each core. Specific gravity was calculated on the basis of ovendry weight and green volume of the cores.

Latewood percentage

Cores were trimmed in the same way as for specific gravity determination. Each was surfaced along its axis with a sharp blade and was examined with a 10X, dissecting microscope with a graduated, moving eyepiece. The latewood was identified as that portion of the annual ring in which the common wall between two cell cavities was equal to or greater than one-half the width of either cell cavity. Both latewood and earlywood were measured to nearest 0.001 inch, separately totaled, and the percentages of latewood calculated.

Tracheid length and microfibril angle

Thin wood sections, approximately 0.015 inch thick and including all 11 growth rings, were sliced along the axis of the core. Small portions of latewood were cut from all 11 growth rings in any given specimen. Fragments were placed in a test tube containing a solution of 50 percent peracetic acid, 35 percent acetic acid, and 15 percent hydrogen peroxide (by volume), and were heated in an oven at 140°F for 16 hours. The test tubes were removed from the oven, filled with distilled water, and shaken vigorously to separate the tracheids. The tracheids were washed several times with water using a suction filter funnel, stained with safranine for 30 minutes, and washed again. They were stored in glass vials containing distilled water until they were examined.

Ten tracheids were selected randomly to represent each core for length and fibril angle determinations. These were placed on a glass slide and viewed through a Reichert Viso-pan microscope[2] previously calibrated with a stage micrometer. All 10 tracheids were measured to obtain an average length. The microfibril angle was measured as the angle between a tracheid's long axis and the long axis of openings in cell wall pits (pinoid slits). Fifty angles (5 from each of 10 separate tracheids) were measured and averaged to obtain a value for each core.

Analysis

All data were analyzed with a factorial analysis. This analysis tested the effects of stocking level (GSL), height, and their interaction upon radial increment, specific gravity, latewood percentage, tracheid length, and microfibril angle. Data from sapling and pole stands were analyzed separately because all previous work on them had indicated that they constitute separate populations. Later, it became evident that there were no practical differences between the sapling and pole sizes in regard to all of the parameters except radial growth. Data was combined to show overall averages by vertical position class except for radial growth (Tables 1 and 2). Figure 1 shows the average DBH and reserve stocking, after the second thinning, for the 18 plots. Obviously, the relationship of basal area (BA) per acre to GSL is not constant but also depends on the average stand diameter. The difference of BA per acre between 20 and 100 GSL for saplings is about 40 square feet per acre, while that for poles is about 80 square feet per acre.

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[2]Trade and company names are used for the benefit of the reader, and do not imply endorsement or preferential treatment by the U.S. Department of Agriculture.

Results and discussion

Radial increment

The tabulation of periodic increments (Table 1) confirms that the GSL plots were a good source of wood samples for comparative evaluation. Diameter growth rates of both saplings and pole were significantly related to GSL and vertical position on the stem.

Analysis of the data revealed no surprises with respect to patterns of growth response. Reductions of stocking were expected to increase the rate of diameter growth of reserved trees, roughly in proportion to release (4). The distribution of increment over the boles also was expected to change differentially in response to release (7, 12).

The pronounced acceleration of growth at stump height in widely spaced saplings and poles (GSL 20) conforms to what Myers (12) interpreted as a physiological reaction to wind stress on stems of exposed trees. This buttressing of the lower boles of GSL 20 trees evidently accounts for the significant interactions which were observed between GSL and vertical position on the stem.

In contrast, there was much less vertical variation in current radial increment in stems of trees in stands thinned to GSL's 60 and 100. This suggests that stands maintained at these levels of stocking will be characterized by comparatively cylindrical lower boles. Uniformity of both ring widths and stem tapers, or the lack of it, could have important implications for some wood processors and users.

Radial growth in the two stand sizes was not as consistent as the patterns of growth. Pole-sized trees grew faster at the lowest level of stocking, and slower at the highest level, than the saplings. The differences were evident at all vertical sampling locations. The reasons for this are not known. However, the accuracy of the information about wood properties does not depend on a thorough understanding of underlying stocking-growth relationship.

Specific gravity

Specific gravity was not significantly affected by GSL, nor by variations in radial increment, in either the sapling or pole stands; nor were there practical differences in specific gravity between stand sizes, at equivalent relative heights. Therefore, the data were combined, and single average values of specific gravity were calculated for all combinations of GSL and stand size (Table 2).

Specific gravity was significantly affected by vertical position on the stem, irrespective of GSL and

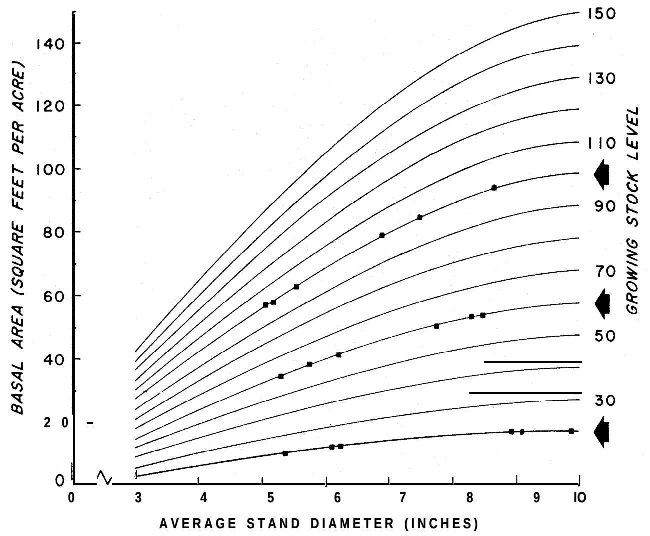

Figure 1. — Standard growing stock levels (GSL) for even-aged ponderosa pine, as established for testing in Westwide study; square dots indicate average DBH and reserve stocking (after second thinning) for 18 plot stands sampled for wood properties.

TABLE 1. — *Average periodic radial increments ± 1 standard error (inches) for stems of ponderosa pine saplings and poles in stands thinned to GSL 20,60, and 100; values are segregated by stand size and vertical sampling location, expressed in percent of height above stump; Black Hills Experimental Forest.*

GSL	Vertical sampling location	10-yr. radial increment	No. of rings per inch
Saplings	(% H)	(in.)	
	0	1.104 ± .079	9
20	25	0.832 ± .049	12
	50	0.850 ± .050	12
	0	0.809 ± .083	12
60	25	0.781 ± .049	13
	50	0.790 ± .041	13
	0	0.681 ± .056	15
100	25	0.607 ± .055	16
	50	0.729 ± .067	14
Poles			
	0	1.314 ± .125	8
20	25	1.035 ± .076	10
	50	1.031 ± .064	10
	0	0.760 ± .057	13
60	25	0.754 ±.056	12
	50	0.836 ± .052	12
	0	0.495 ± .063	20
100	25	0.427 ± .036	23
	50	0.499 ± .044	20

TABLE 2. — *Average values ± 1 standard error of three wood property variables measured in ponderosa pine pole and sapling stands thinned to GSL 20, 60, 100; values are segregated by relative height only; Black Hills Experimental Forest.*

Percentage of height	Specific gravity	Latewood percentage	Tracheid length	Microfibril angle
			(mm)	(degrees)
0	0.417 ±.004	27.36 ± .43	2.08 ± .03	—
25	0.380 ± .003	23.76 ± .40	2.61 ± .03	30.90 ± .24
50	0.351 ± .003	21.01 ± .40	2.70 ± .03	—

stand size. Highest specific gravity was found at stump height, with values declining in a roughly linear fashion from there to the top sample point (Table 2). This pattern of variation is consistent with that found in many other conifers (1, 9, 10, 15, 21).

The practical inferences are A) that stemwood density need not be a matter of concern in the choice of a GSL, at least within the range of 20 to 100; B) that specific gravity will not change appreciably, at any given relative vertical position on the stem, as stands advance from sapling to pole size; and C) that neither manipulation of stocking nor stand development should be expected to alter the natural pattern of decreasing wood density with increasing vertical position in immature tree stems.

Latewood percentage

Because latewood percentage is the principal determinant of specific gravity, it is not surprising that statistical analyses of latewood variation produced outcomes similar to those for specific gravity. In stands of both sizes, latewood percentage declined steadily from the stump to half-height (Table 2). No significant variation was attributable to GSL. The close relationship between specific gravity and latewood percentage has been reported previously (5, 6, 7, 8, 18, 20)

Tracheid length

Analyses also indicated that relative height was the only factor significantly affecting tracheid length. Values in Table 2 show an irregular trend of increasing length with increased vertical position on the stem. The bulk of the reduction in tracheid length occurred in the butt portion of the tree stems, between the stump and 25 percent of total height. The trend was common across GSLs and in both stand sizes.

Other studies of tracheid length have dealt with measurements at only one height in the tree. In southwestern ponderosa pine, for example, tracheid length was found to increase from the pith to the bark (20).

Because tracheid length correlates with strength in unmodified wood, as well as in reconstituted wood products, it is a property of considerable practical importance. However, like specific gravity, it does not appear to be influenced by thinning.

Microfibril angle

This property did not show any significant variation attributable to GSL, stand size, or vertical position on the stem. The overall mean microfibril angle for xylem elements from all sample trees was 30.90 degrees.

A trend towards wider microfibril angles was found in wood laid down during early years of growth of young ponderosa pine in Arizona (19). The difference in microfibril angles was blamed for excessive warping and splitting in dried lumber cut from such trees. Except for the limited findings of the Arizona study, and this one, the effects of silvicultural practices on microfibril angle, if any, are unknown.

Summary and conclusions

Wide differences in stocking in pole and sapling stands resulted in wide differences in diameter growth during the l0-year period after thinning. Pole-sized trees grew faster than saplings at the lowest GSL and slower at the highest GSL. The differences were evident at all relative vertical positions on the stems. Fastest rates of diameter growth were at stump height in the most widely spaced trees. Comparatively uniform rates, from stump upward, were found in moderately (GSL 60)– and heavily (GSL 100) — stocked stands. Differences in diameter increment resulting from thinning were not accompanied by significant differences in wood specific gravity, latewood percentage, tracheid length, nor microfibril angle. However, the first three of these properties were affected significantly by vertical position on the stem, regardless of stand size and stocking. Specific gravity and percentage latewood decreased, whereas tracheid length increased with height, from the stems to mid-stem. Microfibril angle did not vary with position on the stem.

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