EFFECT OF SILVICULTURE ON THE YIELD AND QUALITY OF VENEERS

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Abstract—The structural and aesthetic value of wood is typically sacrificed in an attempt to meet demand. This paper addresses the financial and quality aspects of silvicultural choices as it relates to wood veneers. Five trees each were harvested from an uneven-aged stand and from the following even- aged stands: intensive plantation, conventional plantation, and natural regeneration. The 48-year old loblolly pine trees were peeled at a veneer mill and graded visually (plywood grades) and ultrasonically (LVL grades). The intensive plantation trees, pruned at an early age to produce a large, clear bole, possessed the lowest quality veneer, both in terms of visual and ultrasonic grade. Although these trees did produce large quantities of clear wood, the early, rapid growth rates resulted in a exaggerated conical shape and thus a large slope of grain. The most desirable veneers came from those trees with a modest growth rate during the juvenility period—from the natural regeneration and uneven aged stands.

INTRODUCTION

The primary objective of most current timber management strategies is optimization of wood fiber volume, generally at the expense of wood quality. A shift in public values coupled with harvesting restrictions and the unavailability of old-growth timber has resulted in a higher percentage of the wood basket being supplied by plantation and intensively managed timber stands. The trees which come from these plantation forests are harvested at a young age when compared to virgin and old growth trees, and will thus contain a higher percentage of juvenile wood and invariably lessened physical and mechanical lumber properties.

The effect of silvicultural treatments on the physical properties of wood has been extensively studied. Thinning and fertilization have been shown to significantly alter overall wood specific gravity (Choong and others, 1989; Lear and others, 1977; Cown and McConchie, 1981), earlywood/latewood specific gravity distribution (Choong and others, 1989; Crist and others, 1977), knot size, location, and quantity (Whiteside and others, 1977; Guldin and Fitzpatrick, 1991), tree form (Guldin and Fitzpatrick, 1991), fiber length (Cown and McConchie, 1981; Crist and others, 1977), and juvenile wood formation (Zobel and VanBuijtenen, 1989; Ruark and others, 1991). Although numerous studies have inferred relationships between physical and mechanical wood properties, in actuality the correlations between physical and mechanical properties are low. The best correlation exists between specific gravity and stiffness, with correlation coefficients generally around 0.5 (Schroeder and Atherton, 1973; Senft and others, 1962). Similar correlation coefficients exist between specific gravity and strength (Doyle and Markwardt, 1966; Senft and others, 1962). Thus, although the effect of silvicultural practices on physical properties is somewhat understood, the stiffness and strength of the resulting wood cannot be determined from these physical properties.

The response of mechanical properties to silvicultural treatments is less understood. Bendtsen and Senft (1986) looked at mechanical and anatomical properties in individual growth rings of plantation-grown eastern cottonwood and loblolly pine and found that a large percentage of juvenile wood exists along with a marked decrease in stiffness and strength for the first 10-15 growth rings. Senft and others (1986) found similar findings for a natural stand of 60-year-old Douglas-fir trees. Similar studies have also been conducted (Moody, 1970; Pearson and Gilmore, 1971; Yamamoto and others, 1976), but their conclusions were limited to one type of silvicultural treatment.

This primary objective of this paper is to establish relationships between silvicultural regimes and the one area lacking in the literature: veneer quality. This paper will define some of the relationships between silviculture and veneer quality and value.

METHODS

Five loblolly pine (*Pinus taeda L.*) trees were selected and felled from forest stands subject to different reproduction cutting methods at the Crossett Experimental Forest, Crossett, Arkansas. The reproduction cutting methods investigated in this study are: (a) intensive plantation (the Sudden Sawlog study), (b) conventional plantation (Methods of Cutting study), (c) even-aged natural regeneration (Methods of Cutting Study), and (d) uneven-aged (Good

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Table 1—Average harvested tree statistics from each silvicultural regime

	Intensive plantation	Conventional plantation	Natural regeneration	Uneven-age 50-year trees
No. of Observations	5	5	5	5
Height (ft.)	94.2	93.8	98.6	88.6
Ht. base live crown	41.2	57.0	60.2	40.2
Age (years)	48	48	48	47
Average dbh (in.)	21.1	15.3	16.4	16.4
BAF10 (sq. ft.)	90	118	76	72

Farm Forestry Forty). A thorough description of each stand can be found in Baker and Bishop (1986). In the Sudden Sawlog study, at age 48 the stand had a basal area of 101 sq. ft, and an average dbh of 21.5 inches. The stand was thinned at age 9 to 100 trees per acre (tpa), and at ages 19, 24, and 27 to a final stand density of 41 tpa. The stand was mowed biennially and trees were pruned to 34 feet. The conventional plantation stand was 48 years old, had a basal area of 143 sq. ft. and an average dbh of 15.1 inches. The stand was thinned every 3 years from ages 12 to 30 to a final stand density of 116 tpa. There was no pruning or understory control. The natural regeneration stand at harvest was 48 years old, had a basal area of 90 sq. ft, and an average dbh of 16.3 inches. The stand was originally clearcut and allowed to regenerate naturally. The stand was thinned to a basal area of 80 sq. ft. in at ages 37, 42, and 47. The trees were not pruned, with understory control via prescribed burning at ages 37, 42, and 47. The uneven-aged stand varied from seedlings to approximately 100 years of age. The basal area at time of specimen selection was 65 sq. ft. The stand was thinned to a basal area of 60 sq. ft. at ages 37, 42, and 47. Trees harvested from this stand are traditionally dominant and co-dominant. The trees selected for this study were approximately 48 years of age, regardless of dominance status.

Trees with crooked boles were eliminated from the selection process, thus minimizing the presence of reaction wood. Immediately upon felling, the bole was bucked into 10-foot lengths starting from the stump and proceeding to a 4-inch diameter top. The logs were transported to a local veneer mill, peeled, dried, and then passed through a Metrigard stress-wave timer for determination of transit time. The stacks of veneer were transported to the Southern Research Station, Pineville, LA for visual grading by an American Plywood Association certified grader.

RESULTS AND DISCUSSION

A summary of the harvested tree statistics is shown in table 1. The height of the even-aged trees were all approximately 95 feet whereas the competition of dominant trees in the even-aged stand limited the height of the even-aged trees to 88 feet. The most dramatic differences in the stands were dbh and height to live crown. The greater spacing and understory control allocated the intensive plantation trees resulted in much larger dbh growth. These factors, along with pruning to a minimum 34 feet height, also resulted in the lowest height to live crown. Thus, although the volume of wood per tree from the intensive plantation stands was greater than the other stands, only the lower 40 percent of the bole contained potential knot-free wood. The other even-aged stands had live crowns approximately 60 percent of the total tree height.

The quantity of veneers that resulted from the 5 trees from each stand is shown in figure 1. The average number of veneers that came from each tree in the intensive plantation, conventional plantation, natural regeneration, and uneven-age stands was 126, 65, 81, and 62, respectively.

The visual quality of the veneers and thus their usefulness in the manufacture of structural plywood is summarized in table 2. The trees from the plantation stands produced veneer that was inferior in visual grade to the corresponding trees in the natural regeneration and uneven-aged stands. Approximately 60 percent of the veneers from the intensive plantation stand were graded as D or X. This is due to the resulting knots from the extremely large limbs in this stand. The conventional plantation stand had much fewer D or X grade veneers, but 66 percent of all veneers from this stand were C grade. The natural regeneration and uneven-aged stand produced the best visual grade veneers, with approximately 32 percent of all veneers falling into the A or B grade. This is due primarily to the clear boles in conjunction with very little taper.

Table 2—Percent yield for all veneers from each of the silvicultural regimes based on visual grade

	(Percent yield per grade)					
Management type	A	B	Cp	C	D	X
Plantation: Intensive	3.0	15.5	9.0	12.4	***50.7***	***9.4***
Plantation: Conventional	2.5	9.6	10.2	***65.7***	11.4	0.6
Even Age: Natural regeneration	***16.1***	***13.9***	7.7	35.1	27.0	0.2
Uneven Age: 50-year old trees	***14.3***	***18.6***	7.8	47.9	11.4	0.0

The percent yields of veneers from various stands as graded by transit time via a stress wave timer are summarized in table 3. These values are indicative of veneer stiffness and are essential in the layup of structural products such as laminated veneer lumber and to a lesser degree oriented strand board. A trend similar to the visual grades is observed: the intensive plantation possessing the highest percentage of low stiffness veneers, conventional plantation containing mostly middle grades, and the natural regeneration and uneven-aged stands producing the highest percentage of high stiffness veneers.

The quality of the veneers for each stand varies greatly from the pith to the bark and with vertical location within a tree. A summary of veneer visual grade and veneer stiffness as a function of location within a tree are, respectively, summarized in figures 2 and 3. Although trees from the intensive plantation stand did produce some high quality veneers, these high value veneers were limited to a small region below the live crown and some distance from the juvenile core. The juvenile core and almost all of the veneers at or above the live crown in the intensive plantation stand were of poor visual and structural quality.

From a forest management economics perspective, the quantity and quality of veneer production must translate to per-acre values. The number of trees per acre, their size, and the timing of the stand cost and revenue stream establish the financial return to investment. Dollar values for dry veneer by grade were solicited from buyer sources and reporting services. These values were reduced by harvesting, transportation, and manufacturing costs to establish the value for the expected veneer production from standing stumpage. Stand inventory records were used to reconstruct the diameter distributions and trees per acre for each silvicultural treatment. Tree values were based on their expected veneer yields and financial statistics were calculated. Forest management costs were established using published sources and personal communication (Clason 2000, Dubois and others 1999, Watson and others 1987, Yoho and others 1971).

Table 3—Percent yield for all veneers from each of the silvicultural regimes based on ultrasound propagation times.

	Percent yield per Metrigard (t) range				
Management type	<400	400-469	470-539	540-609	>610
Plantation: Intensive	0.0	11.9	43.3	***36.0***	***8.8***
Plantation: Conventional	0.0	32.4	***49.8***	15.0	2.8
Even Age: Natural regeneration	0.0	***41.3***	35.1	21.5	2.0
Uneven Age: 50 year-old trees	***0.7***	***41.7***	41.4	15.3	1.0

Figure 1—Veneers peeled from 5 trees each of the following silvicultural regimes: (1) intensive plantation, (2) conventional plantation, (3) natural regeneration, and (4) uneven age.

The lowest cost silvicultural system (in dollars expended) was the natural regeneration at $268.97 per acre. The highest cost was the sudden sawlog system at $705.47. The cost for the conventional plantation was $288.23 and for the uneven-aged stand was $358.22. In the case of the uneven-aged stand, the initial value of the stand which produced the revenue stream was also counted as a cost (capital investment).

In terms of internal rate of return (IRR), three of the four systems were similar in financial returns to the capital invested over the 50-year period. The two plantations averaged 9.6 percent and the naturally regenerated stand averaged 10.1 percent IRR. These were in contrast to the uneven-aged system which returned an average of 5.8 percent. The large tree diameters boosted the total veneer yield for the sudden sawlogs, though it was mostly D-grade. The veneer yield from the other three stands was comparable, but the clearcut/natural regeneration stand had the advantage of low cost regeneration, and the uneven aged stand had the disadvantage of high capital investment in the form of initial growing stock.

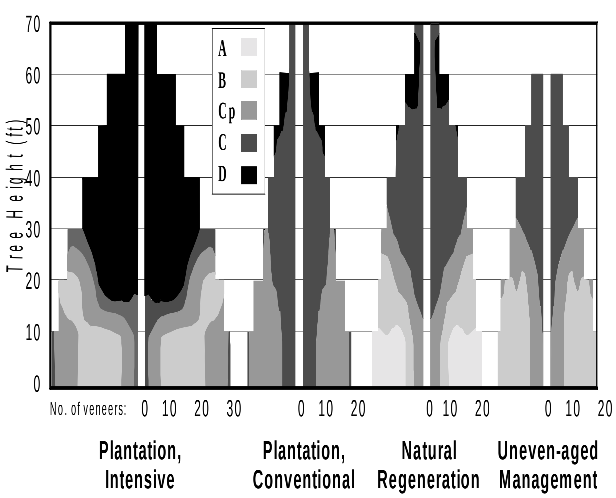

Figure 2—2-dimensional maps of veneer visual grade by location within a tree. Maps are based on the averages of 5 trees per silvicultural regime.

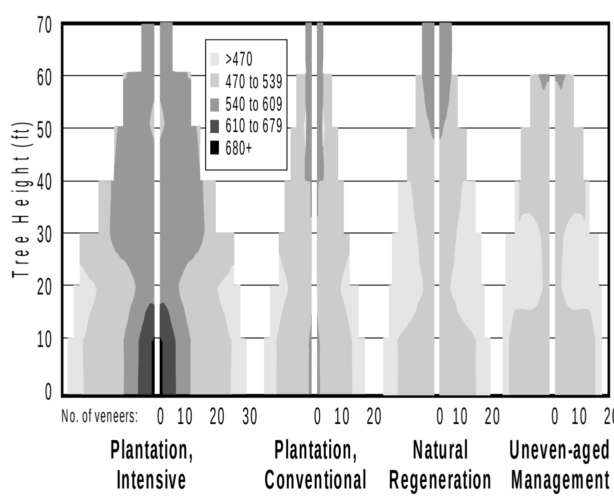

Figure 3—2-dimensional maps of ultrasound transit time, shown in microseconds, for veneers by location within a tree. Due to the inverse relationship, lower transit times correspond to stiffer veneers. All maps are based on the averages of 5 trees per silvicultural regime.

Even-aged systems reflected the natural presence of loblolly pine in the early successional stages of the southern forest and seemed to be the most efficient silvicultural system for management based on financial returns. How those forests are regenerated and managed reflect the objectives of the landowner in regard to the outputs desired. There are legitimate reasons for choosing an uneven-aged system (Baker and others 1996), however, the higher proportion of good veneer grades is offset by the investment carried in growing stock unless careful attention is given to those growing stock levels. As structural grades of plywood continue to be replaced by oriented strand board (OSB), the economics associated with veneer production will change to favor higher grades and lower the relative value of the lower grades, thus affecting the returns of the silvicultural systems accordingly.

CONCLUSIONS

The quantity and quality of veneers was shown to be a function of silvicultural regime as well as location within a tree. Intensively-managed plantation stands produced the greatest number from each tree, averaging 126 veneers per tree. Although the trees were pruned to ensure a clear bole to 34 feet, the resulting veneers were of very poor quality, due to both excessive taper and a low live crown with large limbs. The trees from the conventional plantation stand only averaged 65 veneers per tree. The veneers were of better quality than the intensively-managed plantation stand, but still of mediocre quality. Trees peeled from natural regeneration and uneven-aged stands were of the best quality, averaging 81 and 62 veneers per tree, respectively. The veneers from these 2 stands produced the highest proportion of visual grades as well as the greatest proportion of high stiffness veneers.

The economics of forest stand management, in addition to individual tree values, also incorporate tree populations on a per-acre basis. Outcomes on which management decisions will be based are affected by investments and harvest schedules, as well as market values of the veneer grades produced.

LITERATURE CITED

Baker, J.B. and L.M. Bishop. 1986. Crossett Demonstration Forest Guide. USDA Forest Service General Report R8-GR 6. 55 p.

Baker, J.B.; M.D. Cain, J.M. Guldin, P.A. Murphy, and M.G. Shelton. 1996. Uneven-aged silviculture for the loblolly and shortleaf pine forest cover types. Gen. Tech. Rep. SO-118. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 65 p.

Bendtsen, B.A.; J. Senft. 1986. Mechanical and anatomical properties in individual growth rings of plantation-grown Eastern cottonwood and loblolly pine. Wood and Fiber Science 18(1): 23-28.

Choong, E.T., P.J. Fogg, and E. Shoulders. 1989. Effect of cultural treatment and wood-type on some physical properties of longleaf and slash pine wood. Wood and Fiber Science 21(2): 193-206.

Clason, Terry R. 2000. Forester, LSU AgCenter, Hill Farm Research Station, Homer, LA. Personal communication.

Cown, D.J.; D.L. McConchie. 1981. Effects of thinning and fertiliser application on wood properties of Pinus radiata. New Zealand Journal of Forestry Science 11(2): 79-91.

Crist, J.B., D.H. Dawson; J.A. Nelson. 1977. Wood and bark quality of juvenile jack pine and eastern larch grown under intensive culture. Tappi conference papers: Forest Biology-Wood Chemistry Conference, Madison, WI. 211-216.

Doyle, D.V.; L.J. Markwardt. 1966. Properties of Southern pine in relation to strength grading of dimension lumber. USDA Forest Service Research Paper FPL 64. Forest Products Laboratory, Madison, WI.

Dubois, M.R.; K. McNabb; T.J. Straka. 1999. Costs and cost trends for Forestry Practices in the South. Forest Farmer 32nd Manual Edition. 3-8.

Guldin, J.M.; M.W. Fitzpatrick. 1991. Comparison of log quality from even-aged and uneven-aged Loblolly Pine stands in South Arkansas. Southern Journal of Applied Forestry 15(1): 10-17.

Moody, R.C. 1970. Tensile strength of fingerjoints in pith-associated and nonpith-associated southern pine lumber. USDA Forest Service Research Paper FPL 138. Forest Products Laboratory, Madison, WI.

Pearson, R.G.; R.C. Gilmore. 1971. Characterization of the strength of juvenile wood of loblolly pine (Pinus taeda L.). Forest Products Journal 21(1): 23-30.

Ruark, G.A.; J.R. Saucier; R.G. Campbell. 1991. Managing dense, seed-origin Loblolly stands to utilize the favorable juvenile wood core for sawlog production: A case study. Southern Journal of Applied Forestry 15(1): 5-9.

Schroeder, G.A.; G.H. Atherton. 1973. Mechanical properties of utility grade redwood 2x4 studs. Project No. F914. Forest Research Laboratory, Oregon State University, Corvallis, OR. May 1973.

Senft, J.F.; M.J. Quanci; B.A. Bendtsen. 1986. Property profile of 60-year-old Douglas-fir. In Proceedings, A Technical Workshop: juvenile wood - what does it mean to forest management and forest products. Forest Products Research Society. 17-28.

Senft, J.F.; S.K. Suddarth; H.D. Angleton. 1962. A new approach to stress grading of lumber. Forest Products Journal 12(4): 183-186.

Van Lear D.H.; J.R. Saucier; J.G. Williams. 1977. Growth and wood properties of longleaf pine following silvicultural treatments. Soil Science Society of America Journal 41(5): 989-992.

Watson, W.F.; T.J. Straka; S.H. Bullard. 1987. Costs and Cost Trends for Forestry Practices in the South. Forest Farmer 26th Manual Edition, 28-34.

Whiteside, I.D.; M.D. Wilcox; J.R. Tustin. 1977. New Zealand Douglas-fir timber quality in relation to silviculture. New Zealand Journal of Forestry 22(1): 24-44.

Yamamoto, H.; M. Takahashi; N. Kawaguchi. 1976. The strength properties of plantation-grown todomatsu. Journal of the Hokkaido Forest Products Research Institute 4(291): 1-5.

Yoho, J.G., G.F. Dutrow and J.E. Moak. 1971. What it Costs to Practice Forestry—Costs and Cost Trends in the South. Forest Farmer, March issue, 42-50.

Zobel, B.J. and J.P. Van Buijtenen. 1989. Wood Variation - Its Causes and Control. Springer Series in Wood Science (Editor T.E. Timell). 415 p.