Intensive Hardwood Log Bucker Training using HW Buck Dramatically Improves Value Recovery

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ABSTRACT

It has long been recognized that inappropriate placement of crosscuts when manufacturing hardwood logs from harvested stems (log bucking) reduces the value of logs produced. Recent studies have estimated losses in the range from 28% to 38% in the lake states region. It has not, however, been clear how to correct the problem. Efforts to improve value recovery have followed two general approaches: using technological methods to actually optimize the bucking of each log or having recognized experts train log buckers to make better bucking decisions. This article describes the state-of-the-art for optimizing the bucking of hardwood logs, and documents a log bucker training approach that resulted in improved value recovery of over 30%. Field buckers underwent an intensive training process to help them make better bucking decisions. This training integrated use of HW Buck, a computerized tool to optimize the choice of bucking cuts for hardwood logs, with other more traditional training approaches. Sample hardwood stems were felled and entered into the HW Buck software to determine the individual bucking options that maximized the value of the resulting logs. This component was integrated with the more traditional instruction in defect identification and the fundamentals of grading and scaling rules. Each of the training components was taught both in the field and using prepared slide shows. Emphasis was placed on a set of heuristics (rules-of-thumb) that simplify the bucking decision process. One very useful component of the training program was a visit to the trainees in the field several weeks after the initial training. This allowed the buckers time to practice the techniques covered in the training and to seek clarification concerning any aspect of the training that was unclear. It also allowed the trainers to reinforce the messages of the initial training.

INTRODUCTION

Foresters who have worked with harvesting crews in hardwood stands often see what they view as inappropriate choices for placement of cuts when manufacturing hardwood logs from stems, a process that is often referred to as log bucking. The general reason that the foresters view the choice of bucking cuts as inappropriate is because they produce logs that are less valuable than would be produced with other choices. The problem was considered serious enough that Petro (1975) wrote an entire book focused on the felling and bucking of hardwood stems.

One characteristic of the hardwood log bucking situation made it very difficult to make progress toward improved value recovery: Nobody knew for sure what the best way to buck the stems was. Even recognized experts would disagree about what cuts would produce logs of the greatest value. This deficiency was corrected when optimal bucking technologies were developed. The optimal log bucking technologies were first applied to softwood log manufacturing (Pnevmaticos and Mann 1972), and later extended to the hardwood log bucking problem (Pickens et al. 1992). Studies of softwood bucking practices in New Zealand and the Pacific Northwest have revealed value losses ranging from 5-26% (Geerts and Twaddle 1985, Twaddle and Goulding 1989, Sessions et al. 1989). The most common bucking mistake in softwoods was failure to check log diameter requirements for the target grade (Sessions, personal communication). Most of the studies estimated losses toward the lower end of the range of value lost.

Pickens et al. (1992) estimated value losses between 28% and 35% for hardwood bucking, with the variability resulting from different historical log prices. Unlike the softwood log bucking situation, the causes for value loss resulted from several common mistakes including manufacturing logs with more sweep than necessary, failing to identify and preserve very high-value potential logs, and poor placement of defects, which reduced the available clear lumber. As with softwoods, some of the mistakes involved cutting logs with small end diameters too small for the target log grade. The hardwood losses are much higher than those estimated for softwoods. This result is not unexpected since the hardwood bucking situation is much more complex. Hardwood stems have defects spread along the length of the stem and tend to grow less straight than softwoods. Furthermore, high-value hardwood products are valued mostly for their visual appearance, and there is a premium price for defect-free products.

As suggested by Briggs (1980) for softwoods, Pickens et al. (1993) developed a computerized game named HW buck for training hardwood log buckers. This game allowed buckers to view the stem, select bucking cuts, and compare their cuts with the optimal set of bucking cuts. This program has recently been converted to the Windows operating system and has expanded capabilities (Noble et al. 2005).

The high losses resulting from current field bucking practice indicate a tremendous opportunity to improve profitability in the hardwood industry. Although there is a range of approaches to help improve value recovery, two seem clearly superior. The two approaches are very different, with one relying on technology while the other relies on training. The “high technology” approach is to collect information about the stem shape and defects using various scanning technologies such as visual light, laser, x-ray, or ultrasound, and using this to reconstruct a “virtual stem” which HW Buck can then use to select optimal bucking cuts to manufacture hardwood logs of the greatest value. The “low technology” alternative is to train log buckers to make better bucking decisions using a range of learning approaches including HW Buck.

This paper describes a hardwood log bucker training program that has been shown to dramatically improve log bucker value recovery. This research was a collaborative endeavor between the Wood Education and Resource Center (WERC) of the Forest

Service, Menominee Tribal Enterprises (MTE), and the School of Forest Resources and Environmental Science (SFRES) at Michigan Technological University (MTU).

THE BUCKER TRAINING COMPONENTS

Hardwood log buckers need to master several skills to improve their log bucking performance. Specifically, the buckers need to be able to identify defects on and in hardwood logs, have and understanding of hardwood log grading and scaling rules, and be able to integrate this information to cut logs of greater value. Although these topics seem necessary for manufacturing valuable hardwood logs to most hardwood foresters, none of the trainees who were working on harvesting crews had received even minimal training in any of these areas. The harvesting crews were extensively trained, but the training focused on safe and environmentally sound harvesting practices.

Figure 1: A series of photos depicting an overgrown knot in the defect slide presentation

Defect Identification and Internal Implications Training

Being able to identify defect indicators on hardwood stems is an essential skill when bucking hardwood logs to improve value recovery. Many hardwood log defects are very evident when looking at hardwood stems, but there is also a group of defects that are quite vague and hard to identify. Figure 1 shows a large and obvious defect on a hardwood stem, starting with an external surface view and proceeding into the log as successive boards are cut. The tree has been attempting to heal over the defect, but the boards cut into the defect show extensive rot.

Figure 2 shows a more vague hardwood defect, a medium bark distortion. This defect is identified by the circular pattern in the bark. The boards cut into this defect are clear for several inches, but the knot, which caused the bark distortion, extends into the quality zone of the log. Other vague defects include bird peck and some internal defects such as pitch pockets.

Although these defects are very different, they would each be a grading defect because they limit the length of clear wood that can be cut from the log. The more serious defect in Figure 1 would clearly be larger, and impact more wood. It may also lead to a scale deduction because some wood has become unusable, while the defect in Figure 2 would not result in a scale deduction because all of the wood remains sound.

Figure 2: A series of boards cut into a medium bark distortion.

Log Grading and Scaling Fundamentals

It is crucial to understand the traits that make logs more or less valuable. This evaluation relies on two different characteristics of the log, the grade and scale volume. Grade captures the quality of the log, and therefore its ability to produce valuable products. Scale measures the amount of usable wood in a log, and is determined by subtracting the volume of the unusable portions of the log from the total log volume. Deductions in scale volume occur if either some of the wood is missing because of decay or breakage or if the log deviates significantly from straight.

The goal of this training component was not to make the buckers into expert graders and scalers. Instead, our training focused on having the loggers understand the general principles and be able to saw logs in ways that generally lead to production of more valuable logs. The grading and scaling rules used in this portion of the training in the lake states are established and distributed by the Timber Producers of Michigan and Wisconsin (1988), and are somewhat complex. Sawlog grades depend on the length of clearcuttings on a grading face, sometimes with variable requirements by diameter, and veneer grading rules vary by the organization purchasing the logs; this makes their application difficult. Training focused on identification of potential veneer logs and sawlogs that allow for sawing longer sections of clear lumber.

Bucking to Improve Value Recovery

The HW Buck software was used to allow buckers to evaluate their bucking patterns. Furthermore, the buckers could compare their bucking choices with the optimal bucking cuts. This allowed them to identify mistakes and correct them in the future.

Next, the training presented heuristics (rules-of-thumb) that allow buckers to improve their value recovery. The primary focus was on the following four heuristics:

- Try to cut logs to eliminate sweep and crook
- Try to identify the most valuable log in a section of stem, then place the bucking cuts to preserve this log
- Place defects at or near the ends of sawlogs to maximize clearcuttings
- Make sure that the small end diameter is large enough to qualify for the target grade

Cutting straighter logs reduces cull deductions due to sweep, and can often increase log grade. Identifying the best log and working around it is important because hardwood log prices often jump 50% or more between adjacent grades. Therefore, it is nearly always preferred to cut the log of higher grade. This is particularly important when veneer markets are available. Placing the defects near the ends of sawlogs tends to improve grade recovery, especially the production of #1 sawlogs.

TRAINING FORMAT

The training was delivered over a period of one year, and consisted of an initial 1 ½ day intensive training session with two follow-up sessions. The first follow-up session occurred about one month after the intensive training, while the second follow-up occurred a year later. This structure allowed both a chance to measure the retention of bucking value improvement and reinforcement of the initial training messages. Bucker performance was measured four times. The first two measurements were at the beginning and end of the intensive field bucker trainings session. The third and fourth performance measurements occurred at the beginning of each of the field revisits.

The training involved both field (Figure 3) and indoor components (Figure 4). Although we believed that it would be good to break up long indoor sessions with field sessions, this was not possible because the travel time to the training site was more than ½ hour.

Figure3: Trainees selecting their first choice of bucking cuts.

Figure 4: Trainees use HW Buck game to evaluate alternative bucking cuts.

RESULTS AND STATISTICAL ANALYSIS

Table 1 presents the total monetary value recovered and average percent of the optimal value recovered by each trainee for the initial sets of sample trees (*First* and *Second Try*). The training was administered to two separate groups of buckers (indicated as “A” and “B”), using a different set of six sample trees for each group. The trainees recorded two sets of cuts on the stems in Table 1, one prior to training (*First Try*) and one after the intensive portion of training (*Second Try*). Optimal solution values were calculated by the HW-Buck software using MTE's product class pricing. The average percent recovery is the averaged proportion of each optimal solution's dollar amount that the trainees' bucking solutions yielded. Since this value was calculated for each stem individually before being averaged, it represents a per-tree gain. As the table indicates, most trainees improved from the first set of cuts to the second, with gains or losses between ($159) and $750. One trainee provided exactly the same cuts before and after training (1A), while another trainee's value recovery actually dropped (1B). The average dollar amount gained from training was $83 in group "A" and $326 in group "B." This resulted in an average 3.4 percent increase in value recovery on each tree in group "A," a much larger 9.5 percent in group "B," and 6.8 percent overall. Statistical evaluation using a factorial design analysis of variance (ANOVA) confirmed a significant improvement between the first and second try (p=.003). The factors in the model were tree, bucker, and try. Only main effects were included in the model.

Table 1: Value of logs produced and average percent of the optimal solution recovered by each trainee during the initial training sessions.

	Total Value of Logs Produced				Mean % Recovery per Tree		
Trainee	First Try	Second Try	Optimal	Gain (Loss)	First Try	Second Try	Gain (Loss)
1A	$1,517.80	$1,517.80	$2,506.75	$0.00	68.3%	68.3%	0.0%
2A	$1,610.05	$1,649.85	$2,506.75	$39.80	70.1%	72.8%	2.7%
3A	$1,620.50	$1,675.21	$2,506.75	$54.71	71.9%	73.7%	1.8%
4A	$1,511.70	$1,749.90	$2,506.75	$238.20	66.8%	75.9%	9.1%
Group A Mean	**$1,565.01**	**$1,648.19**	**$2,506.75**	**$83.18**	**69.3%**	**72.7%**	**3.4%**
1B	$1,466.00	$1,307.15	$2,506.75	($158.85)	70.1%	65.3%	(4.8%)
2B	$980.90	$1,728.35	$2,506.75	$747.45	50.6%	70.0%	19.3%
3B	$1,029.90	$1,546.90	$2,506.75	$517.00	55.4%	65.4%	10.0%
4B	$1,009.90	$1,523.05	$2,506.75	$513.15	53.3%	67.7%	14.4%
5B*	$1,067.30	$1,076.75	$2,506.75	$9.45	55.9%	64.5%	8.6%
Group B Mean	**$1,110.80**	**$1,436.44**	**$2,506.75**	**$325.64**	**57.1%**	**66.6%**	**9.5%**
Overall Mean					**62.5%**	**69.3%**	**6.8%**

Table 2 presents the average percent of optimal solution value recovery the trainees earned during the first on-the-job re-visits (*Third Try*) several weeks after the initial training. Since the sample trees and their corresponding values for these visits differed from the initial sets, no relevant comparison of specific log values can be made between the two sessions. These results can be thought of as an approximation of the trainees' retention of ability to select bucking cuts to increase value recovery from the training sessions. As Table 2 shows, some trainees seemed to regress slightly in the quality of their bucking decisions. However, some of the sample trees used in this part of the training were particularly odd or tricky, containing different species that require an extension of defect identification skills to correctly select cut placement. These complexities may account for part of the apparent decline in performance. The average increase in value recovery between try one and try three was only 3.0%, which is less than the 6.8% improvement between the first and second try. ANOVA confirmed that the improvement between the first and third try was statistically significant (p=.009). This was analyzed with a similar factorial model to the comparison between tries 1 and 2, except that try 1 was compared with try 3. Although it was hypothesized that value recovery would rise after the trainees had been afforded the opportunity to apply their skills on the job, gaining comfort within a variety of bucking situations, this did not seem to be the case. As before, the trainees from group "B" seemed to improve more than did those in group "A".

After value recovery was measured, the training team worked with the trainees to reinforce the earlier training messages.

Table 2: Mean percent of optimal value recovered during the first revisit to trainees' job sites (Third Try)

	Mean % of Optimal Recovered		
Trainee	First Try	Third Try	Gain/Loss
2A	70.1%	65.6%	(4.5%)
3A	71.9%	69.2%	(2.7%)
4A	66.8%	62.7%	(4.1%)
Group A Mean	**69.6%**	**65.8%**	**(3.8%)**
1B	70.1%	47.5%	(22.6%)
2B	50.6%	76.4%	25.8%
3B	55.4%	62.9%	7.4%
4B	53.3%	71.8%	18.5%
5B	55.9%	61.9%	6.0%
Group B Mean	**57.1%**	**64.1%**	**7.0%**
Overall Mean	**61.8%**	**64.8%**	**3.0%**

Table 3 presents the average percent of optimal solution value recovery earned by the trainees during the final re-visit (*Fourth Try*), nearly one year after initial training. Once again, buckers from the second group seemed to perform better than those from the first, although they did not noticeably differ in the demographic aspects covered by the bucking survey that was administered during initial training (i.e., years of experience). This discrepancy may simply relate to having sent a more effective message through the lecture and initial field portions of this group's training. Simply put, the research team and MTE staff worked more effectively together the second time out, limitations in the DOS version of the HW Buck software were known and strategies were developed to address MTE's standards, and the research team was more comfortable with the presentation materials. Additionally, the trainees from group "A" seemed to have started at a higher initial level of value recovery, averaging over 69 percent while group "B" only recovered 57 percent, and large improvement is likely more difficult to achieve when one has fairly good technique initially. Whatever the cause, the average percent recovery improvement (G*ain/Loss*) at the culmination of training for group "A" was just above nine percent, while the average for group "B" tripled that amount, reaching 27 percent. Individual trainee improvement, measured as a percentage of the optimal value, ranged from just under seven percent (Trainee 3A) to

Table 3: Mean percent of optimal value recovered during the final revisit to trainees' job sites (Third Try)

	Mean % of Optimal Recovered		
Trainee	First Try	Third Try	Gain/Loss
2A	70.1%	83.7%	13.6%
3A	71.9%	78.6%	6.7%
4A	66.8%	73.6%	6.8%
Group A Mean	**69.6%**	**78.6%**	**9.0%**
1B	70.1%	77.6%	7.5%
2B	50.6%	79.6%	29.0%
3B	55.4%	93.2%	37.8%
5B	55.9%	89.7%	33.8%
Group B Mean	**58.0%**	**85.0%**	**27.0%**
Overall Mean	**63.0%**	**82.3%**	**19.3%**

nearly 38 percent (Trainee 3B), averaging just over 19 percent across both groups (Table 3). The difference between the first try and the fourth try were highly statistically significant ($p<.0001$).

DISCUSSION

With potential gains from intensive hardwood log bucker training of over 30% (19.3%/63.0%) in the gross value of veneer and sawlogs produced, there is tremendous potential for improving profitability in the hardwood industry. The benefits of improved profitability would be expected, based on economic theory, to accrue to the individual harvesting crews who can recover these gains and to the owners of the timber. The benefits will, however, be more broadly spread. For example, mills will have a greater supply of high-quality logs available.

The key to achieving these gains is to deliver quality training to log buckers across the eastern hardwood region. This is, however, not an easy or straightforward task. Market conditions and species characteristics vary greatly over the range of eastern hardwoods. However, the key components of training remain the same: defect ID, log scaling and grading rules, and heuristics to improve hardwood log bucker value recovery.

The regional differences suggest that the training program needs to be adapted to each region. Furthermore, understanding of local and regional markets by the trainer is an important aspect of the training. This situation argues strongly that those delivering the training should be well versed in the specific conditions of the area where the training occurs.

An initiative is in the early stages that will connect the training resources and technical capabilities of the MTU hardwood bucking group with trainers across the eastern hardwood region. The Ohio Forestry Association (OFA), in cooperation with WERC, is taking the leadership role in coordinating this training program. The training approach used is to recognize and address regional differences in both the hardwood resource and hardwood log markets. The strategy selected is to identify regional leaders who will then "training the trainers" who will conduct local training sessions. The regional trainers and the local trainers will both have support by MTU of both existing and future technological and training resources supplied by MTU.

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