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Evaluation of Pulp Top Piece Extraction in Ground-Based Operations

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Summary

Liro investigated the effect of pulp top piece extraction on:
- estimated extraction costs,
- pulp value recovery, and
- cutover waste levels for ground-based operations.

Published tree breakage data from a range of sites formed the basis of this study.

Major findings were:

- At all sites, the cost of extracting pulp top pieces was greater than the revenue from the pulp. This generated a net cost.
- The greater the tree breakage, the larger the net cost.
- The higher the extraction productivity, the lower the net cost.
- Leaving pulp top pieces would increase cutover waste by about $8m^3$/ha on high breakage sites and $3m^3$/ha on low breakage sites.

This study highlights that the economic minimum specification for a forest is based on tree breakage, logging productivity and re-establishment issues. The Microsoft Excel spreadsheet used in the analysis is available from Liro.

Background

Liro has shown that increasing the minimum extracted piece size in cable operations can increase productivity and profits (McMahon et al. 1998). The current study aimed to determine if similar gains could be made in ground-based operations.

The extraction of pulp top pieces reduces logging productivity. This is because more time is spent recovering a given volume. The degree to which this occurs is a function of the logging system, site characteristics, tree breakage and the minimum extracted piece size.

For the purpose of this report, I will focus on two aspects:
- The effect of tree breakage and logging productivity on logging costs and pulp revenue.
- Levels of waste left on the cutover.

Consider that a single pulp top piece may have a value of $0.50 to $3.50 (@$40/m^3). In contrast, a ground-based operation costs about $5.55 per productive minute[1]. Average cycle times may vary from 6 to 10 minutes. Based on these figures, it may appear that pulp top piece extraction is uneconomic.

There are two ways of looking at the profitability of top piece extraction:
1. Extraction of the higher value butt pieces subsidises the extraction of the top pieces.
2. Extraction of pulp should be profitable. It should not reduce the profitability of other log grades.

This report has adopted the second point-of-view. I will focus on the degree to which logging cost ($/ha) exceeds the recovered value per hectare in ground-based operations.

[1] Based on $2500 daily cost and 7.5 productive hours per day

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Importance of tree breakage

As a manually felled tree hits the ground, it typically breaks at 2/3 of its total height. This breakage generates a butt piece, and one or more top pieces. The volume of these individual top pieces is generally less than $0.1m^3$. Top pieces often contribute less than 5% of the total extracted volume and 1% of the extracted value.

Although low on volume and value, top pieces significantly affect the number of pieces available for extraction. This, in turn, affects the extraction costs. Simply, the more top pieces there are, the more cycles that are required to extract them. The more cycles required, the greater the cost.

Another factor is the minimum extractable piece size specification. The smaller the minimum specification, the more pieces that will be recovered.

These effects are shown using selected data from Fraser et al. (1997), which investigated breakage in manually clear-felled radiata. In their study, top pieces were classified by length, ranging from 1.2 m to > 6 m (SED greater than 10cm). Top piece SEDs or volumes were not measured in their study. In this report, piece volumes were estimated using an SED of 10cm and a taper of 1cm/m length. All top pieces were assumed to be pulp pieces.

The number of pieces available for extraction will affect the productivity of an operation. For example, consider two ground-based operations with similar capabilities. One works on a low breakage site (Kaweka) and the other on a high breakage site (Ngaumu)[2]. As the minimum specification length decreases, there are more merchantable pieces per hectare at Ngaumu than at Kaweka (Figure 1).

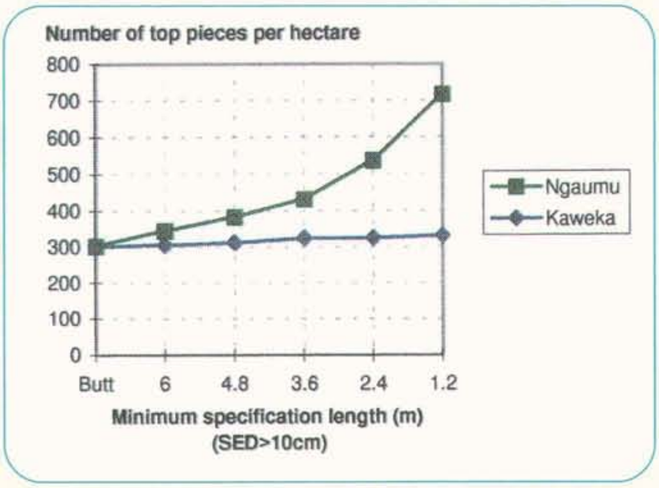

Figure 1 - Effect of minimum specification on number of merchantable pieces per hectare for Kaweka (low breakage site) and Ngaumu (high breakage site)

As the minimum specification length decreases, productivity decreases. This is more pronounced at Ngaumu than at Kaweka (Figure 2a) because of the larger number of top pieces at Ngaumu. In turn, this means that greater gains in productivity can be made at Ngaumu than at Kaweka if the specification length is increased.

These changes in productivity will influence logging costs per hectare. Any change in minimum specification that reduces productivity, should increase extraction costs. Conversely, any change in specification that increases productivity should reduce extraction costs.

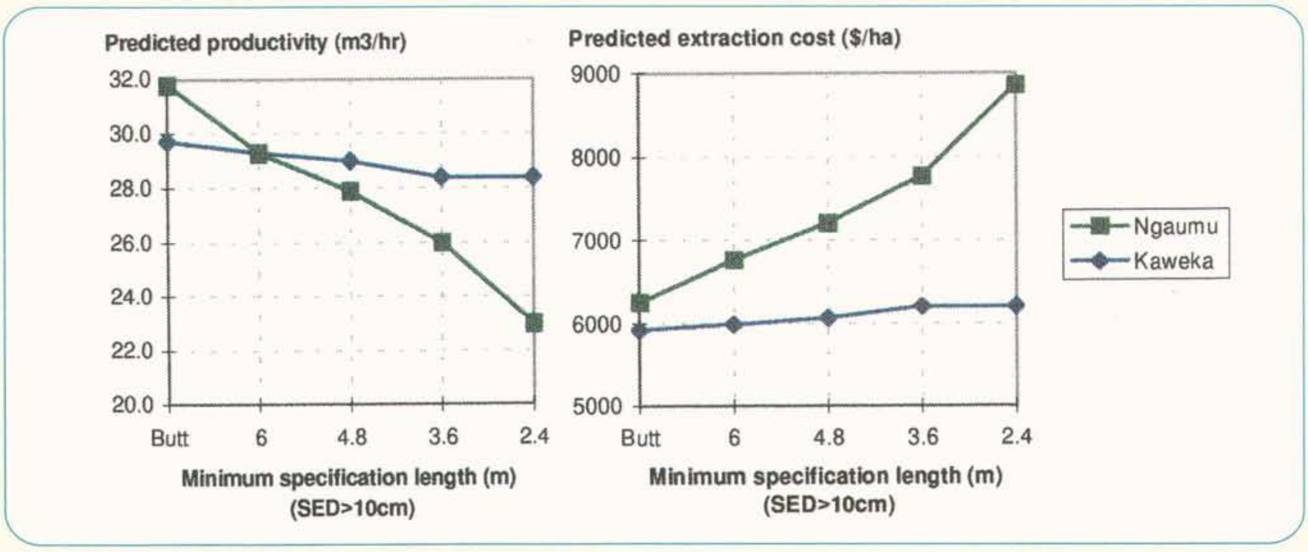

Figure 2 - Example of predicted (a) extraction productivity and (b) extraction costs for a range of minimum length specifications

Note: The following assumptions were made in the above calculations:
Productivity = 10 (Drag vol) $^{0.6}$
Drag Vol = 3.5 pieces x average piece size
$2,500 per 7.5 hour productive day
Pulp value $40 per m^3
Transport costs have not been included

[2] In this report, low breakage sites were defined as having >40% unbroken felled and high breakage sites were defined as having <20% unbroken felled trees based on the breakage study of Fraser et al. (1997).

This can be shown in Figure 2b. As the minimum length is reduced, the predicted logging costs increase more rapidly at Ngaumu than at Kaweka. The increase in logging costs outweighs the increased revenue from the pulp top pieces. This results in a net cost per hectare. Figure 3 shows the net costs over a range of minimum length specifications, for Ngaumu and Kaweka.

At Ngaumu, the net cost quickly increases as smaller pulp top pieces are extracted. Changing the minimum length specification from 3.6m to butts only could save $1180 per hectare. Conversely, changing the minimum specification from 3.6m, to 2.4m length could increase net costs by $960 per hectare.

The increase in net costs at Kaweka is less than Ngaumu. Savings of about $230 per hectare could be made by changing the minimum length from 3.6m to butts only.

Net cost estimates (given the assumptions shown in Figure 3) for 20 sites studied by Fraser et al. (1997) are shown in the Appendix.

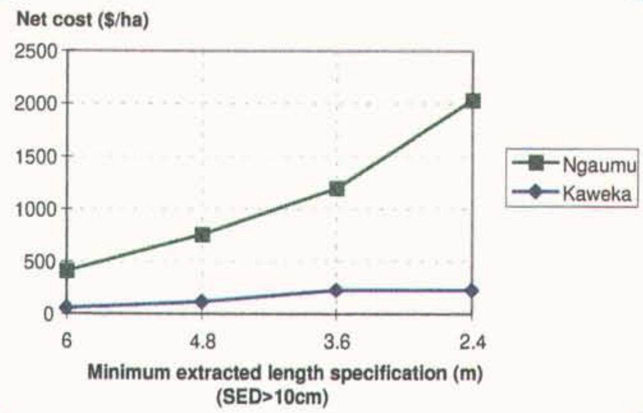

Figure 3 - Predicted net costs for Ngaumu (high breakage site) and Kaweka (low breakage site)

Effect of mechanisation on breakage

Mechanised felling has the potential to reduce tree breakage. This, in turn, will affect the economics of pulp top piece extraction. Tree breakage data for mechanised felling is not readily available, making it difficult to provide clear trends. However, according to Andy Gordon (Mensuration Scientist, *Forest Research*) mechanisation is likely to increase the relative break height from 2/3, to 4/5 tree height. Thus, mechanisation will reduce the volume of pulp tops and is likely to reduce the number of broken pieces. For the same daily cost, mechanisation will reduce the net cost of pulp top piece extraction compared to a manual operation. However, if mechanisation is more expensive, then the benefit of reduced breakage may be offset.

Effect of logging productivity

Productivity will affect the net costs, as it influences the time required to log an area. Consider two systems with the same daily cost. The higher productivity system will extract a given number of top pieces faster (and at a lower cost) than the lower productivity system. Hence, the net costs will be less for the higher productivity system.

This can be demonstrated using data from Fraser et al. (1997). Figure 4 shows predicted net costs given three average drag sizes (3, 4 and 5 pieces per drag).

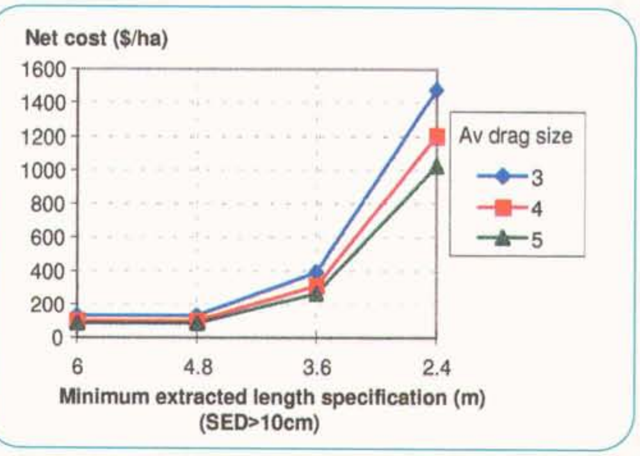

Figure 4 - Effect of drag size (average number of pieces) on net costs

Note: The following assumptions were made in the above calculations:
Kinleith breakage data
Productivity = 10 (Drag vol) $^{0.6}$
Drag Vol = average no. pieces x average piece size
$2,500 per 7.5 hour productive day
Pulp value $40 per m^3
Transport costs have not been included

Cutover waste levels

A possible concern when leaving pulp top pieces on the cutover, is the potential for increased hindrance during re-establishment. The amount of waste left will be a function of tree breakage and the minimum specification applied.

For example, Table 1 shows how much extra waste could be generated for two specification changes, at three high and three low breakage sites.

	Increase in waste (m^3/ha)	
	3.6m, 10cmSED to 4.8m, 10cmSED	3.6m, 10cmSED to butt pieces only
High breakage sites		
• Ngaumu	2.4	8.2
• Kaingaroa North	2.0	7.5
• Tapanui	1.3	4.5
Low breakage sites		
• Kaweka	0.6	1.5
• Woodhill	0	0
• Glenbervie	0.7	2.6

Table 1 - Increase in cutover waste due to two specification changes

At the high breakage sites, changing the minimum length from 3.6m to butts only would increase waste volumes by up to $8m^3$ per hectare. At the low breakage sites, the waste volume would increase by up to $3m^3$ per hectare. Note, that the lack of top pieces longer than 3.6m at Woodhill meant that there was no increase in cutover waste.

Conclusions

This report has summarised the effects of pulp top piece extraction in ground-based operations. Although based on published tree breakage data, the findings demonstrate the drivers and effects of economical pulp top piece extraction.

Analysis has shown the following:

- Savings in logging costs can be made by retaining pulp top pieces on the cutover.
- Substantial cost increases are likely if extracting smaller volume pulp top pieces from a site.
- These savings or costs are greater on sites with high breakage and/or low productivity logging systems
- The amount of additional waste on the cutover is a function of the specification change and tree breakage. For instance, increasing the minimum length from 3.6m to butts only would add an $8m^3$/ha on high breakage sites and $3m^3$/ha on low breakage sites.

The definition of a single minimum pulp specification is impracticable due to the effects of site, crop, tree breakage, extraction productivity, and pulp demand. The identification of an appropriate minimum specification for pulp is therefore best defined given local conditions. The Microsoft Excel spreadsheet used in the analysis of the study data is available from Liro.

References

Fraser, D., Palmer, D., McConchie, D. and Evanson, T. (1997) : Breakage in manually felled clearfell radiata pine. LIRO Project Report PR63.

McMahon, S., Evanson, T., Hall, P. and Baillie, B. (1998) : Cable extraction of pulp: Effect of minimum extracted piece size on productivity. Liro Report 23(14).

Appendix

	Net cost ($/ha)				
	6	4.8	3.6	2.4	1.2
Glenbervie	190	250	390	540	1200
Riverhead	190	190	760	1430	2840
Woodhill	0	0	0	70	280
Tairua	260	440	660	1320	1800
Rotoehu	340	680	1290	2440	3670
Tarawera	790	1020	1360	1700	3060
North Kaingaroa	480	800	1240	2170	3810
South Kaingaroa	290	400	910	1750	3390
Kinleith	120	120	350	1330	2500
Mangatu	120	500	710	840	1600
Mohaka	400	1120	1620	3300	5330
Kaweka	50	110	230	230	290
Gwavas	0	370	770	1180	2150
Ngaumu	380	720	1180	2140	3740
Nelson	0	360	650	970	2190
Golden Downs	80	340	550	830	1650
Ashley	90	250	400	710	1220
Otago Coast	210	300	401	950	2370
Tapanui	220	370	610	1400	3710
Invercargill	210	250	400	500	1200