Value recovery with harvesters in southeastern USA pine stands

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Summary

Cut-to-length is not the harvesting system of choice in the southeastern USA although it is perceived to be more environmentally friendly and to have the ability to recover more value from cut stems. In this paper we address the value recovery aspect of harvesters by comparing the optimal recoverable value, as calculated by optimization software, to the actual value recovered by the harvesters at three sites. The actual values recovered at the sites were respectively 93, 90 and 94%. At all the sites the harvesters tended to cut fewer but longer logs than the optimal solution suggested.

Keywords: *Harvester, value recovery, optimization, AVIS*

Introduction

In Scandinavian countries the cut-to-length (CTL) harvesting system is the system of choice with almost 90% of the total volume of wood harvested attributed to this system (Chiorescu & Gronlund, 2001). The picture in North America is completely different with only 20 to 30% of logging being done by CTL (Gellerstedt & Dahlin, 1999). CTL is used even less in the southeastern USA, with not more than 1% of loggers using this system (Greene et.al., 2001), although it is perceived to have many environmental and value recovery advantages.

Value recovery is the process whereby stems are cut into logs according to pre-determined specifications with the objective to obtain the highest possible value. The maximum value is only recovered if the most valuable products (e.g. plylogs and sawlogs) are optimized. Value recovery plays an integral part in determining the profitability of harvesting as the profits of such an operation are dependent on the volume produced, the unit value of the products and the unit cost of production [profit = volume*(value – cost)] (Twaddle and Goulding, 1989).

In 39 mechanized value recovery studies performed in Sweden, Finland, USA, Australia, and New Zealand summarized by Murphy (2003), the value loss ranged from 1 to 68% with an average of 20%. Boston and Murphy (in review) reported a value loss of 6 and 42% respectively in two mechanized log-making operations in the southeastern USA.

The objectives of this study were therefore to: 1) determine the difference between the optimal recoverable value as calculated by optimization software and the actual value recovered by each harvester; 2) determine the difference between the optimal recoverable value and the actual value recovered by each harvester per product; and 3) determine the reasons for under and over recovery of products.

Methods

Three loggers were selected to participate in the study. All three used Ponsse Ergo harvesters with H73 harvester heads and the Ponsse Opti optimization system. At all the sites *Pinus spp.* (predominantly *P. taeda*) was harvested from natural pine stands and the method of payment for the wood was per unit of wood harvested. Site A, which was located in central Georgia, was clearfelled, while sites B and C, which were situated in central Alabama, were thinned.

At site A, 61 trees were selected for inclusion in the study, whereas 60 trees were included at sites B and C. At site A, the trees were selected and marked by the researcher, whereas at site B and C the harvester operator selected the trees to be felled. After the selected trees were felled they were marked with an identification number, and the tree number and stump height recorded. A tape was then attached to the large end (butt) of the stem and the following recorded: 1) Large end diameter (LED) of the butt over bark (OB); 2) DBH OB (only at sites B and C; at site A the DBH was recorded on the standing trees); 3) diameters OB at corresponding lengths from the butt; 4) quality features with their corresponding beginning and the ending lengths from the butt; and 5) tree height, excluding the stump. Once the data were recorded, the harvester operator optimized the felled trees while the researcher recorded, from within the cab, the products manufactured as well as their corresponding small end diameters (SED) and lengths. Once the felled trees were optimized, the researcher measured the actual SED or LED over bark and the length of each of the optimized logs.

The log dimension specifications, quality dimensions and stumpage prices for the different products were obtained from the harvester operator and the appropriate manager, as they were required to run the optimization (Table 1). At site A the specification for knots, sweep and external defects were the same for sawlogs and CNS logs but lower for pulp logs. The quality specifications decreased from plylogs to pulp logs at site B and at site C the quality specifications decreased from sawlogs to pulp logs.

Table 1. Log dimension specifications and prices at all sites.

Site	Log type	Minimum SED (cm)	Lengths (m)	Price (US$/m^3)
A	Sawlogs	20	3.8, 5.0, 6.2	30.75
	*CNS logs	15	3.8, 5.0	12.75
	Pulp logs	5	3.7 to 4.9	2.10
B	Plylogs	23	5.4	35.00
	Sawlogs	20	5.1	20.00
	CNS logs	15	3.2, 3.8	10.00
	Pulp logs	5	3.0 to 6.1	2.50
C	Sawlogs	19	3.8, 5.1	20.00
	Pulp logs	8	4.3, 4.9, 5.5, 6.1	2.50

* CNS = chip-'n-saw

After all the required data were collected and the input files created, the AVIS (Assessment of Value by Individual Stems) optimization software was used to determine the optimal and actual value recovered (New Zealand Forest Research Institute 1995).

Results

Site A

Sixteen percent of the stems were cut to the exact optimal value. In the optimal solution, AVIS manufactured 289 logs with a total volume of 60.4 m^3 and a value of $1596.89, whereas in the actual solution (before adjusting for out-of-specification logs) 241 logs with a total volume of 60.4 m^3 and a value of $1512.03 were made (Table 2). Therefore, a total value loss of $84.86 (5.3%) occurred. Thirty-four of the logs (five plylogs, three CNS logs and 26 pulp logs) in the actual solution were out-of-specification and the values of these logs were therefore decreased to reflect their true value. This resulted in an additional value loss of $33.45, thereby increasing the total value loss to $118.31(7.4%). At this site 92.6% of the value was recovered.

Table 2. Optimal and actual number of logs, volume, value and length recovered at site A before adjustments for out-of-specification logs.

SITE A	Saw	CNS	Pulp	Total
# of logs: optimal	173	50	66	289
# of logs: actual	117	53	71	241
*Optimal – actual	–56	+3	+5	–48
*% Difference	–32.4	+6.0	+7.6	–16.6
Volume: optimal (m^3)	48.8	5.5	6.1	60.4
Volume: actual (m^3)	45.1	7.8	7.5	60.4
*Optimal – actual (m^3)	–3.7	+2.3	+1.4	0.0
*% Difference	–7.6	+41.8	+23.0	0.0
Value: optimal ($)	1512.92	71.91	12.06	1596.89
Value: actual ($)	1396.07	101.00	14.96	1512.03
*Optimal – actual ($)	–116.85	+29.09	+2.90	–84.86
*% Difference	–7.7	+40.5	+24.0	–5.3
Length: optimal (m)	752.6	209.0	292.4	1253.9
Length: actual (m)	652.9	251.8	331.6	1236.2
*Optimal – actual (m)	–99.7	+42.8	+39.2	–17.7
*% Difference	–13.2	+20.5	+13.4	–1.4

* A positive value = over recovery (actual > optimal)
* A negative value = under recovery (actual < optimal)

In the optimal solution 173 sawlogs with a total volume of 48.8 m^3 and a value of $1512.92 were manufactured, whereas in the actual solution the corresponding numbers were 117 sawlogs with a total volume of 45.1 m^3 and a value of $1396.07 (Table 2). The under recovery of value, volume and number of sawlogs was caused by the actual solution favoring longer sawlogs over shorter ones. In the optimal solution 71% of the sawlogs were less than 5 m while in the actual solution 87% of the sawlogs were 5 m or longer. By cutting more, short sawlogs the optimal solution produced a greater cumulative length of sawlogs (Table 2). The value of the five out-of-specification sawlogs cut in the actual solution was reduced by $29.65, thereby increasing the value loss of sawlogs to $146.50.

In the optimal solution, AVIS manufactured 50 CNS logs with a total volume of 5.5 m^3 and a value of $71.91, whereas in the actual solution 53 CNS logs with a total volume of 7.8 m^3 and a value of $101.00 were made (Table 2). The volume and value recovered, the number of CNS logs, and the total length of all the CNS logs were therefore greater in the actual solution. In the actual solution 26% of the CNS logs were a nominal 3.8 m, whereas in the optimal solution 68% of the CNS logs were 3.8 m. As with the sawlogs, the actual solution preferred to cut longer CNS logs that reduced the actual value recovery of such logs. However, the value loss caused by the preference for longer CNS logs was more than made up for by the value from sawlog material that was actually cut into CNS logs. Three CNS logs in the actual solution were out-of-specification and had to be downgraded to pulp logs, decreasing the over recovery of CNS logs by $5.96 to $23.13.

In the optimal solution, AVIS manufactured 66 pulp logs with a total volume of 6.1 m^3 and a value of $12.06, whereas in the actual solution 71 pulp logs with a total volume of 7.5 m^3 and a value of $14.96 were made (Table 2). The actual volume, value, number of pulp logs, and the length of all the pulp logs were therefore greater than the optimal. In the optimal solution 100% of the pulp logs were shorter than 5 m, while in the actual solution 44% of the pulp logs were shorter than 5 m. As before, the actual solution favored to cut longer pulp logs thereby reducing the value of the pulp logs actually cut. However this value loss was more than made up for by the value from CNS material that was cut to pulp logs. The value of the pulp logs were increased by $2.16 to $17.12 as a result of adjustments made to out-of-specification saw, CNS and pulp logs.

Site B

Only five percent of the stems were cut to the exact optimal value. In the optimal solution, AVIS manufactured 255 logs with a total volume of 35 m^3 and a value $701.31, whereas in the actual solution (before adjusting for out-of-specification logs) 220 logs with a total volume of 34.2 m^3 and a value of $641.36 were made (Table 3). Therefore, a total value loss of $59.95 (8.5%) occurred. Four of the logs (two plylogs and two CNS logs) in the actual solution were out-of-specification. The value of these logs were reduced to reflect their true value and resulted in an additional value loss of $11.99, thereby increasing the total value loss to $71.94 (10.3%). At this site 89.7% of the value was recovered.

Table 3. Optimal and actual number of logs, volume, value and length recovered at site B before adjustments for out-of-specification logs.

SITE B	Ply	Saw	CNS	Pulp	Total
# of logs: optimal	34	29	101	91	255
# of logs: actual	29	26	92	73	220
*Optimal – actual	–5	–3	–9	–18	–35
*% Difference	–14.7	–10.3	–8.9	–19.8	–13.7
Volume: optimal (m^3)	12.7	6.7	10.8	4.8	35.0
Volume: actual (m^3)	10.8	6.5	11.2	5.7	34.2
*Optimal – actual (m^3)	–1.9	–0.2	+0.4	+0.9	–0.8
*% Difference	–15.0	–3.0	+3.7	+18.8	–2.3
Value: optimal ($)	445.27	133.82	107.68	14.54	701.31
Value: actual ($)	383.31	130.05	111.01	16.99	641.36
*Optimal – actual ($)	–61.96	–3.77	+3.33	+2.45	–59.95
*% Difference	–13.9	–2.8	+3.1	+16.9	–8.5
Length: optimal (m)	183.6	147.9	366.6	416.8	1114.9
Length: actual (m)	153.7	130.3	343.2	363.5	990.7
*Optimal – actual (m)	–29.9	–17.6	–23.5	–53.2	–124.3
*% Difference	–16.3	–11.9	–6.4	–12.8	–11.1

* A positive value = over recovery (actual > optimal)
* A negative value = under recovery (actual < optimal)

Thirty-four (34) plylogs with a total volume of 12.7 m^3 and a value of $445.27 were manufactured in the optimal solution, whereas in the actual solution 29 plylogs with a total volume of 10.8 m^3 and a value of $383.31 were made (Table 3). The under recovery was caused by five potential plylogs that were cut into sawlogs, e.g. a 5-meter sawlog was made instead of a 5.4-meter plylog, although the SED was sufficient to make the plylog. Another two out-of-specification plylogs in the actual solution were downgraded to sawlogs, which further increased the value loss of plylogs by $27.28 to $89.24.

In the optimal solution 29 sawlogs with a total volume of 6.7 m^3 and a value of $133.82 were manufactured, whereas in the actual solution 26 sawlogs with a total volume of 6.5 m^3 and a value of $130.05 were made (Table 3). The under recovery ($3.77) was caused by nine potential sawlogs that were cut into CNS logs in the actual solution. However, the two out-of-specification plylogs that were downgraded to sawlogs added $15.38 to the value of the sawlogs cut, therefore producing a net over recovery of $11.61 in sawlog value.

One-hundred-and-one (101) CNS logs with a total volume of 10.8 m^3 and a value of $107.68 were manufactured in the optimal solution, while the actual solution made 92 CNS logs with a total volume of 11.2 m^3 and a value of $111.01 (Table 3). The actual volume and value recovery were therefore greater, although the number of CNS logs and the total length of all the CNS logs were less than the optimal. In the actual solution 88% of the CNS logs had a nominal length of 3.8 m, whereas in the optimal solution 71% were 3.8 m. The actual solution therefore favored making longer CNS logs. The over recovery of value and volume was caused by cutting some sawlogs into CNS logs, although some CNS logs were in turn cut into pulp logs. However, the downgrading of sawlogs to CNS logs more than made up for the loss of CNS material to pulp logs. Due to two CNS logs being out-of-specification the value of these logs was further reduced by $0.09.

In the optimal solution, AVIS manufactured 91 pulp logs with a total volume of 4.8 m^3 and a value of $14.54, whereas in the actual solution 73 pulp logs with a total volume of 5.7 m^3 and a value of $16.99 were made (Table 3). The actual volume and value recovery was therefore greater, although the number of pulp logs and the total length of all the pulp logs were less than in the optimal solution. The over recovery of pulp logs was caused by the downgrading of some CNS material to pulp logs.

Site C

Forty-seven percent of the stems were cut to the exact optimal value. In the optimal solution, AVIS manufactured 161 logs with a total volume of 25.9 m^3 and a value $380.92, whereas in the actual solution (before adjusting for out-of-specification logs) 140 logs with a total volume of 25.5 m^3 and a value of $357.46 were made (Table 4). Therefore, a total value loss of $23.46 (6.2%) occurred. Twenty-six pulp logs in the actual solution were out-of-specification and the actual value recovered was therefore reduced by a further $0.10, which increased the total value loss to $23.56 (6.2%). At this site the actual solution recovered 93.8% of the optimal value.

Table 4. Optimal and actual number of logs, volume, value and length recovered at site C before adjustments for out-of-specification logs.

SITE C	Saw	Pulp	Total
# of logs: optimal	70	91	161
# of logs: actual	59	81	140
*Optimal – actual	–11	–10	–21
*% Difference	–15.7	–11.0	–13.0
Volume: optimal (m^3)	17.8	8.1	25.9
Volume: actual (m^3)	16.5	9.0	25.5
*Optimal - actual (m^3)	–1.3	+0.9	–0.4
*% Difference	–7.3	+11.1	–1.5
Value: optimal ($)	356.75	24.17	380.92
Value: actual ($)	330.42	27.04	357.46
*Optimal - actual ($)	–26.33	+2.87	–23.46
*% Difference	–7.4	+11.9	–6.2
Length: optimal (m)	312.9	478.7	791.6
Length: actual (m)	275.5	474.7	750.2
*Optimal - actual (m)	–37.4	–4.3	–41.4
*% Difference	–11.9	+3.0	–5.2

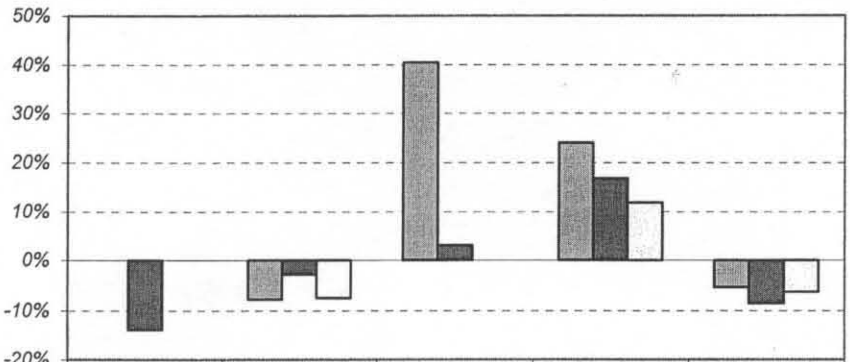
* A positive value = over recovery (actual > optimal)
* A negative value = under recovery (actual < optimal)

Seventy (70) sawlogs with a total volume of 17.8 m^3 and a value of $356.75 were manufactured in the optimal solution, whereas in the actual solution 59 sawlogs with a total volume of 16.5 m^3 and a value of $330.42 were made (Table 4). The actual volume, value, and number of sawlogs recovered were therefore less than the optimal. The under recovery was caused by the actual solution favoring longer sawlogs over shorter ones. In the optimal solution 49% of the sawlogs were 3.8 m while in the actual solution only 31% were a nominal 3.8 m. By cutting more, shorter logs the optimal solution produced a greater cumulative length of sawlogs (Table 3).

In the optimal solution 91 pulp logs with a total volume of 8.1 m^3 and a value of $24.17 were manufactured, whereas in the actual solution 81 pulp logs with a total volume of 9.0 m^3 and a value of $27.04 were made (Table 4). The actual volume, value and the total length of all the pulp logs were therefore greater, although the number of pulp logs was less than the optimal. In the actual solution 72% of the pulp logs were 6 m and longer, whereas in the optimal solution only 41% of the pulp logs were 6 m or longer. Hence, as with the sawlogs, the actual solution preferred to cut longer pulp logs that reduced the recoverable value of such logs. However, the value loss caused by the preference for longer pulp logs was more than made up for by the added value from sawlog material that was sub-optimized into pulp logs.

Discussion and Conclusion

At all sites the under recovery of higher-value products (plylogs and/or sawlogs) was associated with an observed over recovery of lower-value products (CNS and/or pulp logs) (Figure 1).

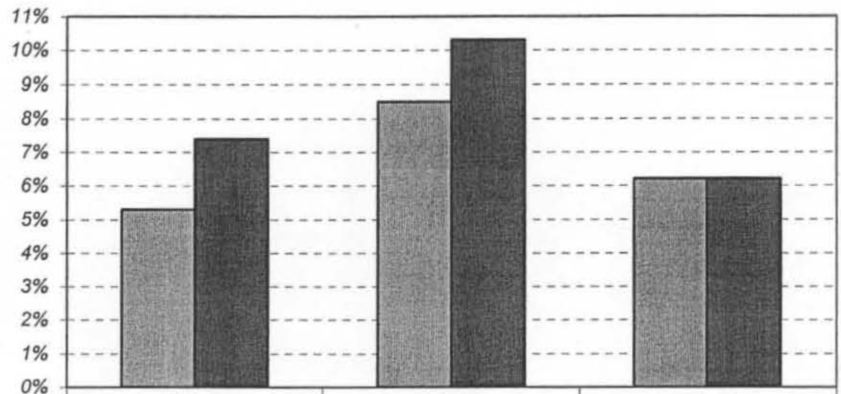


	Ply	Saw	CNS	Pulp	Total
Site A		-7.7%	40.5%	24.0%	-5.3%
Site B	-13.9%	-2.8%	3.1%	16.9%	-8.5%
Site C		-7.4%		11.9%	-6.2%

Figure 1. Percentage over and under recovery of value for all products at all sites before adjustments for out-of-specification logs.

The under recovery of the sawlogs at both sites A and C was caused by the preference of the actual solution to manufacture longer logs. The harvesters at both these sites appeared to have been programmed to optimize the longer sawlog lengths before the shorter ones. The rationale behind this could be that the logger preferred to handle fewer, longer logs or that the mills also preferred the longer lengths. The higher portion of longer lengths could be achieved by programming the computer with a higher relative price for such logs. At site A the total value loss increased from 5.3 to 7.4% after the value of out-of-specification logs were reduced appropriately. The corresponding increase in value loss at site C was negligible (Figure 2).

At site B, both plylogs and sawlogs were under recovered in value which resulted in an over recovery of CNS and pulp logs (Figure 1). The under recovery of the plylogs was caused by the cutting of potential plylogs into sawlogs. Some potential sawlogs were also cut into CNS logs. The error was caused by the harvester's diameter measuring system as it was shown in the optimal solution that the SED values were within specification. It is therefore imperative for the harvester operator to calibrate the measuring system on a regular basis. This downgrading of sawlogs led to an over recovery of CNS logs. In turn some CNS logs were downgraded to pulp logs leading to an over recovery of such logs. At this site the actual solution preferred to first cut the longer CNS and pulp log lengths. The value loss this preference caused, was more than made up for by the downgrading of higher value logs to lower value logs. The total value loss increased from 8.5 to 10.3% after out-of-specification logs were downgraded appropriately (Figure 2).



	Site A	Site B	Site C
Before	5.3%	8.5%	6.2%
After	7.4%	10.3%	6.2%

Figure 2. Value loss at all sites before and after adjustments for out-of-specification logs.

The value losses reported at the three sites included in this study are similar to the value loss of 6% reported by Boston and Murphy (in review) in a similar study conducted in the southeastern USA. They are also at the lower end of the range as reported by Murphy (2003) from 39 studies worldwide.

A further study should be conducted to ascertain the reasons why loggers preferred to make the longer lengths and if the costs savings from making and handling fewer, longer logs make-up for the loss in value recovered.

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