Proceedings of the 62nd International Convention of
Society of Wood Science and Technology
October 20-25, 2019 – Tenaya Lodge, Yosemite, California USA

Comparison of juvenile wood depictions to wood property maps from mature longleaf pine

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Abstract

Early illustrations of juvenile wood in hard pines have depicted a central core of wood, varying little by diameter or cambial age, to be nested within mature wood tapering to the upper portion of the stem; other depictions show greater complexity in attributing the variability of this central core of wood with its proximity to the crown and/or actual maturity of the tree when the wood was formed. The present discussion addresses the degree to which different representations of juvenile wood (corewood) are applicable to mature longleaf pine (*Pinus palustris* Mill.) trees. Wood property maps were derived from X-ray densitometry data gathered from different tree heights. Results suggest that the more complex illustrations of juvenile wood appear to align with the study trees, attributable in part to their maturity, and near maximum attainable height.

Key words: Corewood, juvenile wood, mature wood, southern pine, wood properties

Introduction

Juvenile wood (corewood) has been widely studied given its high contribution to the wood resource, especially for usable timber obtained at short rotation ages. Reviews of juvenile wood in the literature provide insight into its physiological origin, anatomical features, properties (e.g., chemical, physical) and utilization (Zobel and van Buijtenen 1989; Zobel and Sprague 1998; Larson et al 2001; Lachenbruch et al 2011; Moore and Cown 2017). Juvenile wood is

commonly shown as a central core of wood within mature wood tapering to the upper portion of the stem (Fig. 1a). Taking into account that wood juvenility may be attributed to the proximity to the tree crown when formed, Lachenbruch et al (2011) provides a novel illustration (Fig. 2b) showing nested growth rings shown as being juvenile near the crown, but maturing as they progress down the bole of the tree to its base. An illustration put forth by Kibblewhite (1999) shows even greater complexity in attributing the variability of this zone of wood with its proximity to the crown and/or actual maturity of the tree when the wood was formed; thus, juvenile wood terminology being reserved for that wood formed when the tree itself was of a juvenile age (Fig. 1c).

Wood property data gathered at different heights and radial positions have been used to generate tree maps that generally show a central core of wood that is lower in specific gravity (SG) from the base of the tree to the top. The reader is referred to maps reported in the literature (Auty et al 2014; Dahlen et al 2018; Longuetaud et al 2016; Schimleck et al 2018). A few tree maps depict variability in the central core with respect to tree height for individual trees (Trendelenburg 1935; Downes et al 2009); trees used for these two studies were well over 100 years in age. The objective of this report is expand upon the discussion of wood properties from a sampling of mature longleaf pine (*Pinus palustris* Mill.) trees in the context of the aforementioned illustrations of juvenile and mature wood zones.

Materials and Methods

Ten 70-year-old longleaf pine trees covering a range of diameters at breast height (14.5 to 49.8 cm) and total heights (17.6 to 27.5 m) were sampled in the Palustris Experimental Forest, Alexandria, LA, USA. Tree-specific data and the experimental procedures can be found in Eberhardt et al. (2018, 2019). Briefly, all study trees were marked to retain the northern and southern cardinal directions on 5-cm-thick disks cut at stump height (15 cm), followed by 77 cm above ground level, then every 61 cm along the tree bole. Densitometry afforded bark to pith data that were processed to provide wood property data (e.g., ring SG) and width for each growth ring. To create the wood property maps, the actual position for each data point was converted to a relative position in each tree. These positions were rounded to the nearest 0.05 increment and a mean parameter value was then calculated for each point across all of the sample trees. Further details and references for the generation of the maps can be found in Eberhardt et al. (2019).

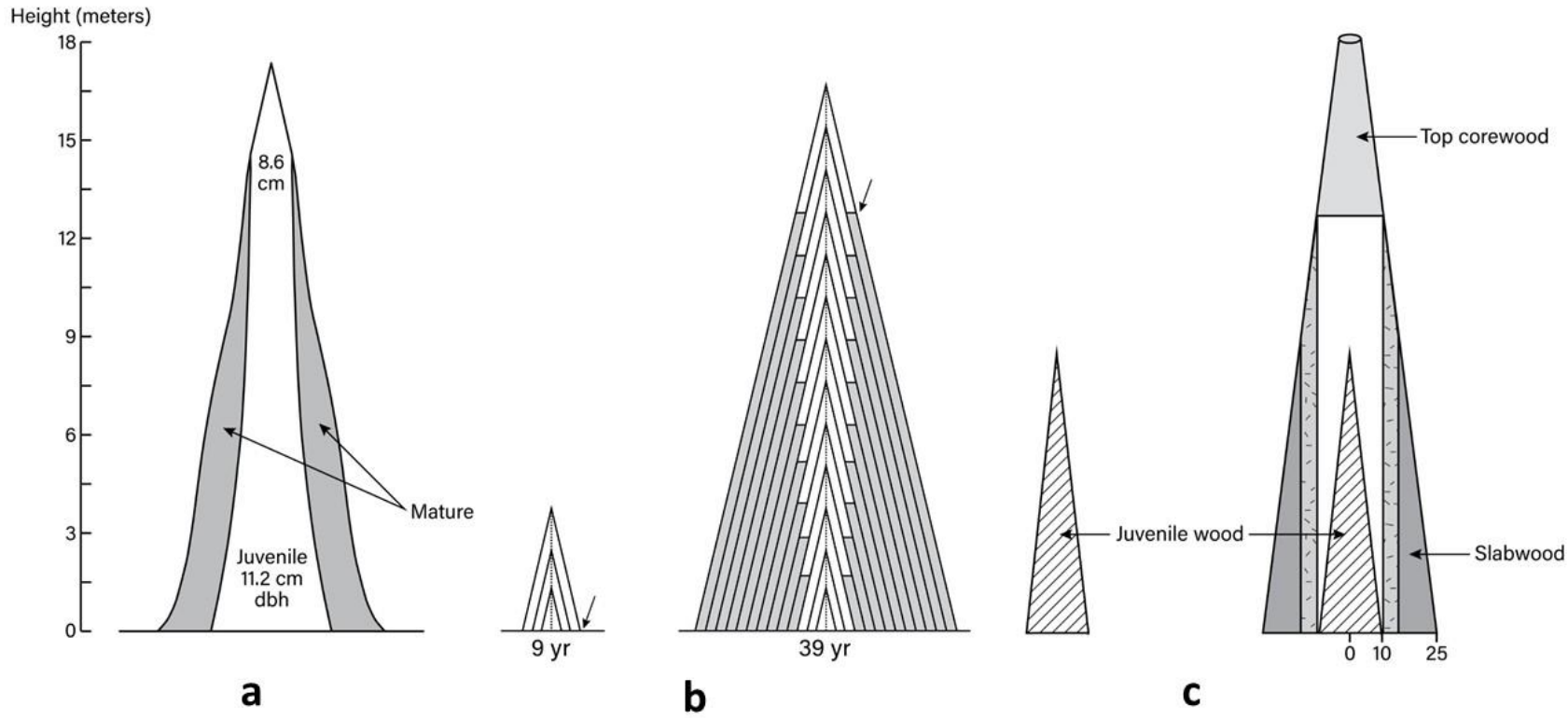

Figure 1: Illustrations of juvenile wood adapted/redrawn from the literature: a, Zobel and Blair (1976); b, Lachenbruch et al. (2011); c, Kibblewhite (1999).

Results and Discussion

Similar to other maps of the southern pines, either based on single trees, averaged data among many trees, or models representative of even larger groups of trees, the map in Figure 2a shows a central core of lower density wood (SG < 0.475) running the length of the tree bole. This essentially continuous zone of lower SG wood, that may be attributed to juvenile wood (corewood), supports the illustrations by Zobel and Blair (1976) and Lachenbruch et al. (2011) shown in Figures 1a and 1b, respectively. Also similar to these illustrations, the mature wood tapers to the upper regions of the stem; however, in the tree map the zone of lower SG wood does not extend from the pith to the bark at the top of the tree. In other words, similar to the lower relative heights, ring SG increases moving from pith to bark over the tree map profile.

Also, it is readily apparent in the tree map that there is zone of lower SG wood that is wider at mid-height than at the lower and higher relative heights. This observation is not restricted to mature longleaf pine, with a zones of low SG wood near the mid-height being wider for loblolly pine at relatively young ages of 13 and 22 years (Schimleck et al 2018). Such observations do not invalidate the juvenile wood illustrations but instead demonstrate that more complex density profiles for specific groupings of trees may be present and measurable.

Typical of other tree maps reported in the literature, there is higher ring SG wood towards the base of the tree; however, in said tree SG maps, this does not extend all the way to the wood closest to the bark. In the tree map shown here (Fig. 2a) this pattern is more consistent with density traces taken at breast height where ring SG increases through juvenile wood formation, plateaus in the mature wood zone, and declines in the wood close to the bark (Eberhardt and Samuelson 2015; Jordan et al 2008; Spurr and Hsiung 1954). Also of interest is the fairly symmetrical regions of high ring SG above the relative height of 0.7. This observation is consistent with Kibblewhite's (1999) illustration (Fig. 1c) showing the wood in the crown (so called "top corewood") to be different than the juvenile wood zone at the base of the tree, and have properties similar to mature wood.

For the study trees, the average top disk diameter was 2.8 cm and the average number of rings included was 7. Indeed, ring widths within the juvenile core (ca. ≤ 7 annual rings) are quite narrow well into the top of the tree crown. Thus, the tree map for ring width shows narrow rings at the top of the tree and extending down the bole to the base, in the outermost zone of wood near the bark. Superficially this may seem to be contradictory to what we know about southern pine wood quality, with narrow rings and higher ring SG as a feature normally associated of higher wood quality in the mature wood zone; however, since the study trees are mature and near their maximum attainable height, it can be easily rationalized that ring widths would be narrow at the top, and extending down the mature wood to the base. A parallel can be drawn to the illustration by Lachenbruch et al. (2011), with the outermost growth ring extending from the top of the tree to the base, irrespective any maturation that may occur with increasing distance from the crown. Altogether, the tree maps generated here for a group of

mature longleaf pines appear to support tree profile put forth by Kibblewhite (1999). Finally, the more recent conceptualization of juvenile wood has been described by Burdon et al (2004) is not provided

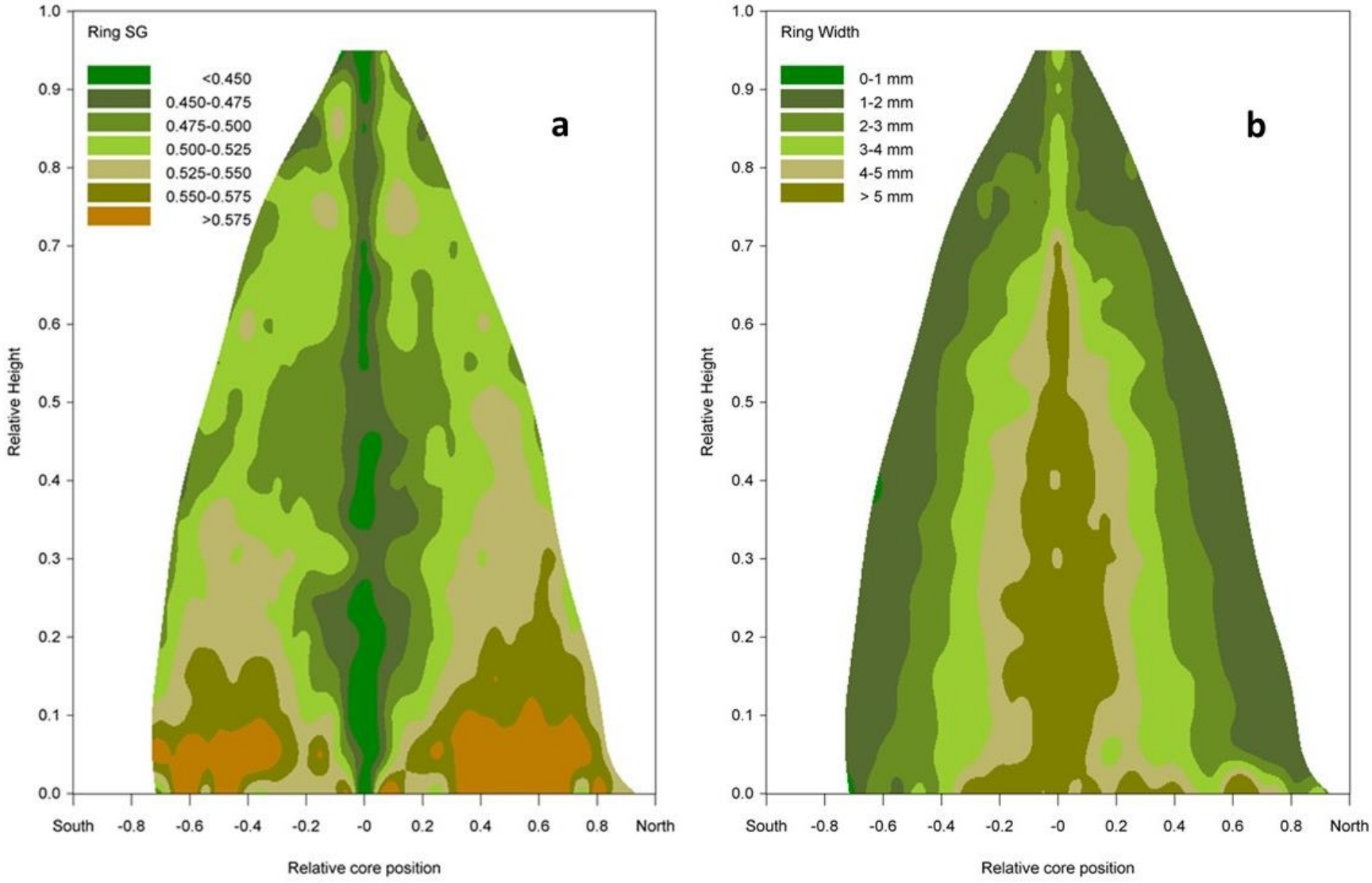

Figure 2: Wood property maps for mature longleaf pine: a, ring specific gravity (SG); b, ring width.

here, but parallels that by Kibblewhite (1999) having the central core of wood (≤ 10 growth rings) maturing from the base of the tree to the top.

Summary and Conclusions

Results suggest that the more complex illustrations of juvenile wood appear to align with the study trees, attributable in part to their maturity, and near maximum attainable height.

Acknowledgements

Karen K. Nelson at the UDSA Forest Service, Forest Products Laboratory, skillfully prepared the illustrations of juvenile wood redrawn/adapted from those in the literature.

References

Auty D, Achim A, Macdonald E, Cameron AD, Gardiner BA (2014) Models for predicting wood density variation in Scots pine. Forestry 87:449-458.

Burdon RD, Kibblewhite RP, Walker JCF, Megraw RA, Evans R, Cown DR (2004) Juvenile versus mature wood: A new concept, orthogonal to corewood versus outerwood, with special reference to *Pinus radiata* and *Pinus taeda*. Forest Sci 50(4):399-415.

Dahlen J, Montes C, Eberhardt TL, Auty D. 2018. Probability models that relate nondestructive test methods to lumber design values of plantation loblolly pine. Forestry 91:295-306.

Downes GM, Drew D, Battaglia M, Schulze D (2009) Measuring and modelling stem growth and wood formation: An overview. Dendrochronologia 27:147-157.

Eberhardt TL, Samuelson LJ (2015) Collection of wood quality data by X-ray densitometry: A case study with three southern pines. Wood Sci Technol 49:739-753.

Eberhardt TL, So C-L, Leduc DJ (2018) Wood variability in mature longleaf pine: Differences related to cardinal direction for a softwood in a humid subtropical climate. Wood Fib Sci 50(3):323-336.

Eberhardt TL, So C-L, Leduc DJ (2019) Wood property maps showing wood variability in mature longleaf pine: does getting old change juvenile tendencies. Wood Fib Sci 51(2):193-208.

Jordan L, Clark A III, Schimleck LR, Hall DB, Daniels RF (2008) Regional variation in wood specific gravity of planted loblolly pine in the United States. Can J For Res 38:698-710.

Kibblewhite RP (1999) Designer fibres for improved papers through exploiting genetic variation in wood microstructure. Appita J 52(6):429-435.

Lachenbruch B, Moore JR, Evans R (2011) Radial variation in wood structure and function in woody plants, and hypotheses for its occurrence. In: Size- and Age-Related Changes in Tree Structure and Function. FC Meinzer, B Lachenbruch, TE Dawson, Eds. Springer: Berlin, Germany. pp. 121-164.

Larson PR, Kretschmann DE, Clark A III, Isebrands JG (2001) Formation and properties of juvenile wood in the southern pines: A synopsis. USDA Forest Service, For. Prod. Lab. Gen. Tech. Rep. FPL-GTR-129, 42 pp.

Longuetaud F, Mothe F, Fournier M, Dlouha J, Santenoise P, Deleuze C (2016) Within-stem maps of wood density and water content for characterization of species: a case study on three hardwood and two softwood species. Ann For Sci 73:601-614.

Moore JR, Cown DJ (2017) Corewood (juvenile wood) and its impacts on wood utilization. Curr Forestry Rep 3:107-118.

Schimleck L, Antony F, Mora C, Dahlen J (2018) Comparison of whole-tree wood property maps for 13- and 22-year-old loblolly pine. Forests 9:287

Spurr SH, Hsiung W-Y (1954) Growth rate and specific gravity in conifers. J For 52(3):191-200.

Trendelenburg R (1935) Schwankungen des Raumgewichts wichtiger Nadelhölzer nach Wuchsgebiet, Standort und Einzelstamm. Zeitschrift des Vereines deutscher Ingenieure 79(4):85-89 [in German].

Zobel B, Blair R (1976) Wood and pulp properties of wood and topwood of the southern pines. Appl Polym Symp 28:421-433.

Zobel BJ, Sprague JR (1998) Juvenile Wood in Forest Trees. Springer-Verlag, Berlin. 300 pp.

Zobel BJ, van Buijtenen JP (1989) Wood Variation: Its Causes and Control. Springer-Verlag, Berlin. 363 pp.

Proceedings of the 2019 Society of Wood Science and Technology International Convention

Convention Theme: Renewable Materials and the Wood-based Bioeconomy

Edited by Susan LeVan-Green

Overall General Chair*: *Eve Haviarova, Purdue University, USA

October 20-25, 2019
Tenaya Lodge
Yosemite National Park, California, USA