Characterization of Juvenile Wood in Lodgepole Pine in the Intermountain West

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Abstract

Juvenile wood (core wood) is typically characterized as being less dimensionally stable and having lower mechanical properties than mature wood. Determination of the age of transition from juvenile wood to mature wood can provide basic information needed to assess dimensional stability and better utilize small-diameter trees growing in the intermountain west as solid-sawn products and as structural composites. While there is considerable information available on the variation of specific gravity with the age of the tree for western conifers, specific gravity is not useful for predicting dimensional stability, and as a single predictor of mechanical properties only explains about 50% of the observed variation. Determination of the age of transition between juvenile wood and mature wood, and some of the factors that could effect this transition, is important when making judgments about utilization options for naturally occurring stands of trees in the intermountain west region of the United States.

Lodgepole pine (*pinus contorta*) trees were harvested from four different sites in the US intermountain west to include site variations affecting growth, such as elevation, precipitation, and growing seasons. Bolts were extracted from each tree and processed to extract a single, radial-sawn board from each bolt. From each board, longitudinally-oriented samples were taken for every 5th growth ring, measuring approximately 5 x 5 mm in cross section with lengths ranging from 125 to 350 mm. Longitudinal shrinkage was measured in each sample as it dried from green to oven dry conditions. Later, the average microfibril angle was determined for the same samples.

A good correlation was found between longitudinal shrinkage and microfibril angle, suggesting that either method could be used to determine the juvenile wood transition in lodgepole pine. In addition, a significant difference in the juvenile wood transition period was found between sites. These results are useful for establishing parameters meaningful to the characterization of juvenile wood in the western conifers when utilized as solid-sawn products and structural composites.

Keywords: A. Lodgepole pine, B. Juvenile wood, C. Mature wood, D. Longitudinal shrinkage, E. Microfibril angle.

Introduction

There are approximately 10.19×10^{12} m^3 (net) of softwood growing stock in the western United States, excluding Alaska and the Great Plains (Smith *et al.* 2009). Of the 52.6×10^6 ha of western timberland not reserved for timber harvest and meeting minimum productivity standards, it has been suggested that 11.7×10^6 ha are high priority areas for fuel reduction treatments (Figure 1).

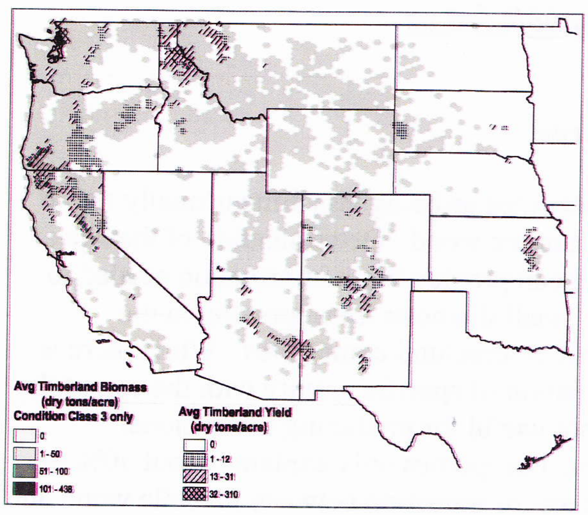


Figure 1. Potential high-priority fuel reduction thinning opportunities on timberland in western United States (Vissage and Miles, 2003)

Most trees in these high priority treatment areas are in diameter classes below 25 cm diameter at breast height (dbh), though the majority of the biomass falls in diameter classes above 25 cm dbh (Woodall 2003). Thinning at risk stands is often imperative to reduce fire risk, even for stands that are eventually to be subjected to controlled burns. Because the costs of fuel reduction treatments often exceeds the value of the material removed, finding higher value uses for the thinnings is a major focus of Forest Service Research (Forest Service 2003).

Historical and contemporary studies have identified the occurrence of juvenile wood to be a major impediment to more efficient utilization. Juvenile core material in a tree shrinks longitudinally much more than does mature material, which can affect the dimensional stability of wood-based products (Gorman 1985). While extensive literature is available on the occurrence of juvenile wood in many western species, especially Douglas-fir, much of the available information is based on variation in specific gravity with tree age (Figure 2). Koch (1994) notes that juvenile wood appears to be less pronounced in lodgepole pine than in most other western species. Determination of the age of transition between juvenile wood and mature wood, and some of the factors that could effect this transition is important when making judgments about utilization options for naturally occurring stands of trees in the intermountain west.

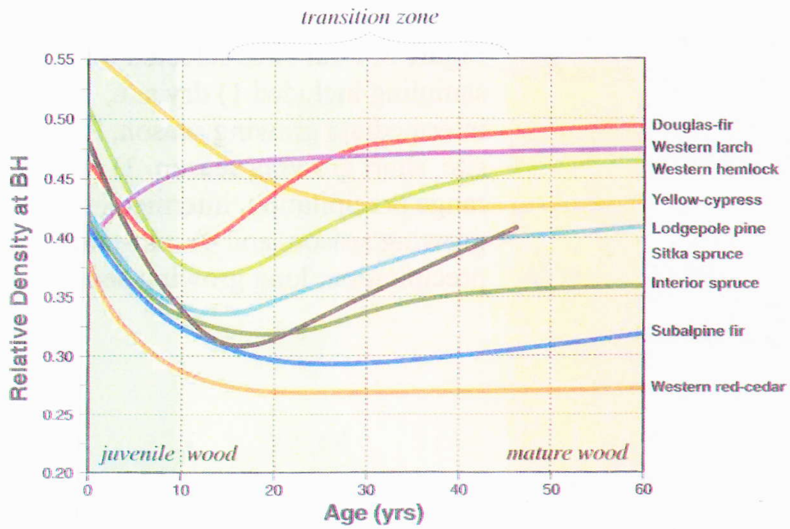


Figure 2. Juvenile wood in western species (Jozsa and Middleton 1994).

Clarke and Saucier (1989) concluded that the period of juvenility in slash and loblolly pine was influenced by environmental factors associated with geographic location. The variation with geographic location appeared to be related to climatic factors such as temperature (length of the growing season) and seasonal rainfall patterns. The study also showed that while planting density did not alter the length of the juvenile wood period, planting density did influence the size of the juvenile wood core, by controlling radial growth. Shuler *et al.* (1989) also note that microfibril angle in young-growth ponderosa pine did not vary significantly with either site index (from 55 to 100) or dbh (from 23 to 36 cm). It has generally been found that the largest variation in microfibril angle in softwoods occurs in the buttlog (Jozsa and Middleton 1994; Schuler, et al. 1989, Voorhies and Groman 1982).

Longitudinal shrinkage and microfibril angle are correlated, and can be used as indicators for demarcation of the juvenile wood-mature wood transition (Clark *et al.* 2006, Harris and Meylan 1965, Yin *et al.* 1994). The objective of this study was to measure longitudinal shrinkage and microfibril angle to estimate the juvenile wood-mature wood transition in lodgepole pine across a wide range of geographic locations in the western U.S. This was intended to provide a better understanding of the fundamental properties that influence utilization options for small-diameter trees harvested from western forests to improve forest health and reduce fire hazards.

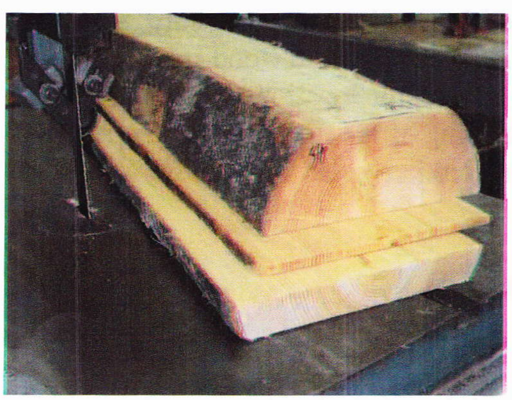
Materials and Methods

Sampling was limited to lodgepole pine trees 13 to 33 cm in diameter growing in Idaho and Montana. We sampled and assessed lodgepole pine trees from 1) a relatively dry site with an intermediate growing season (Helena National Forest in Montana), 2) a relatively wet site with a short growing season (Panhandle National Forests in Idaho), and 3) a mid-range precipitation site with an intermediate growing season site (Payette National Forest in Idaho), and 4) a site with mid-range precipitation and a long growing season (Kootenai National Forest in Montana) (Figure 3).

Figure 3. Four sites selected for sampling included 1) dry site, intermediate growing season, 2) wet site, short growing season, 3) mid-range precipitation, intermediate growing season, and 4) mid-range precipitation, long growing season.

Five to six trees were selected from each site. Information on site quality, trees age, and stocking density was recorded for each sampling location. The trees were selected based on straightness of bole and absence of defect. A 1.5 m bolt was cut from the butt-log of each tree and processed to extract a single, radial-sawn board from each bolt.

From each board, longitudinally-oriented samples were taken at the 3rd, 6th, 9th, 12th, 15th, 20th, 40th, and 60th annual growth rings from both sides of the pith, each measuring approximately 5 x 5 mm in cross section, with lengths ranging from 125 to 350 mm (Figure 4). Longitudinal shrinkage was measured in each sample as it dried from green to oven dry conditions. The average microfibril angle was then determined for the same samples using x-ray diffraction techniques (Verrill *et al.* 2001).



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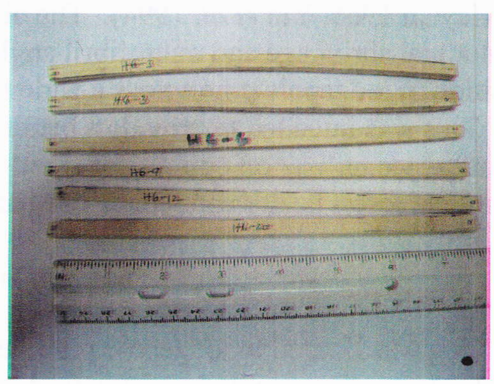

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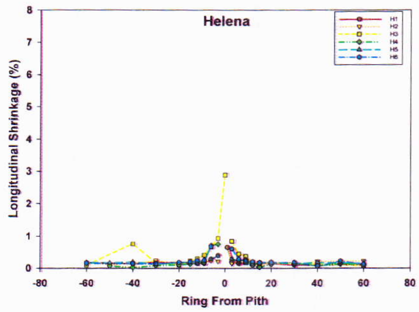
Figure 4. Sample preparation consisted of a) sawing a single, radially-oriented board from each bolt, then b) extracting samples to measure green to oven-dry shrinkage.

Results

The longitudinal shrinkage information clearly showed a distinction between the four geographic locations sampled (Figure 5). Both the duration and magnitude of longitudinal shrinkage varied by location, with the greatest shrinkage occurring in the samples collected from the Panhandle National Forests of Idaho. The least shrinkage occurred in the samples collected from the Helena and Kootenai National Forests in Montana, and these samples also exhibited the least overall longitudinal shrinkage.



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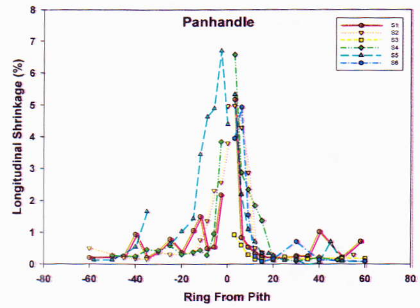

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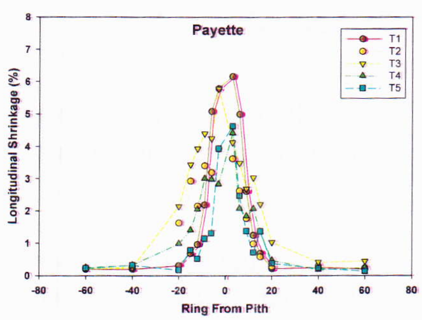

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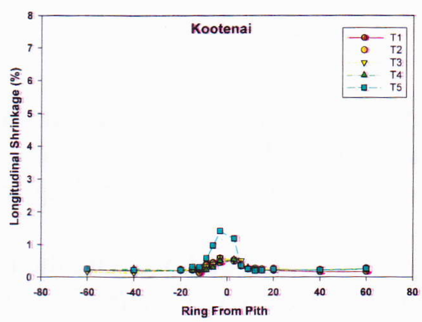

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Figure 5—Longitudinal shrinkage values at various ring positions for the trees sampled from the a) Helena National Forest, b) Panhandle National Forests, c) Payette National Forest, and d) Kootenai National Forest sampling locations.

The microfibril angle measurements also showed a distinction between the four geographic locations sampled (Figure 6). Again, the duration and magnitude varied by location, with the greatest duration occurring in the samples collected from the Panhandle and Payette National Forests of Idaho. The least duration occurred in the samples collected from the Helena and Kootenai National Forests in Montana, suggesting that the juvenile wood period was shorter for these two locations than the two locations in Idaho.

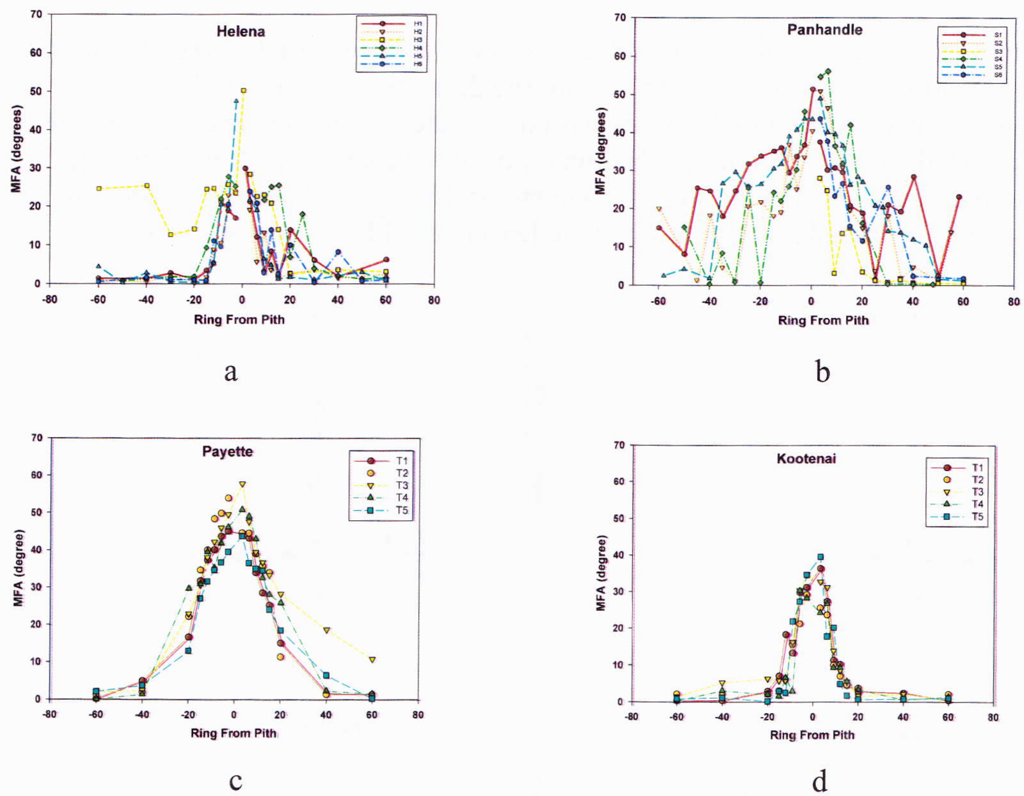

Figure 6—Microfibril angle values at various ring positions for the trees sampled from the a) Helena National Forest, b) Panhandle National Forests, c) Payette National Forest, and d) Kootenai National Forest sampling locations.

A good correlation was found between the lower values of longitudinal shrinkage and microfibril angle, as shown in Figure 7. The values for longitudinal shrinkage varied considerably for each site, especially when the microfibril angle increased beyond 20 degrees. Overall, it appears that either longitudinal shrinkage or microfibril angle could be used to estimate the juvenile wood period for trees located at each of the sites.

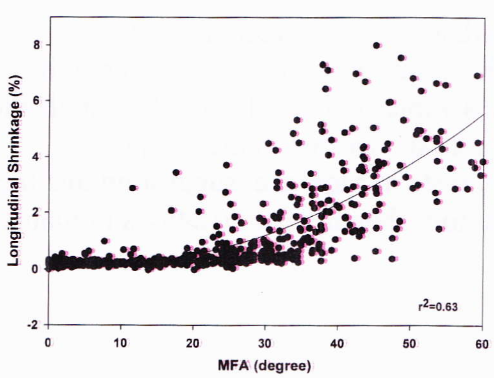

Figure 7. Quadratic regression fit between longitudinal shrinkage and microfibril angle for all measurements.

A segmented regression analysis was applied to each MFA and LS data set to obtain an indication of when the trees transitioned to mature wood. An example of such a regression fit is given in Figure 7. The results are given in Table 1.

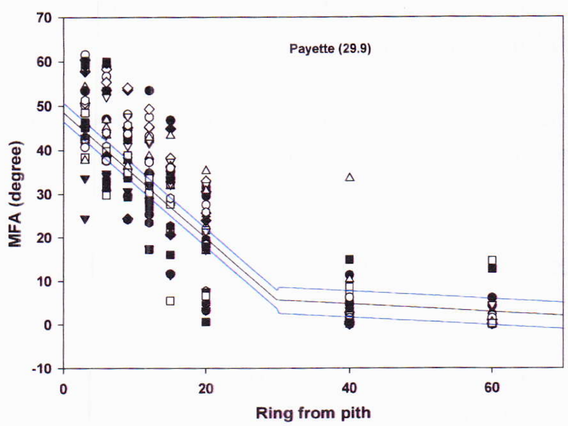

Figure 8. Segmented regression example.

Table 1: Summary of segmented regression prediction of juvenile wood transition

National Forest	Longitudinal shrinkage	Microfibril angle
Helena	8.7	14.0
Panhandle	13.9	30.1
Payette	20.8	29.9
Kootenai	10.0	13.3

Conclusions

A good correlation was found between longitudinal shrinkage and microfibril angle, confirming that either method could be used to determine the juvenile wood transition in lodgepole pine. In addition, significant differences in the juvenile wood transition period were found between the four sites. These results are useful for establishing parameters meaningful to the characterization of juvenile wood in the western conifers when utilized as solid-sawn products and structural composites.

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