EFFECT OF CURVE SAWING ON LUMBER RECOVERY AND WARP OF SHORT CHERRY LOGS CONTAINING SWEEP

Brian H. Bond and Philip Araman[1]

Abstract.—It has been estimated that approximately one-third of hardwood sawlogs have a significant amount of sweep and that 7 to nearly 40 percent of the yield is lost from logs that have greater than 1 inch of sweep. While decreased yield is important, for hardwood logs the loss of lumber value is likely more significant. A method that produced lumber while accounting for log curvature (sweep) would allow greater volumes and higher value material that would also contain less warp when dried. While this technology is being utilized for softwood processing, it has not been accepted by the hardwood industry.

A lumber recovery study conducted on mostly 8-foot-long grade 2 and 3 cherry logs at a mill utilizing a curve sawing gang, produced greater lumber volumes from cants that were curve sawn than from cants that were straight sawn. Increases in overrun ranged from 6 to 18 percent while lumber recovery improvements ranged from 0.5 to 1.3 for 8-foot logs containing 1-3 inches of sweep. Since the curve sawing gang used in the recovery study was limited in the maximum amount of sweep that could be handled during sawing (1¾-inches per 10 feet), simulation software was used to predict the potential increase in volume recovery of the logs sawn if the machine had been able to handle the maximum amount of sweep. Results indicated that lumber recovery increases proportionally with the amount of sweep in the log assuming that the machine could accommodate maximum sweep. Measurements of warp after drying indicated that the boards produced by curve sawing contained significantly more bow and crook than boards produced by straight sawing. While these differences are significant, the actual amount of bow (less than ½ of an inch) and crook (1/8th of an inch) would not likely significantly impact rough mill yield when processed. Twist was not significantly different between the two groups and did not exceed ¼ inch.

INTRODUCTION

Approximately one-third of hardwood saw logs have a significant amount of sweep, enough to incur sweep deductions of 5 percent or more (Hamner and others 2007). Common hardwood log grading scale deduction estimators predict that approximately 13 percent (range: 7 to almost 40 percent) of the yield from logs that have over 1 inch of sweep is lost (Hamner and others 2007). These yield losses are likely more significant for smaller-diameter logs. Although decreased yield is of importance, the loss of lumber value is probably more significant for hardwood logs. When curved logs are sawn using straight sawing methods, the highest valued material is removed from the outer portions of the log in order to straighten the log for further processing. In so doing, more of the highest quality wood is removed as slab wood destined for the chipper. The remaining lumber will likely be lower in value as it contains portions of the lower grade interior of the log as well as sections from the higher grade exterior.

In addition to volume and value losses, the lumber produced from logs sawn using traditional methods often contains greater amounts of warp when dried due to the severe grain angles produced. A method that produces lumber while accounting for log curvature and sweep would allow for increased volumes and

[1]Associate Professor (BHB), Department of Wood Science and Forest Products, Virginia Tech, 1650 Ramble Road, Blacksburg, VA 24061; and Research Team Leader (PA), USDA Forest Service, Southern Research Station, Blacksburg, VA 24060. BHB is corresponding author: to contact, call (540)231-8752 or email at bbond@vt.edu.

higher-valued material that would also contain less warp when dried. This technology is being utilized for softwoods, but the hardwood industry has yet to accept it. Research demonstrating the potential gains by utilizing curve sawing technology would allow for greater utilization of the hardwood resource, increase the value of the material produced, and afford hardwood lumber producers the opportunity to be more competitive.

Curve sawing technology utilizes gang-saw machinery to allow logs or two-sided cants with sweep to be cut parallel to the log surface or axis. There are two basic curve sawing techniques; one method manipulates a curved cant through stationary saws and the other method uses articulating saws that follow the contour of the log. It has been demonstrated that curve sawing technology increased lumber recovery in softwood logs containing sweep (Wang and others 1992). Since curve sawn boards are cut along the grain, the potential for producing higher quality lumber increases. Curve sawn lumber from softwood logs containing sweep are on average wider and longer than lumber sawn using straight sawing techniques (Petree 1998). Softwood lumber recovery in logs using curve sawing techniques was reported to yield increases up to 16 percent (Wang and others 1992). No published information exists about the potential yield increase in hardwood logs, or more importantly about the potential for a grade yield increase.

With the current increase in raw material costs and reduction of lumber prices, the profit margins of hardwood sawmills are decreasing. Any processing method that would allow for an increase in lumber volume concurrent with a value increase would provide an invaluable benefit to the hardwood lumber industry. Therefore, a study was conducted to determine the value and volume improvements that are possible in sawing hardwood logs using curve sawing techniques in comparison to traditional straight sawing methods.

OBJECTIVES

We undertook this study with the following objectives:
1) Compare the lumber grade and yield differences between curve sawing and traditional straight sawing for hardwood sawlogs containing sweep.
2) Compare the amounts of warp that occur after drying for lumber sawn from logs with sweep using curve sawing versus straight sawing techniques.

METHODS

One hundred sixty-two U.S. Forest Service grade 2 and 3 (U.S. Forest Service 1966) cherry logs with small-end diameters of 12-14 inches and lengths of 8-10 feet were selected and measured at a sawmill in Pennsylvania. The logs were measured for length, large-end diameter, and small-end diameter (to enable volume estimation, as well as for log scale deductions (including sweep). Length and diameter limitations were used to keep sample sizes to a minimum, yet provide reliable and repeatable results. The length restriction was a function of logs brought into the mill log yard, as very few logs over 10 feet contained measurable sweep. Logs were separated into two categories, those with 1-3 inches of sweep and those with 3 or more inches of sweep.

Lumber Recovery

Each group of logs was processed separately through the mill. Processing consisted of scanning each log for scaling information, debarking, and processing into a two-sided cant at the band saw headrig, which also had a circle saw chipping head. The logs were processed such that the cants were sawn with the faces

being perpendicular to the sweep. Cants were then processed by a curve sawing gang that had an arbor, which could move +/- 4 degrees, and could handle a maximum sweep of 1¾ inches in 10 feet. All lumber produced was 4/4-inch thick. As part of the processing at the gang saw, each cant was scanned using a high-resolution industrial laser profile scanner which measured both the profile and thickness of each cant. After sawing, the outermost board on one side of the cant was marked for warp measurement. All lumber produced by each experiment was graded by a National Hardwood Lumber Association-certified grader and separated by each log grouping for further evaluation. Due to an error in lumber data collection, only the lumber produced from logs within the 1- to 3-inch sweep category was available for accurate recovery comparison.

Warp Evaluation

For each cant sawn, one outside board was marked and measured for bow, crook, twist, and cup. A table developed for the study was used to measure board deviance from flat to 1/8th -inch increments. The lumber was then stacked and dried using a conventional kiln schedule for 4/4-inch cherry. After drying, each marked board was measured for width and length. Each marked board was remeasured for warp, and also every fifth board for a total of 279 boards. Comparisons for cup, bow, twist, and crook were made for each log grade and sawing technique using a two-tailed t-test comparison of means, assuming equal variances and α=0.05.

Simulation Analysis of Curve Sawing

Since the curve sawing gang could process a log only with a maximum sweep of 1¾ inches in 10 feet, simulations were run to determine the potential volume production if greater curvature could have been sawn. Of the 162 cants measured and processed in the sawmill, 104 (64 percent) were 8 foot long, with single sweep ranging from 0.2 to 6.4 inches. Sawing simulations were performed on a sample of these 8-foot cants to compare yield differences between curve and straight sawing. The simulation software used in the analysis was Edger11 (1.0)© developed by Nelson Brothers Engineering (Vancouver, WA).

Before the simulation was performed, the cants were segmented into 1-inch sweep categories. Sweep was determined for each cant by measuring the maximum deviation from a straight line extending from one end to the opposite end. All sweep measurements were performed on the cant images generated by the simulation software. Samples were then pulled from each sweep category to use in the sawing simulation. The following samples were then pulled from each sweep category: Five cants, 0-2.0 inch range; 10 cants each, 2.1-3.0, 3.1-4.0, and 4.1-5.0 inch ranges; and five cants from the 5.1-6.0 inch range (40 total cants). The full dataset of logs sawn was not available due to a data storage error during the recovery study. The distribution of each sample was representative of the larger dataset distribution from which it was obtained.

Sawing simulations were then performed on each of these sample cants using simulation software. First, each cant was straight sawn into 4/4 lumber. No blade movement was allowed during sawing, but skewing of the blades was permitted during sawing. The number of boards produced and the dimensions of each board were recorded. Next, the same cants were curve sawn into 4/4 lumber, allowing the saw blades to pivot during sawing. For the curve sawn cants, a maximum allowable curvature of 6 inches per 8 feet was used. As with the straight sawn lumber, the number of boards and the dimensions of each board were recorded. Based on the dimensions of each board, total volume yield (in board feet) was calculated for each cant while using both the straight- and curve-sawing setups.

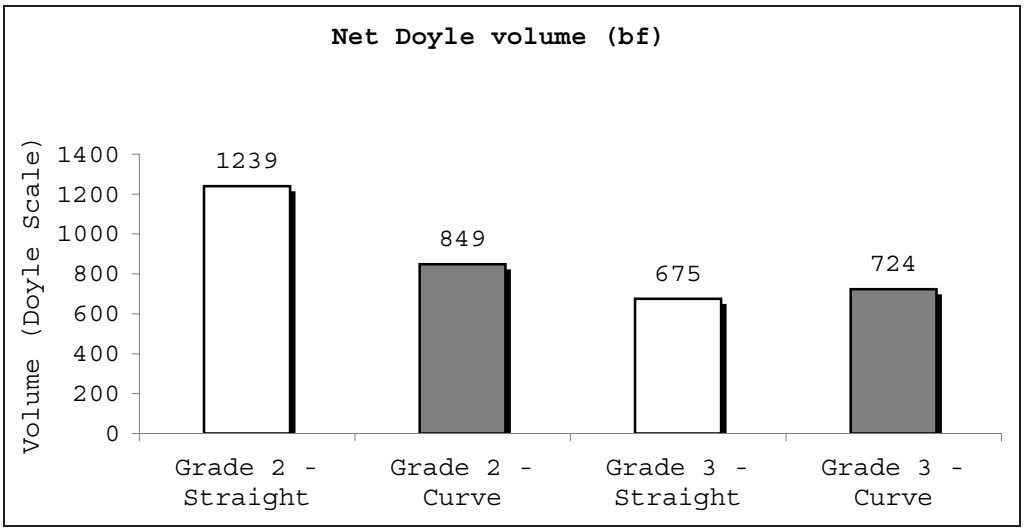

Figure 1.—Net log volume for each group tested (Doyle Scale).

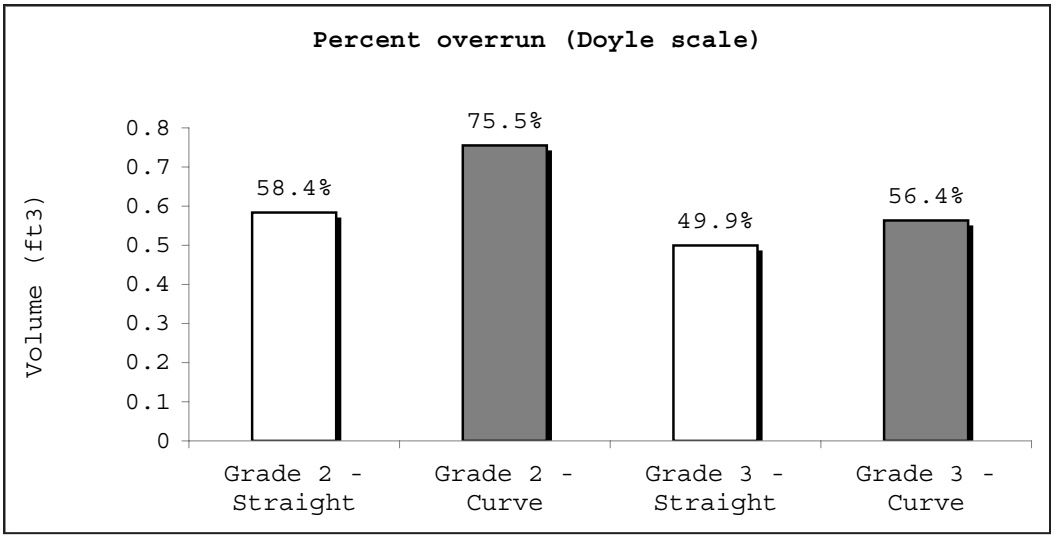

Figure 2.—Percent overrun (Doyle Scale) of each group tested.

RESULTS AND DISCUSSION

One hundred sixty-two logs were measured and processed through the mill. Scan data were collected for all logs; however, a file-saving error resulted in only 104 two-sided cants for use as input in the sawing simulations. Seventy-eight logs were tracked for evaluation of output: for lumber volume and value, and warp after drying. Even though the diameter, length, and sweep distribution (2.5 inches on average) was not significantly different between the log grade sample groups, the net log scale differed for each (Fig. 1); therefore, all data were compared with reference to the input volume.

Volume Recovery

Both lumber recovery factor (LRF) and overrun (based on net Doyle scale) values were calculated for each sample group. Each measure is considered comparable since it is based on the log volume input and the lumber volume output for each log grade and sawing method. Overrun was 18 percent greater for cants produced from curve sawn grade 2 logs and 6 percent greater for cants that were curve sawn from grade 3 logs (Fig. 2). The LRF was 1.3 and 0.5, respectively, greater for cants curve sawn from grade 2 and 3 logs than for

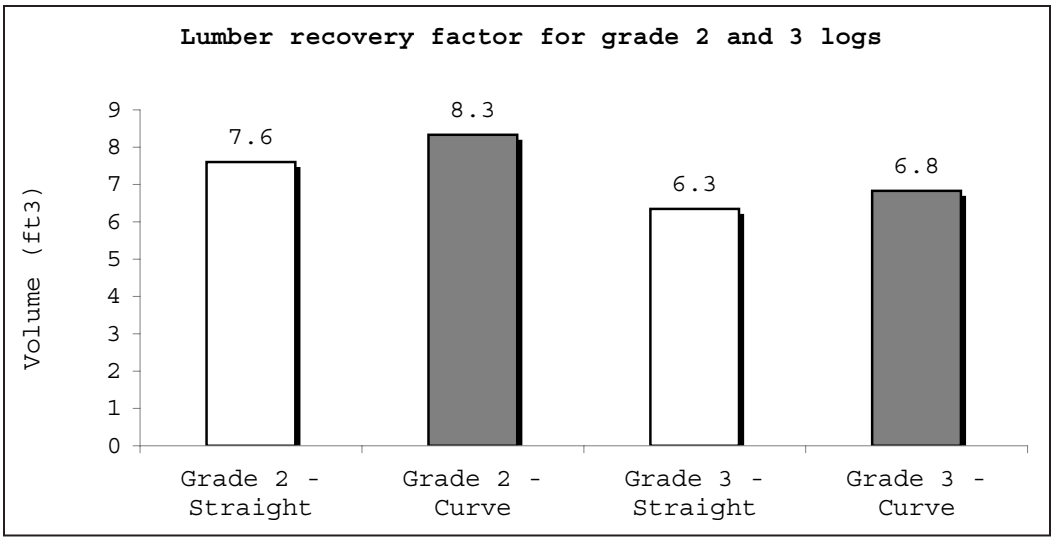

Figure 3.—Lumber recovery factors for each group sawn.

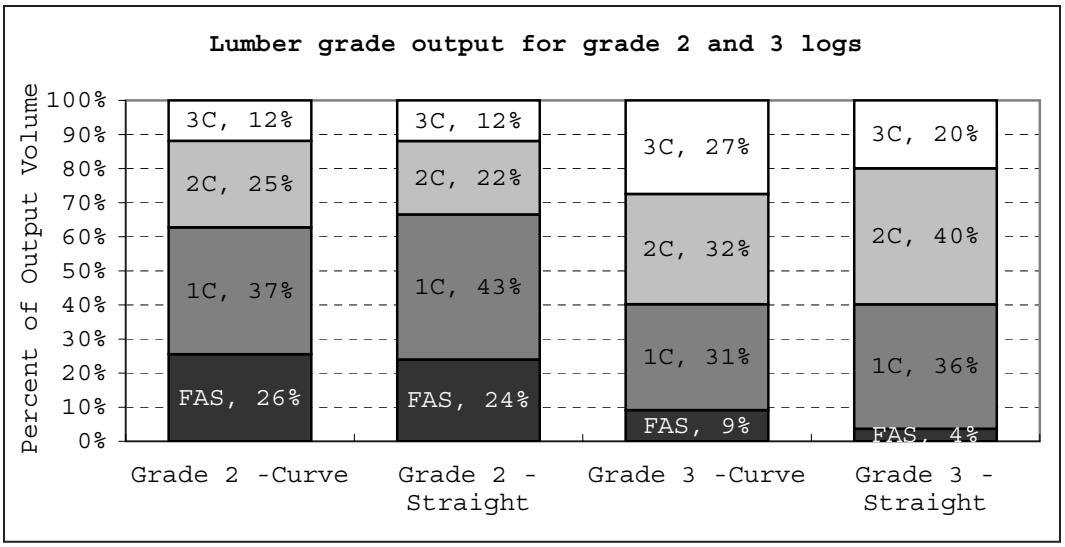

Figure 4.—Percent of lumber grade recovered from grade 2 and 3 logs.

those straight sawn, regardless of log grade (Fig. 3). While Wang and others (1992) reported greater softwood recovery values, their study utilized smaller diameter (4.4 to 7.1-inches) and longer (all 16-foot) logs. The impact of curve sawing on yield is much greater for smaller diameter and longer logs based on a log's geometry. Our values are closer to those reported by the softwood industry (Westergard 1995).

Value Recovery

Figure 4 indicates that curve sawn cants produced greater volumes of FAS lumber than straight sawn cants, regardless of the original log grade. When the lumber value per board of log input is compared (Fig. 5), curve sawn cants produced higher values than those that were straight sawn. Lumber values were determined using values obtained from the Hardwood Review Weekly (2007). The increased value indicates that the ability to curve saw logs (with sweep up to 3 inches) significantly increases lumber value output for grade 2 and 3 cherry sawlogs.

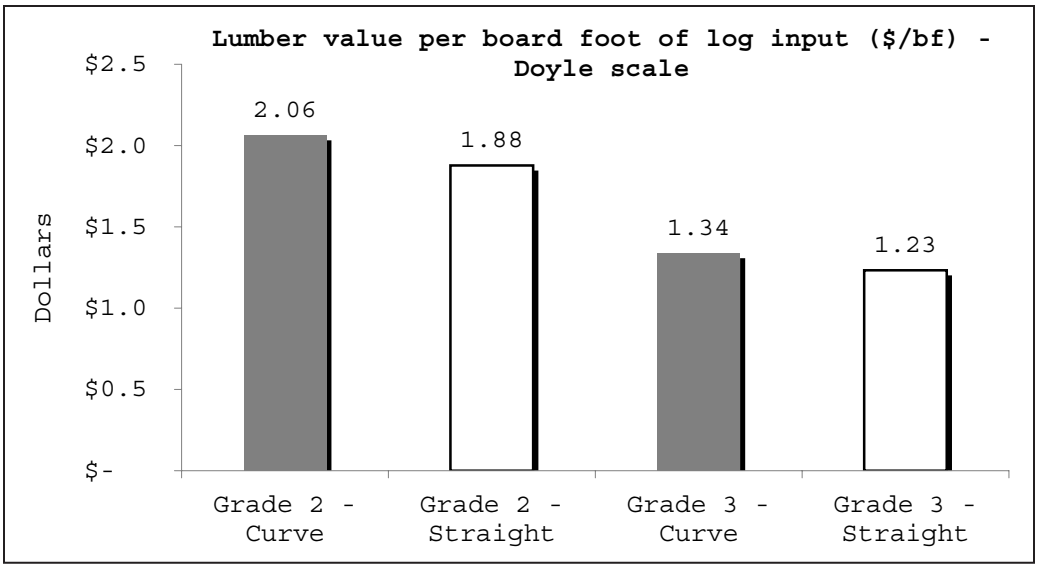

Figure 5.—Lumber value per board foot of log input ($/bf Doyle scale).

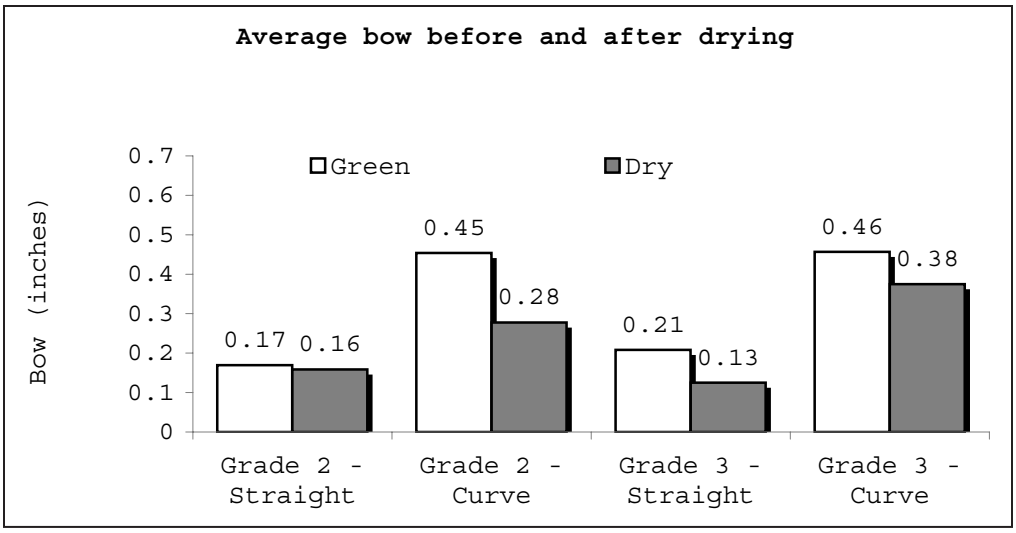

Figure 6.-Average bow in jacket boards measured before and after drying.

Warp

One concern with curve sawing is that the boards produced will have significant amounts of bow. Results of warp measurements for only the jacket boards (those measured both before and after drying) indicated that bow is reduced during the drying process (Fig. 6); however, bow does still exist. When compared with softwood drying results (Bedard and Tremblay 2004), curve sawing hardwood does tend to result in slightly more bow than found in straight sawing logs containing sweep; however, the amount of sweep is no greater than ½ inch in 8-foot lumber (Fig. 7). Crook also was significantly greater for lumber produced by curve sawing; however, the actual difference is approximately 1/8th of an inch (Fig. 7). Twist was not significant between the two groups for either sawing method or for log grade (Fig. 7). This finding is in direct contrast to the results obtained for softwood (Bedard and Trembay 2004), where twist was the cause of the greatest amount of degrade.

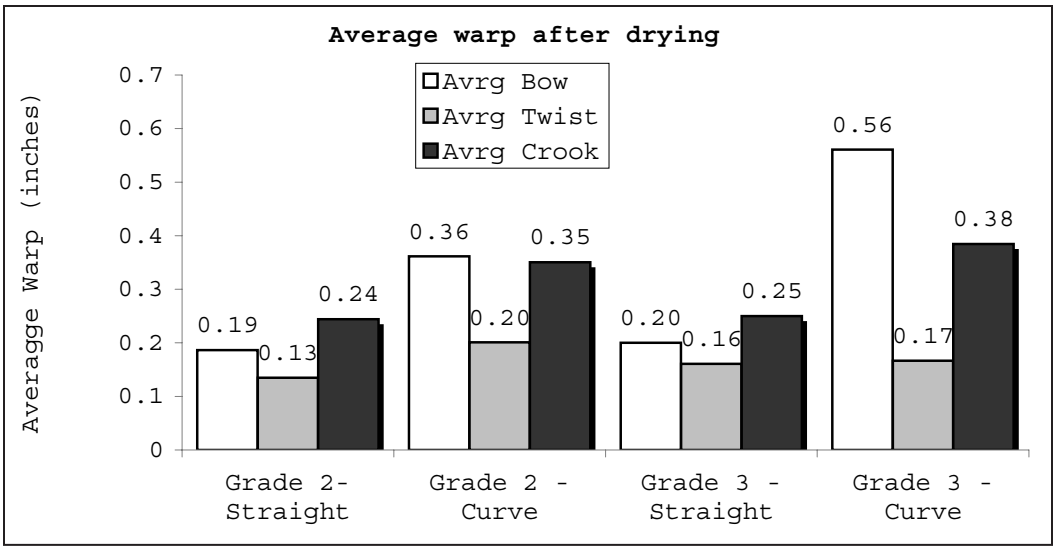

Figure 7.—Average warp (bow, crook and twist) in lumber after drying for each grade and sawing method.

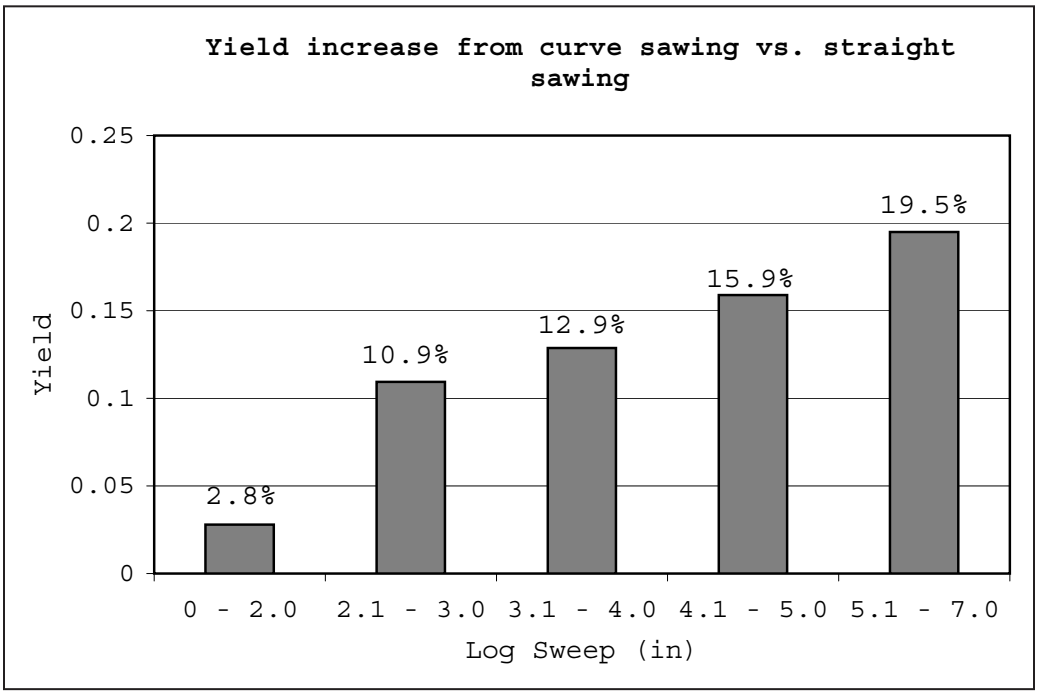

Figure 8.-Yield increase from curve sawing versus straight sawing for simulations.

Simulation

Since the curve sawing equipment used in this experiment was limited due to the amount of sweep that could be tested, cants were measured and tested using simulation to determine if greater recovery gains could be made with an increase in curve sawing capability. The results indicated that curve sawing definitely results in increased lumber yield, regardless of the amount of sweep that the machine could accommodate (Fig. 8). However, the greatest potential for yield recovery is being able to utilize sawing technology that will handle the maximum amount of sweep within the log. The simulation showed that as the percentage of sweep increased, the ability to recover volume increases proportionally, if the sawing machine can actually process the maximum sweep in the log.

CONCLUSIONS

This lumber recovery study produced greater lumber volumes for curve sawn cants than for straight sawn cants. Increases in overrun for 8-foot logs ranged from 6 to 18 percent and the lumber recovery increase ranged from 0.5 to 1.3 (for 8 foot logs containing 1 to 3 inches of sweep). Boards that were curve sawn did have significantly more bow and crook than boards that were produced by straight sawing. While these differences are significant, the actual amount of bow (less than ½ of an inch) and crook (1/8th of an inch) would not likely significantly impact rough mill yield when processed. Twist was not significantly different between the two groups and did not exceed ¼-inch.

The results clearly indicate that volume recovery is greater when curve sawing hardwood cants produced from logs containing sweep, even when those logs are relatively short (predominantly 8 feet in length). Greater increases would be possible with longer and/or smaller diameter logs. While the curve sawing gang used in the recovery study was limited, simulation software was used to predict the potential log recovery increase if the machine had been able to accommodate the maximum quantity of sweep. Results indicated that lumber recovery increased with the amount of sweep in the log, assuming that the machine could accommodate the maximum sweep in processing. Given that sawmills often spend hundreds of thousands of dollars on new equipment to obtain a 2 percent increase in yield, it is surprising that more hardwood sawmills have not adopted this technology based on the results obtained—as the minimum gain was 2 percent. Not only does this technology result in greater lumber recovery for the species and grade of logs sawn, it resulted in significantly increased value output.

ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of Omar Espinoza, graduate student and research assistant at Virginia Tech; and Matt Winn, forestry technician, USDA Forest Service, Blacksburg. VA.

LITERATURE CITED

Bedard, P.; Tremblay, C. 2004. **Impact of curve sawing on kiln-drying and MSR grading.** Forest Products Journal. 54(9): 69-76.

Hardwood Review Weekly, 23(50) August 24, 2007. Charlotte, NC: Hardwood Publishing, Inc.

Hamner, P.; White, M.; Araman, P. 2007. **The frequency and level of sweep in mixed hardwood saw logs in the eastern United States.** Forest Products Journal. 57(9): 23-27.

National Hardwood Lumber Association (NHLA). 2007. **Rules for the measurement and inspection of hardwood and cypress lumber.** Memphis, TN: National Hardwood Lumber Association. 136 p.

Petree, J. 1998. **Sawing on the learning curve.** Timberline. Timber Industry Newsline Trading Post. 4(8): 8-11.

U.S Forest Service. 1966. **Hardwood log grades for standard lumber.** Res. Pap. FPL-63. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Wagner, F.T.; Gorman, T.M.; Pratt, K.L.; Keegan, C.E. 2002. **Warp, MOE, and grade of structural lumber curve sawn from small-diameter Douglas-fir logs.** Forest Products Journal. 52(1): 27-31.

Wang, S.J.; Munro, B.D.; Giles, D.R.; Wright, D.M. 1992. **Curve sawing performance evaluation.** Forest Products Journal. 42(1): 15-20.

Westergard, B. 1995. **The evolving sawmill.** Logging and Sawmilling Journal. 16(3): 24-27.

United States
Department of
Agriculture

Forest Service

**Northern
Research Station**

General Technical
Report NRS-P-24

Proceedings 16th Central Hardwood Forest Conference

West Lafayette, IN
April 8-9, 2008