Comparison of Timber Utilization Between A Tree-length and An In-wood Chipping Harvesting Operations

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ABSTRACT: Two 25-year old pine plantations in Alabama, one for in-wood-chipping (IWC) and another for tree length (TL) harvesting operations, were selected to determine the proportion of the standing merchantable timber resource and value that got to a manufacturing facility. Amount of sawtimber after merchandizing in the woods was found to be 80.6 percent of inside bark volume as compared to potential volume for trees from the IWC operation and 103.4 percent for TL. The TL operation merchandized sawtimber tops that were smaller than specified by mill. Pulpwood inside bark volume after merchandizing in the woods was 163.4 percent in the IWC harvesting operation and 38.6 percent for the TL as compared to potential pulpwood. The percent of potential volume for pulpwood and sawtimber that was not recovered from the woods was 9.5 percent for TL and 2.9 percent for IWC. At current market price for pine sawtimber and pulpwood, the TL harvesting operation had an increase of 0.4 percent of value and the IWC harvesting operation had a reduction of 15.9 percent of value from final products as compared to potential value.
Keywords: tree-length, in-wood-chipping, cut-to-length, harvester, skidder.

INTRODUCTION

In the United States, Finland, and Sweden, private ownership types control large amount of forestland, while in Canada most is owned by the government (Koskela and Ollikainen, 1999). There are 13 million hectares of plantations in the southern region of the U. S., which is one sixth of total forest area of this region. By the year 2000, plantations are expected to provide 43 percent of the South's total softwood supply and expected to provide 65 percent by 2030 (Stokes and Waston, 1997).

The 22 million acres or 95 percent of timberland in Alabama is privately owned out of which 70 percent is owned by NIPF (Zang et al. 1998, Forestry Facts, 1997). In 1995, Alabama forest industries produced approximately $13.2 billion, of which $8.5 billion worth from pulp, $3.6 billion from lumber (Forestry Facts, 1997).

Landowners desire maximum returns for their stumpage, the value of the standing trees. Procurement organizations for mills want to maximize profit on trees they buy. Increasingly, loggers are being required to merchandise for maximum utilization. Often harvesting systems, which are designed for high productivity with minimal merchandising are being asked to extract highest values, which jeopardizes profits of logging contractors. Dykstra and Heinrich (1996) have emphasized that properly conducted cutting operation should maximize the value of the logs prepared for extraction and facilitate extraction activities. Lanford and Stokes in (1996) concluded that a forwarder system harvesting cut-to-length (CTL) wood had lowest cost per cord but was only 1 percent less than the skidder system cutting 7.5-foot wood, and the skidder system produced 1 percent more wood than the forwarder with CTL wood. Also in this study, it was concluded that there was no significant difference in the tree volume recovered between the forwarder and skidder systems. Favreau (1998) found that a tree length (TL) system had significantly more breakage of trees during harvesting than a CTL system.

Available literature reflects that research has been conducted on the productivity and costs on the different harvesting systems in the US South, but there is little information on levels of timber utilization from different harvesting systems.

OBJECTIVES

Compare utilization of timber resources among tree-length (TL) and in-woods chipping (IWC) harvesting systems[3].
Specific goals were to:
1. Determine the proportion of the standing merchantable timber resource that gets to manufacturing facilities using the two harvesting systems.
2. Compare the revenue per unit of wood that is generated by the two harvesting approaches.

METHODOLOGY

To properly determine the level of timber utilization from the harvesting systems trees were measured at the stump and followed through to the first point of manufacturing. The TL harvesting system produced tree lengths in the woods for saw timber and pulpwood trees. Sawtimber trees were topped at a target of 5.0 inches top diameter inside bark (d.i.b.). Tops were left in the woods for possible recovery with another operation. Pulpwood trees were topped at 2.5 inches top d.i.b. The IWC system merchandized sawtimber trees in the same way and tops were not chipped. The pulpwood trees were chipped in their entirety. The CTL system was not studied during this phase of this study. By measuring each tree to its

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highest value use prior to processing and after it had been delivered, a degree of utilization could be determined for the two harvesting approaches.

Selection of sample plots:

In order to reduce bias, trees for this study were selected from similar stands. Mead Coated Board Corporation provided the TL and IWC harvesting operations. Both TL and IWC crews were considered some of the best for overall performance and quality of work. Two25-year old pine plantations were selected. Trees were selected to get a representative sample from each 1-inch DBH class. Prior to felling, each tree was assigned an identification number, which was followed throughout the study.

Harvesting system machines:

The TL operation had a sawhead feller-buncher, two grapple skidders, a delimbing gate, and a hydraulic knuckleboom loader with a pull-through delimber. The IWC operation had two sawhead feller-bunchers, three grapple skidders, a hydraulic knuckleboom loader with a pull-through delimber, and an in-woods flail chipper. All sawtimber and pulpwood from the TL operation was hauled on tractor-trailer style haulers; chips were transported in chip vans.

Measurement methods:

1) Measurement before and after felling: Before felling, DBH outside bark was measured to 0.1 inch with a caliper. The highest level of utilization was identified which classified each tree as pulpwood or sawtimber. After felling, down tree measurements of outside bark diameter, bark thickness and lengths were recorded at various points on the tree. At each measurement point, diameter and bark thickness was measured and recorded. Stump height plus the felling kerf was considered to be 6 inches above the ground, so DBH measurements were taken at 4 feet from the butt end (Figure 1).

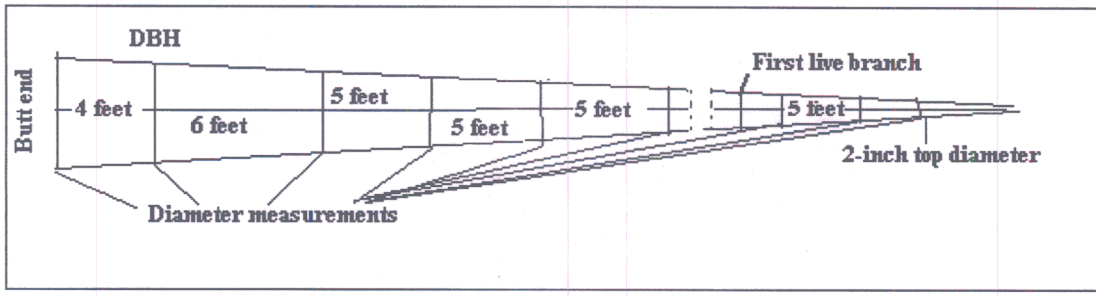

Figure 1. Measurement of tree after felling.

The butt end was measured for diameter and bark thickness and served as a reference point for all the measurements. The third set of measurements were taken at ten feet from the butt. Thereafter, outside bark diameter and bark thickness were measured at five-foot intervals (Figure 1) up the bole to a point where the top was either broken and lost or the top diameter was 2 inches outside bark. Product quality identified as sawlog or pulplog were recorded at each measurement point. Height to the first live limb and the total height were also recorded.

2) Measurement at the landing: Measurements were taken after TL material was delimbed and merchandized in the woods. Both length and outside bark diameter at the small end after merchandizing TL logs were recorded for each sawlog and pulplog. No additional measurements were taken of pulpwood trees for the IWC operation since they were chipped in their entirety.

3) Measurement at the mill: Random length TL sawlogs for both TL and IWC operations were delivered to sawmill and stored separately so that they could be processed at one time. Bucking at the mill was conducted by an experienced merchandiser. The sawmill had cut off saws mounted at 2-foot intervals from 10 feet and beyond to 16 feet. Saw kerf was 7/16 inch for each cut. A trim allowance of 3 inches for each cut and 4 inches for the fixed 16-foot length between two saws. Bucking at mill for TL sometimes required squaring of the butt and cutting of a pulplog portion from the top. Trees were processed linearly through the merchandiser. The operator was responsible for cutting the highest value from each TL piece.

Field measurement procedures:

1) Potential sawtimber and pulpwood: Down tree measurements taken immediately after felling allowed potential highest utilization to be calculated for each tree. In this regard, volume of sawlog down to five inches top d.i.b. from the butt for sawlog trees were calculated as potential sawlog volume and the remaining portion down to 2.5 inches top d.i.b. was taken as potential pulplog volume. For pulpwood trees, all volume down to 2.5 inches top d.i.b. from the butt was calculated as potential pulpwood volume. Cubic volume calculations were calculated for each segment of the tree bole. Where field measurements were not taken at the

each diameter needed, diameter and length interpolation were made. This was used to determine sawlog top end.

2) Sawtimber and pulpwood volume after merchandizing at the landing: Full trees were skidded from the stump area to the landing for processing and loading and chipping. For the IWC chipping operation, trees deemed pulpwood quality were chipped directly into vans and no additional measurements were taken. For these trees, the down tree measurements taken at the stump were considered indicative of the volume that was chipped. While some small limbs may have been lost in the skidding and handling during chipping, their volume was too small to measure accurately.

On the IWC operation, trees considered to be sawtimber quality were skidded and delimbed with a pull-through delimber. The loader operator estimated where 5-inch top d.i.b. occurred and topped the tree accordingly. As noted, tops from sawtimber trees were left in the woods and were not chipped. Resulting top diameter and merchantable length were recorded for the appropriate tree identification.

For the TL operation, all trees were skidded in full tree form to the landing for loading. Prior to arriving at the landing, trees were backed through a delimbing gate. Trees considered to be only pulpwood quality were finish delimbed and topped with the pull through loader. The loader operator estimated where a 2.5-inch top occurred. Top diameters and merchantable length were recorded for each tree. Sawtimber trees were processed and measured in the same manner except 5.0 inches top d.i.b. was the target. While target top diameters were theoretically inside bark measurement, bark at these tops was only 0.1 to 0.05 inch thick which is too precise for an operator to distinguish accurately from a position inside a loader cab. In practice, outside bark diameter was not distinguished from inside bark. Tops from sawtimber trees were left in the woods.

3) Sawtimber merchandizing at the mill: For both IWC and TL operators, TL sawtimber was hauled to the sawmill. Study trees from these truckloads were accumulated at the mill yard so that they could all be merchandized at one time. Tree lengths were bucked to log lengths by a single operator on the mill's feeder conveyor. The trees were moved lengthwise to a series of cutoff saws creating log-lengths varying from 10 to 16 feet in length. A three-inch trim was left on each log and four inches trim for those logs that were bucked in the 16-foot fixed saws. Where the butt had an uneven cut or damage, the butt was "squared up" prior to bucking into logs. Butt trims were sent to make boiler fuel. After all sawlogs were cut out any remaining top piece was sent to be made into pulpwood chips. Sawlog lengths were recorded including trim and saw kerf with appropriate tree identifications.

Office calculations procedures:

Interpolation of diameter and lengths was done by the simple method of ratio and proportion of lengths and diameters. Calculation of volume was done by taking an average radius of big end and small end for each segment. Potential volume for sawtimber was calculated by adding calculated volume of each segment of the tree from butt to 5.0 inch top d.i.b. The rest of potential volume from 5.0 inches d.i.b. up to 2.5 inches was assigned as the potential pulpwood volume. Likewise, potential pulpwood volume for pulpwood trees was determined by adding calculated volume of each segment of the tree from butt to volume up to 2.5 inches top d.i.b.

RESULTS

In-wood-chipping harvesting operation

All together 86 pine trees were taken for IWC harvesting operation. Potential sawtimber trees that were chipped for pulpwood resulted volume loss for sawtimber. Amount of sawtimber after merchandizing in the woods was found to be 80.63 percent inside bark volume compared to potential volume for trees in IWC harvesting system. This was due to error in the merchandizing as targeted to 5.0 inches top d.i.b. and due to sending potential sawtimber TL logs to the chipper. Top d.i.b. from IWC harvesting system for sawtimber was 49 percent below 5.0 inches and 51 percent above it (Figure 2). However, it was found that 19.47 percent of potential sawtimber volume was chipped or portion of it left in the woods, compared to potential sawtimber as designated at the time of felling. The portion of tree that was left in the woods after merchandizing the sawtimber was considered pulpwood. There was decrease by 19.66 percent of inside bark volume of sawtimber in the mill compared to the potential sawtimber calculated originally in IWC harvesting system (Table 1). Loss of volume as kerf and squaring the butt was only 0.32 percent compared to sawtimber as merchandized in the woods.

Tree length harvesting operation

All together 71 trees were observed in TL harvesting system. The TL harvesting system had 103.4 percent inside bark volume of sawtimber after merchandized at the landing and 103.3 percent in the mill compared to potential sawtimber for trees. This was due to the fact that 59 percent of TL stems that were merchandized in the woods had less than the targeted 5.0 inches top d.i.b. and 41 percent at 5.0 inches targeted diameter or above (Figure 2). However, the volume of pulpwood remained 39.5 percent after merchandizing in the woods as compared to potential pulpwood volume estimated. Decrease of sawtimber in the mill for kerf and squaring the butt was only

0.14 percent inside bark volume as compared to volume that was merchandized in the woods.

Pulpwood left in woods from top and other

The percent of potential inside bark volume for pulpwood and sawtimber that was left in the woods after merchandizing at the landing was 9.48 percent for TL harvesting system and 2.87 percent for IWC harvesting system. There was no loss of top leftover for pulpwood that was chipped in the woods because whole trees were chipped in IWC harvesting system.

Final change in volume and value

Average prices for three quarters as published in Timber Mart-South for southeastern pine pulpwood and sawtimber were $6.71and $36.08 per ton respectively (Timber Mart-south, 2002). The average weight for one cubic foot of green loblolly pine was calculated to be 69.19 pounds (Saucier et al. 1981). Calculations of potential values for IWC and TL logging operations were done based on unit price of sawtimber and pulp log per ton. Higher value of sawtimber compared pulpwood caused more monetary loss in IWC harvesting compared to TL harvesting system though overall loss of volume was higher in TL harvesting system. There was loss of 15.89 percent in monetary value for IWC operation compared to potential sawtimber and pulpwood calculated. However, TL logging operation had an increase of 0.45 percent of monetary value compared to potential volume for sawtimber and pulpwood calculated (Table 1). IWC logging operation had 97.13 percent volume recovery compared to potential wood volume, but TL logging operation had only 90.52 percent of potential volume recovery.

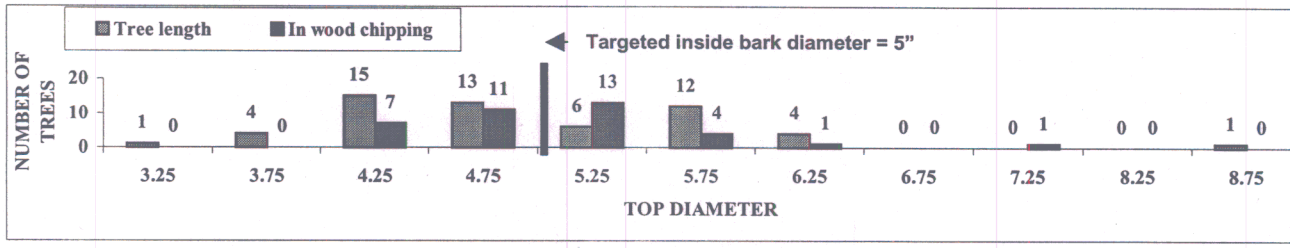

Figure 2. Distribution of inside bark top diameter after merchandizing at the landing.

Table 1. Potential and final units of wood and value in TL and IWC harvesting systems

Harvesting operation	Product	Price/ ton ($)	Potential wood volume, weight and value				Final wood volume, weight and value				Change in value (%)
			Cubic feet	Ton	%	Total Price ($)	Cubic feet	Ton	%	Total Price ($)	
Tree length	Sawtimber	36.08	1,090.0	37.71	80.0	1,423.82	1,125.8	38.95	91.3	1,430.19	+0.45
	Pulpwood	6.71	272.7	9.44	20.0		107.7	3.73	8.7		
In-wood-chipping	Sawtimber	36.08	706.6	24.45	79.9	923.35	567.7	19.64	66.1	776.31	-15.92
	Pulpwood	6.71	178.2	6.16	20.1		291.7	10.09	33.9		

Figures 3 and 4 show the final change in percent of potential pulpwood and sawtimber as the end product by one inch DBH classes for TL and IWC logging operations. For up to 8-inch DBH class, 83 to 100 percent of potential sawtimber was converted to pulp logs or pulp chips in TL and IWC harvesting operations. As the DBH class increased from 8-inch, the proportion of potential sawtimber that was converted to pulp log or pulp chips was reduced. However, most of the potential pulp log portion from 13-inch and above DBH class trees contributed in increase of sawtimber compared to potential sawtimber. This was due to both harvesting operations merchandizing less than 5-inch top d.i.b. for sawtimber. This contributed up to 14 percent increase in value in the 16-inch diameter class for TL and up to five percent in 15-inch diameter class in IWC logging operations. This increased value of wood by 0.45 percent for TL logging operation compared to potential value calculated.

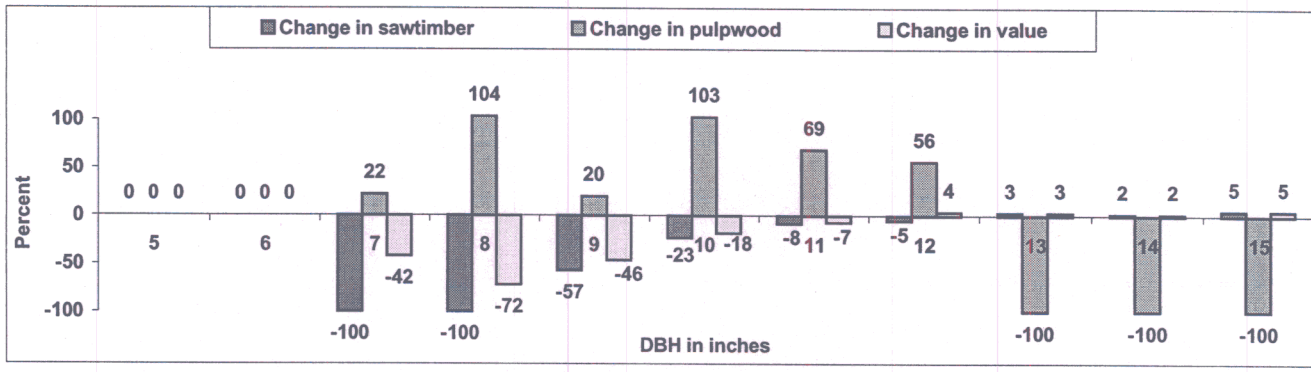

Figure 3. Change in percent of volume and value of potential pulpwood and sawtimber for IWC.

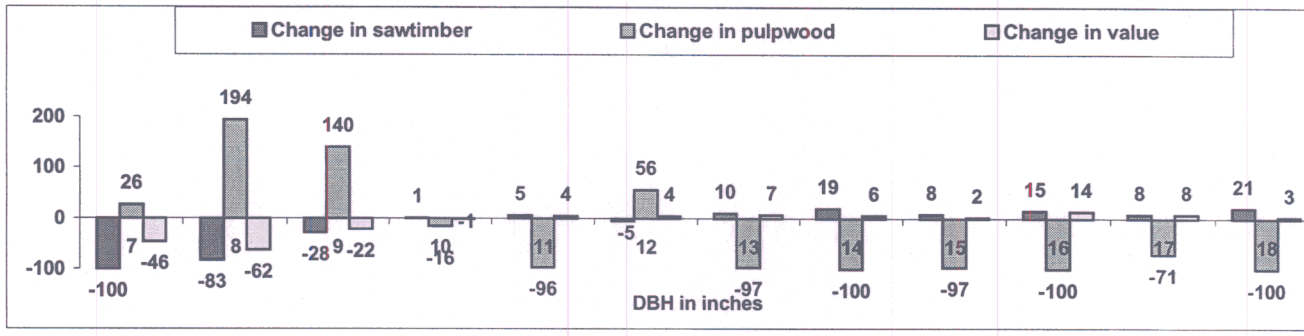

Figure 4. Change in percent of volume and value of potential pulpwood and sawtimber for TL.

CONCLUSION

This study showed that wood recovery was higher from IWC harvesting as compared to TL harvesting operation in clear felling for 25-year old pine plantation. However, monetary wise, landowners will have more income from TL harvesting operation as compared to IWC harvesting operation. DBH classes 13-inch and above were profitable to both operations as compared to potential value calculated.

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