SPLIT- *VERSUS* FULL-TAPER SAWING OF PRUNED PLANTATION-GROWN LOGS

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ABSTRACT

Trials in three sawmills directly compared conversion of pruned, plantation-grown, *Pinus radiata* D.Don logs by split-taper and full-taper sawing systems. No decided advantage from either system was found in recovery of defect-free Clears, either by volume or by lengths. Full-taper sawing reduced total conversion by 3.4–4.7%, conversion to combined clears grades by 2.2–6.5%, and gross log values by 4.9–10.9%. Full-taper sawing was more difficult to implement, required additional cutting to square cants and blocks, and was estimated to lower mill production rates by 5–20%. Combined results proved full-taper sawing inappropriate for conversion of pruned plantation-grown logs.

Keywords: pruned logs; sawing systems; split-taper; half taper; full-taper; clearwood recovery; log conversion.

INTRODUCTION

For many years there has been dispute in New Zealand over the relative merits of split-taper and full-taper sawing of artificially pruned plantation-grown logs. (Split-taper is also known as half-taper sawing.) Although opinions are divided also in Canada and the United States, at present the majority of North Americans seem to favour the full-taper approach on their naturally pruned large logs. This may be influenced partially by the fact that their large Japanese market has a preference, and pays a premium, for parallel grain orientation in species such as hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and this can only be achieved by full-taper sawing.

The weight of North American opinion has exerted a strong influence in New Zealand and several mills have been trialling the full-taper approach on pruned *P. radiata*. In the last year Interface Forest & Mill (IF&M) conducted studies directly comparing split- and full-taper sawing in three sawmills and some of those results are reported here. The names of the mills have been withheld to preserve confidentiality. Prior to the studies, the mills were aware that the full-taper approach caused some loss in total conversion but this was believed to be more than offset by an increase in clears grades, particularly in full-length clears.

Mill A was sawing clearwood to random width mouldings grades, maximising wides, for the United States market. Mills B and C were producing mouldings and millwork grades in predominantly narrow sizes. Therefore, these studies covered the two extremes. Sizes sawn, grading criteria, and timber pricing structures differed markedly between mills but, because methods in all IF&M sawing studies on pruned logs are standardised, basic results may be directly compared. Study techniques have evolved from the methods of Park & Leman (1983). Important aspects are that the quality and clearwood potential of each study log are defined by measurement and, in addition to evaluating recoveries by the timber grades specific to the mill, all produce is also graded and tallied by a simplified set of grades common to all types of pruned log sawing. These simplified grades are also recognised by the Autosaw sawing simulator (Todoroki 1990). The reasons for applying simplified grades are to provide for appraisal of mill performance using Autosaw, to provide for direct comparisons with simulation established benchmarks, and to allow results from various mills to be directly compared. Most mills recognise and recover a completely defect-free Clear grade but definitions of secondary clears vary greatly. However, as indicated later in this paper, combined clears grades from any mill can be directly related to straightforward Clear + Clear 1 Face grades. Further, results from over 60 pruned log sawing studies conducted by this author have shown that the levels of recovery in Clear + Clear 1 Face grades are accurate indicators of a mill's efficiency in grade sawing pruned logs, irrespective of the specific timber grades and markets the mill is cutting for.

OBJECTIVES

The objectives of these analyses were to convert results from the three mills to a common basis and then directly compare split- and full-taper sawing in terms of:

(1) Total conversion to sawn timber;

(2) Conversion to Clear grade (primary clears);

(3) Conversion to Clear 1 Face grade (secondary clears);

(4) Value recovered per cubic metre of log sawn.

DATA

Pruned Log Samples

Two sets of 18 pruned *P. radiata* logs, one set to be sawn to split-taper and the other to full-taper, were selected from the yard at each mill. Therefore, results presented here are from sawing a total of 108 logs. Sampling aimed to span the full range of log quality available and match sample sets at each mill by external log characteristics. Paired sub-sets of six logs were selected to span the diameter range found in each of three log stacks. Each log stack contained pruned logs of different specification and/or logs drawn from different forest locations.

Sawing

All mills used a carriage with independent knees and a band-saw for primary log breakdown. Downstream machines varied from a simple breastbench in the smallest mill (Mill A) to a combination of resaws and edgers in the largest (Mill C). Nominal sizes sawn and timber grades recovered by each mill were common to both split- and full-taper sawing systems and are summarised in Table 1. (Actual sizes recovered and differences in overcut levels are not relevant to the purpose here and so have been omitted.) The approach to full-taper sawing varied among the mills and a summary of methods showing salient differences is given in Table 2. An equivalent summary for split-taper sawing is unnecessary because,

TABLE 1–Sizes sawn and timber grades recovered

	Mill A	Mill B	Mill C
A. Clearwood grades			
Target grades	US Mouldings, US Shop	Mill Clear & Mouldings	Mill Clear & Mouldings
Thickness	36 mm	38 mm	48 mm
Widths	Random 125 to 450 mm	Moulding & millwork 50, 65,75, 90, 100, 125, 130, 150 mm	Moulding & millwork 69, 108, 136 mm
Alternative grades	NZ Clear & #1 Cuttings	Mill Premium Cuttings & Select	Mill Clear, Mouldings, Cuttings
Thickness	25 & 40 mm	25 mm	25 & 48 mm
Widths	NZ standard 75, 100, 150, 200, 250 mm	NZ standard 50, 75, 100, 150, 200, 250, 300 mm	Mill specific 69, 108, 136 mm
B. Knotty and pith grades (from log centres)			
Grades	NZ Dressing, Framing, Cut of Log	NZ Dressing, Framing, Merch, Box	Mill K Grade, Industrial
Thickness	25 & 50 mm	25 & 50 mm	48 &102 mm
Widths	NZ standard 75, 100, 150, 200 mm	NZ standard 50, 75, 100, 150, 200, 250 mm	Mill specific 136, 102 mm

TABLE 2–Summary of full-taper sawing systems

	Mill A	Mill B	Mill C
Face 1			
Taper set	Full	Full	Full
Thicknesses	Main 36 mm, 25 mm allowed	Main 38 mm, 25 mm allowed	48 mm only
Turn 1	90°	90°	90°
Face 2			
Taper set	Full	Full	Full
Thicknesses	Mainly 36 mm, 25 mm allowed	Mainly 38 mm, 25 mm allowed	48 mm only
Turn 2	180°	180°	90°
Face 3			
Taper set	Nil	Restricted, 30 mm max.	Full
Thicknesses	Mainly 36 mm, 25, 40 mm allowed	Mainly 38 mm, 25 mm allowed	Mainly 48 mm, 25 mm allowed
Squaring cut (wedge)	Not required	Yes	Yes
Cant sizes	Adjusted to knotty core 150 or 200 mm	Adjusted to knotty core 100, 150, or 200 mm	1 fixed size all logs 136 mm
Cant			
Taper set	Full	Restricted , 30 mm max.	Half
Thicknesses	36, 25, 40, 50 mm	38, 25, 50 mm	48, 25, and 1 x 100 mm
Squaring cut (wedge)	Yes	Yes	Yes

Note: Thicknesses recovered per face and cant sizes for split-taper sawing were the same as shown above for full-taper although sawpatterns varied, the basic application was the same. For split-taper sawing the log was set to half-taper on the opening face and also on the second face which was at right angles to the opening face. For sawing on the other two faces, with the opposing squared face against the carriage, the knees were set in line. In effect this meant half-taper was applied to each of the four faces, all sawcuts were parallel to the central axis of the log, and the taper of the log was evenly split. Grades, thicknesses, priorities, and cant sizes for split-taper were the same as shown in Table 2 for full-taper. Examples of the split- and full-taper sawpatterns from each mill, which include both primary and secondary breakdown to final thicknesses, are given in Fig. 1–3.

Mill C made the greatest use of full-taper so, in addition to the sawpatterns, Fig. 3 includes X and Y plane views of a log and its knotty core to demonstrate how timber was recovered over the whole log length. Points to note from full-taper sawing (Fig. 3b) are that waste wedges were produced from more than just the base of logs and contained a lot of clearwood, and that full-taper sets tended to displace defect cores which usually ran diagonally across cants as shown in the diagram.

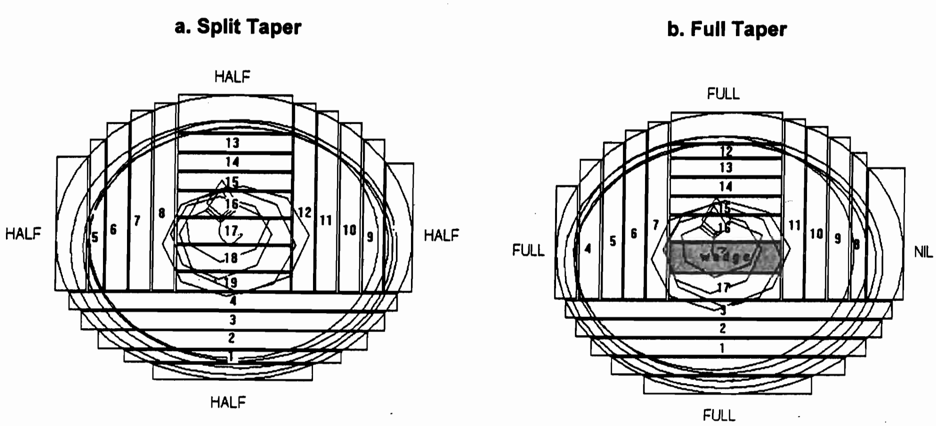


FIG. 1–Examples of sawpatterns and taper sets at Mill A.

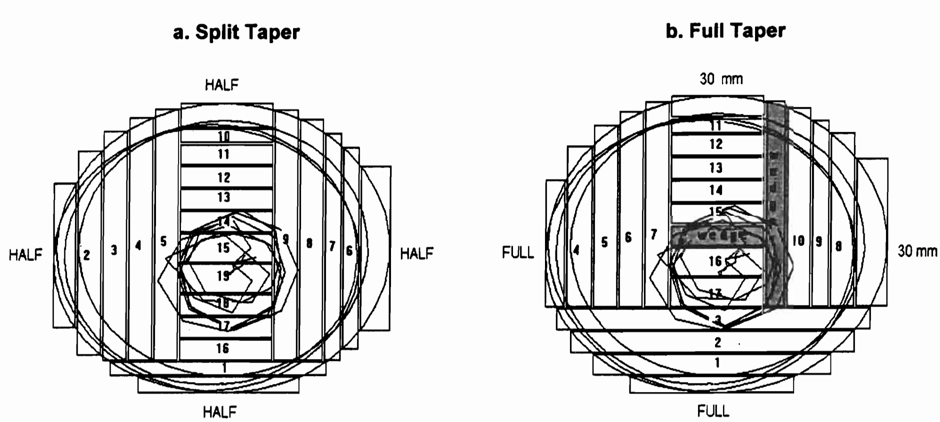
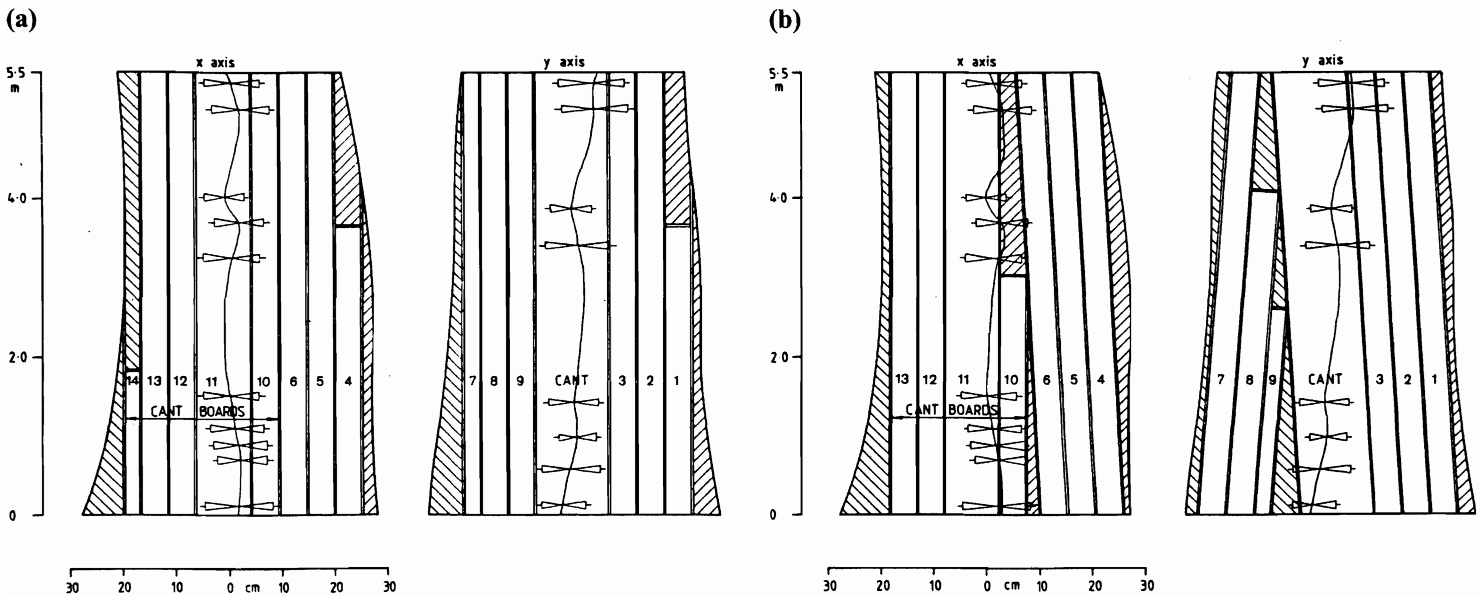
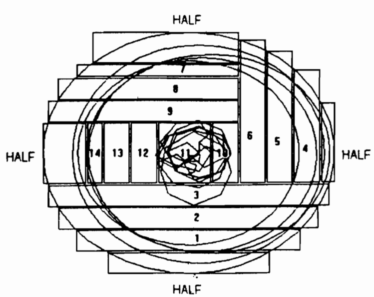


FIG. 2–Examples of sawpatterns and taper sets at Mill B





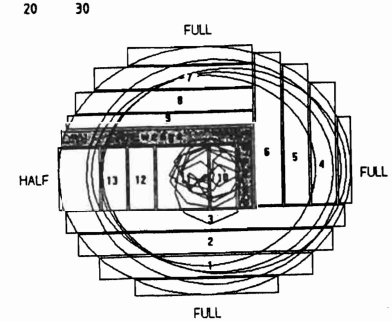


FIG. 3—(a) Example of primary log breakdown and taper sets for split-taper sawing at Mill C. X and Y plane views show full log and knotty core profiles and how timber was recovered over the whole log length.

(b) Example of primary log breakdown and taper sets for full-taper sawing at Mill C. The full-taper system has been superimposed over the same log used to demonstrate split-taper (Fig. 3a) to show differences in wood waste and intersection of the knotty core. A total of five waste wedges are created under this full-taper system, with three being in the upper half of the log, and the defect core is most often displaced to run diagonally across the cant.

A major difference between general sawing at the three mills was in width recovery. In Fig. 4 width recoveries in three broad classes are compared; narrows 50–136 mm, standards 150–200 mm, and wides ≥225 mm. Mill A maximised standards and wides, Mill B produced a mixture of widths but with more than half as narrows, and at Mill C all timber was recovered as narrows. Therefore, the range of width options was well represented in these studies.

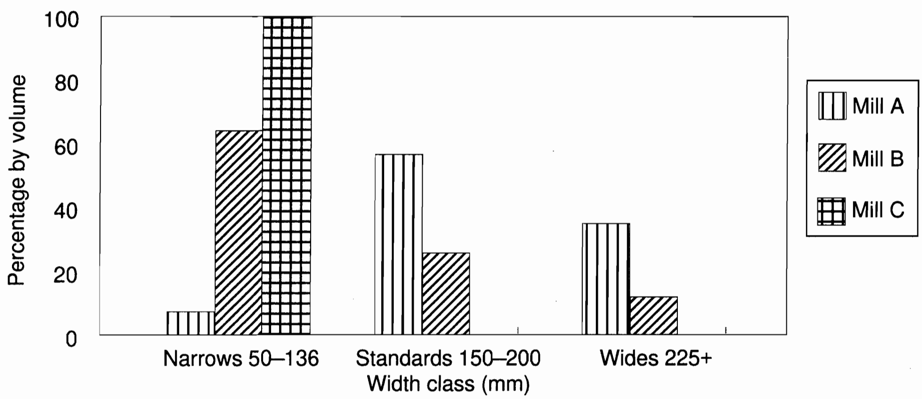


FIG. 4–Comparison of widths recovered at each of the three mills.

METHODS

A double study, in which externally matched paired sample sets of 18 pruned logs were sawn to split-taper and full-taper systems, was carried out at each mill. In all but one situation, sawing systems were those developed by the mill and mill personnel controlled the sawing. The one exception was split-taper sawing at Mill B where study personnel nominated the sawpattern and controlled primary log breakdown at the headrig. Timber was green graded first by the mill to mill-specific grades and then twice by study personnel to simplified mill-independent grades. The first of these simplified grading routines included the effects of resin pockets and the second ignored them. Each double study was conducted at two levels to produce both batch results and relationships, derived from individual log analyses, between log quality and recovery. A major advantage in the latter is that sample sets do not need to be well matched and direct comparisons are valid over common sections of the log quality range. Batch results and results from mill-specific grades are limited and not directly comparable between mills. Resin pockets are randomly occurring defects which affect timber grade but do not influence sawing decisions. Therefore, inter-mill comparisons made here are based on relationships derived from individual log analyses using IF&M grading criteria with resin pockets ignored. Methods of data acquisition and analyses are described briefly below.

At the mill, the under-bark profiles of each sample log were measured, using nine intervals, in two planes at right angles to provide data on size and shape as well as for accurate calculation of log volume. Logs were colour coded on the ends and sawn in sub-sets of six at normal mill operating speed. Application of the sawpattern was recorded by diagram as logs were broken down and the path of all pieces through the mill was tracked by horizontal colour stripes applied on entry to the various machine centres. All timber was marked by log of origin prior to docking and mill exit. In the yard, timber was graded and tallied by log and, for Mills B and C only, the journey of each piece through the mill was recorded. Then the knotty centre of each was "rebuilt" to provide for plotting and measurement of the defect core.

The quality of each log sawn was determined from the measurements taken and expressed as the indices Conversion Potential factor (CP) and Pruned Log Index (PLI) (Park 1989); CP is a single expression of log size and shape which relates directly to total conversion, and PLI combines measurements on log size and shape with the diameter of the defect core to provide an absolute measure of pruned sawlog quality and clearwood potential. Full descriptions of the indices and their formulas are given in Appendix 1.

Non-linear regression analyses were used to derive relationships between log quality, conversions, and value from split-taper and full-taper sawing in each of the mills. CP was used to determine total conversion levels and PLI was used to determine levels of clears recovery, i.e., conversions to Clear and Clear 1 Face grades. PLI was also related to gross log value. Gross log value ($\$/m^3(r)$) is the value of all timber and residues recovered from 1 m^3 of debarked log. It does not include the cost of sawing. Gross log values here are based on the chip credit and green roughsawn price list for IF&M timber grades (Table 3). That price list includes the most common sawmill equivalents to IF&M grades and is a composite of the widely varying mill lists being used at the time of these studies. Only one of the mills had been applying length premiums and, owing to differing mill objectives concerning widths (*see* Fig. 4), composite width premiums would be misleading. Therefore, length and width premiums were both inappropriate to the purpose here and were excluded.

TABLE 3–Composite green rough-sawn timber price list (no length or width premiums)

Simplified grade	Sawmill equivalent	Price ($\$/m^3$)
Clear	Defect-free clear	1,000
Clear 1 Face	Clear 1 face and both edges	850
No.1 Cuttings	70% in clear-cuttings 1 m or longer	700
No.2 Cuttings	60% in clear-cuttings 0.6 m or longer	500
Knotty	May include Dressing, No.1&2 Framing, Merchantable, and Cut of Log	375
Pith In	May include Cut of Log, Industrial, and Box	200

Chip credit = $\$50/m^3$

RESULTS

Grade Equivalence

Before examining and comparing results based on IF&M timber grades it is important to establish how well IF&M clears relate to mill-specific clears grades. A typical example is given in Fig. 5 where IF&M combined clears grades, i.e., Clear + Clear 1 Face, from individual logs are plotted and regressed against recovery in Clear + Mouldings + Select + Premium Cuttings grades from Mill B. A dotted 45° line ($x=y$) has also been included to show where a perfect correlation would fall.

Conversion and Value

The relationships derived between log quality indices and total conversions, conversions to clears grades, and gross log values for each of the sawing systems in each of the mills are listed in Appendix 2.

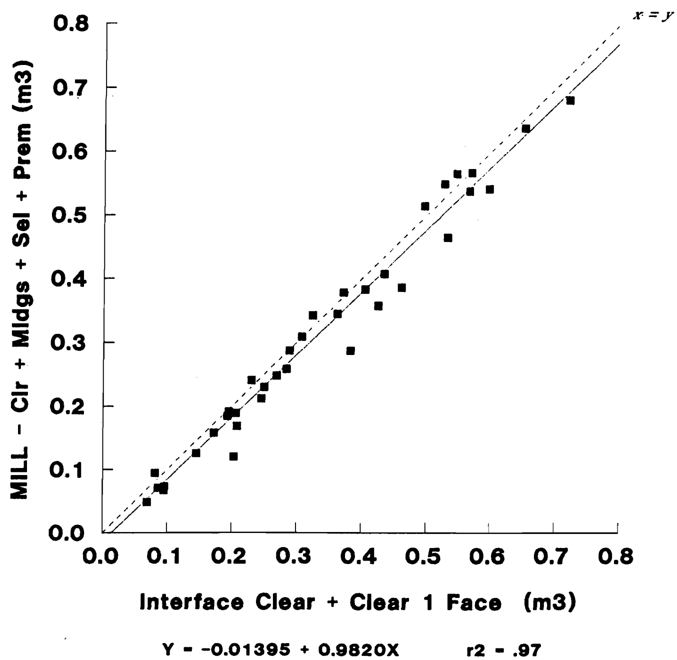


FIG. 5–Example, using results at Mill B, of a typical relationship between IF&M simplified clears grades and mill-specific clears grades.

Clears recoveries (all lengths), across the range of PLI common to all sample sets, are given by mill in Fig. 6a–c. These differentiate primary (Clear) and secondary (Clear 1 Face) clears as recovered from each of the sawing systems. At Mill A (Fig. 6a) split-taper sawing gave better recovery of Clear in the lower portion of the PLI range but full-taper produced higher Clear recovery from the best logs. At Mill B (Fig. 6b) that trend was reversed. At Mill C (Fig. 6c) split-taper gave higher Clear recovery right across the range. When combined clears grades are considered, split-taper shows higher recoveries in all instances. An important point to appreciate is that the amount of full-taper sawing applied varied, and it increased from Mill A through to Mill C—*see* Sawing. There was an overall advantage in clears recovery from split-taper sawing and this advantage increased as full-taper options were more completely applied.

Relationships between gross log value and PLI for split- and full-taper sawing from each mill are compared in Fig. 7a–c. The overall advantage of split-taper sawing indicated from clears recoveries in Fig. 6, and the increase in this advantage as full-taper is more completely applied, become more obvious when gross log values are considered. This is because the differences in total conversion to sawn timber exert influence, additional to clears recovery, on gross log values.

In general, log quality sampled at each of the mills was similar but it should be recognised that logs of PLI higher than 9.0 are the "cream" of crops and unlikely to represent more than 5% of any mill's annual log intake. Analyses of all available data (not shown) indicated that, providing these mills continued to purchase the best pruned logs available, pruned log quality

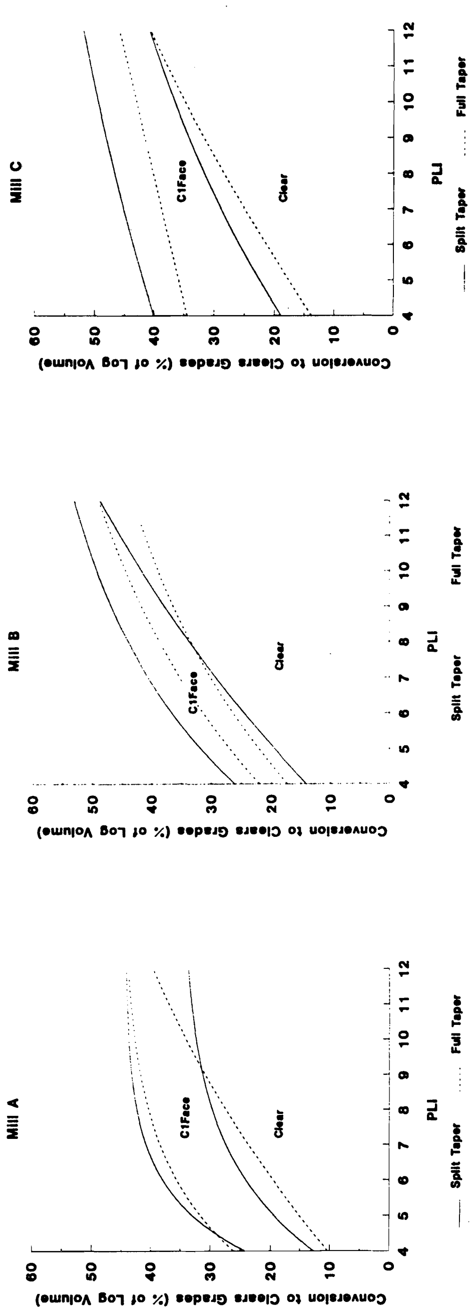


FIG. 6–Conversions to IF&M Clear and Clear 1 Face grades, from each mill and each sawsystem, across the common range of PLI.

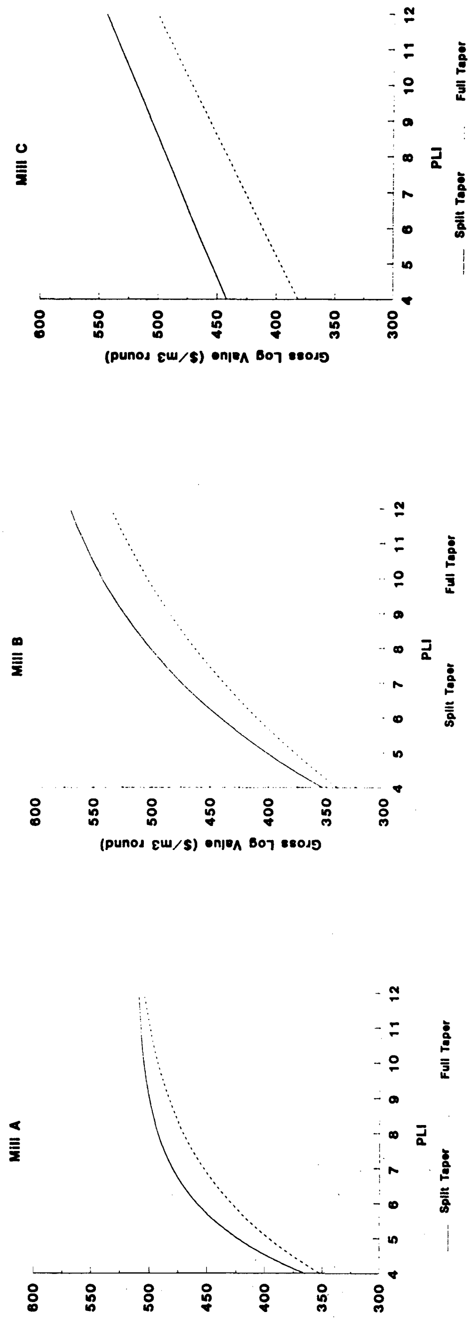


FIG. 7–Gross log values, from each mill and each sawsystem, across the common range of PLI.

over the next year could be expected to average CP 3.1 and PLI 7.5. Recoveries and values from the "average log" were compared (Table 4) by substituting the above values in the equations given in Appendix 2. Results confirmed split-taper as the superior system. Taking split-taper sawing as the base, full-taper sawing showed reductions of 3.2–4.7% in total conversion and nearly all of those losses were in clears grades. Gross log values from split-taper sawing at $487–$489 were remarkably similar under the price list used. Gross log values from full-taper sawing ranged from $463 down to $434, showing reductions in returns of $24–$53 which translate to losses of 4.9–10.9%. Losses increased as full-taper options were more completely applied, i.e., from Mill A through to Mill C. Those losses in gross log value were very significant and may best be placed in perspective by applying them to the expected annual cut of pruned logs. On an annual cut of 40 000 m^3 of pruned logs, which was the best estimated average across the three mills, full-taper sawing would reduce returns by $0.96 million to $2.12 million under the price list used.

TABLE 4—Comparisons of recoveries and values from the average log (Conversion Potential factor = 3.1, Pruned Log Index = 7.5)

Conversion to	Sawing system	Mill A (% of log)	Mill B (% of log)	Mill C (% of log)
Clear	Split taper	28.7	31.5	30.3
	Full taper	25.6	31.8	26.7
	Difference	***3.1***	***–0.3***	***3.6***
Clear 1 Face	Split taper	13.0	10.9	15.7
	Full taper	13.9	5.2	12.8
	Difference	***–0.9***	***5.7***	***2.9***
Other grades	Split taper	17.2	16.7	15.0
	Full taper	15.8	18.9	16.8
	Difference	***1.4***	***–2.2***	***–1.8***
Total—all grades	Split taper	58.9	59.1	61.0
	Full taper	55.3	55.9	56.3
	Difference	***3.6***	***3.2***	***4.7***
		($/m^3(r))	($/m^3(r))	($/m^3(r))
Gross log value	Split taper	$487	$489	$487
	Full taper	$463	$452	$434
	Difference	***$24***	***$37***	***$53***
		(4.9%)	*(7.6%)*	*(10.9%)*

Full-length Clears

Percentages of log volume converted to full-length clears only were isolated and regressed against PLI. The relationships derived are included in Appendix 2. Conversion to full-length clears from the "average" log is summarised in Table 5 which was composed by substituting PLI 7.5 in the equations. When split-taper sawing is taken as the base, conversion among mills to full-length Clear ranges from –1.0% to 3.7% and there is no decided advantage from either sawing system. However, when combined clears (Clear + Clear 1 Face) are considered there is a consistent advantage from split-taper sawing, ranging from 1.2% to 3.3%.

TABLE 5–Conversion to full-length clears from the average log (Pruned Log Index = 7.5)

Mill	Sawing system	Full-length recovery in:		
		Clear (% of log vol)	Clr 1 Face (% of log vol)	Total clears (% of log vol)
Mill A	Split taper	16.6	10.1	26.7
	Full taper	12.9	12.6	25.5
	Difference	***3.7***	***–2.5***	***1.2***
Mill B	Split taper	13.4	7.5	20.9
	Full taper	14.4	3.2	17.6
	Difference	***–1.0***	***4.3***	***3.3***
Mill C	Split taper	19.7	13.4	33.1
	Full taper	19.2	10.6	29.8
	Difference	***0.5***	***2.8***	***3.3***

Effects on Mill Production Rates

Prior to these studies all three mills acknowledged that production rates went down whenever they applied full-taper sawing systems. To quantify that accurately would require a different type of study from those conducted here. However, by identifying the production-limiting machine centre(s) and determining the number of passes required to complete the processing of 1 m^3 of log, estimates of differences in production rates between sawing systems were calculated for Mills B and C. Insufficient data were gathered on Mill A for this purpose.

Production-limiting machines at Mill B were the breast-bench and the resaw, both of which had return systems, and delays at either caused waiting time at the headrig. The large amount of recycling required to completely square and finish the two wedge-shaped flitches produced per log under full-taper sawing (*see* Fig. 2b) increased the number of passes required at the breast-bench by 6.3% and the number of passes required at the resaw by 26.5%. This was estimated to reduce overall mill production rate by 15–20%.

Production at Mill C was governed by the speed at which the headrig could produce pieces for the many downstream machine centres. A high number of double thickness flitches were produced at the headrig and sent to the horizontal resaw for secondary flitch production. When full-taper sawing, an additional cut was required to square the cant (*see* Fig. 3b). This increased the number of headrig passes by 10% and was estimated to reduce the overall mill production rate by 5%.

CONCLUSIONS

Conclusions drawn from these results are limited to artificially pruned plantation-grown logs. For all logs included in these studies the smallest part of the knotty core was in the butt end, which is the largest part of the log, and the maximum diameter of the knotty core occurred in the top half of the log. Over the past 10 years this author has sampled and internally assessed pruned logs from well in excess of 100 stands spread throughout New Zealand, and can confirm that the basic shape of knotty cores as found in these studies is typical of at least 95% of current forest crops. However, results here may not be directly applied to naturally pruned logs with irregular knotty cores and/or branches remaining on some faces.

Most of the conclusions listed below are based on components of conversion of the "average" pruned log expected by all three mills over the year following these studies. While clears recoveries in terms of components of conversion may be less familiar to many than percentages of sawn outturn, the former has been chosen throughout this paper as the only sensible way of accommodating differences in total conversions and mill strategies to bring all results to a common base. This may tend to minimise the differences found to those less familiar with conversion to grade. To assist with perspective, expected differences in percentages of sawn outturn would be approximately double the differences in conversion to grade shown below.

(1) Full-taper sawing reduced total conversion rates by 3.2–4.7%

(2) Full-taper sawing did not increase recovery in primary clears. In one mill these were similar under both sawing systems. In the other two mills full-taper caused reductions of over 3%.

(3) Full-taper sawing did not improve recovery in full-length primary clears. There was no decided advantage from either sawing system.

(4) Full-taper sawing reduced recovery in combined clears grades by 2.2–6.5%.

(5) Full-taper sawing reduced full-length recovery in combined clears grades by 1.2–3.3%.

(6) Full-taper sawing reduced gross log values by \$24–\$53, or 4.9–10.9%, under the price list used.

(7) On an annual pruned log cut of 40 000 m^3, exclusive implementation of full-taper sawing would result in losses of \$0.96 million to \$2.12 million under the price list used.

(8) Full-taper sawing is more difficult to implement and was estimated to lower mill production rates by 5–20%.

(9) The disadvantages in full-taper sawing (1–8 above) increase as taper options are more completely implemented.

(10) Full-taper sawing is a poor option and an inappropriate system for the conversion of pruned plantation-grown sawlogs.

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APPENDIX 1

PRUNED SAWLOG INDICES

Conversion Potential factor and Pruned Log Index

The clearwood potential of a pruned sawlog depends on log size, log shape, and the size of the defect core. (The defect core, a description of the pruned knotty core applicable to sawlogs only, is the "cylinder" inside the log which contains the pith, pruned branch stubs and occlusion scars. The size of this core is expressed by its diameter.) Those measurable log variables are combined in Pruned Log Index (PLI) which is a single expression of pruned sawlog potential to produce clears grade timber "off the saw", i.e., without grade enhancement by docking or defecting.

Conversion of pruned sawlogs has two important aspects. The first is total conversion to sawn timber (all grades), and the second is conversion to clears grades alone. While the second is part of the first, the ratio of one to the other, and hence clears grades percentages of sawn outturn, can vary markedly depending on the mill, the sizes produced, and the overall sawing strategy. Therefore, PLI is calculated in two stages, the first of which produces a sub-index known as Conversion Potential factor (CP).

CP relates directly to total conversion to sawn timber and is derived from measurements of log size and log shape only. Log size is expressed by diameter under-bark 1.3 m from the butt end which relates well to log volume for a given length, in butt logs is virtually the same point as dbh, and is common to pruned logs of all lengths. All the variables influencing log shape are collectively expressed by reducing the log to two basic components—wood which is common to the whole length of the log and wood which is not. Measurements of log profiles in two planes at right angles, either manually or by twin axis scanner, provide for the calculation of a column from four quarter ellipses. The semi-axes for these ellipses are the minimum radii measured from the central or Z axis of a log in both the X and Y planes. The volume of this column of "common wood" is divided by the log volume to derive a reduction factor to be applied to the diameter.

$$\text{Conversion Potential factor (CP)} = (D_{1.3})^{0.2} \times (\text{Cvol}/\text{Lvol})^{0.5}$$

where $D_{1.3}$ = diameter (mm) under-bark 1.3 m from the butt end of a log
Cvol = volume of common wood (m^3)
Lvol = under-bark log volume (m^3)

The log size and shape variables used to calculate CP are then combined with defect core size to derive PLI.

$$\text{Pruned Log Index (PLI)} = ((D_{1.3} - DC)/10)^{0.5} \times (D_{1.3}/DC) \times (\text{Cvol}/\text{Lvol})^{1.6}$$

where DC = defect core diameter (mm).

(Note: PLI expresses basic pruned log quality and does not include randomly occuring defects such as resin pockets. These are accounted for by deriving grade reduction factors based on their frequency and size.)

APPENDIX 2

RELATIONSHIPS DERIVED FROM SAMPLE SETS OF 18 PRUNED LOGS

Y	X	Sawing system	Model	Coefficients a	Coefficients b	Coefficients c	r^2	RMS
MILL A								
Conv. to Clear (all lengths)	PLI	Split taper	Y = a + b.exp(–cX)	34.92	–94.87	0.3626	0.91	8.898
		Full taper	Y = a + b.exp(–cX)	69.86	–83.59	0.08478	0.81	23.29
C to Full Length Clear	PLI	Split taper	Y = a + b.exp(–cX)	18.70	–105.4	0.5237	0.55	35.96
		Full taper	Y = a + b.exp(–cX)	62.89	–78.04	0.05939	0.67	27.19
Conv. to Clr + Clr 1 Face (all lengths)	PLI	Split taper	Y = a + b.exp(–cX)	44.45	–197.3	0.5692	0.96	4.908
		Full taper	Y = a + b.exp(–cX)	45.09	–76.30	0.3477	0.82	22.40
Conv. to Full Length Clr + Clr 1 Face	PLI	Split taper	Y = a + b.exp(–cX)	28.59	–187.8	0.6165	0.63	45.39
		Full taper	Y = a + b.exp(–cX)	42.74	–61.87	0.1704	0.68	42.20
Total Conversion	CP	Split taper	Y = a + b/X	109.1	–155.6		0.73	2.873
		Full taper	Y = 1/(a + bX)	0.03547	–0.00561		0.53	9.789
Gross Log Value—\$/m³(r)	PLI	Split taper	Y = a + b.exp(–cX)	512.0	–1109	0.5066	0.96	212.8
		Full taper	Y = a + b.exp(–cX)	518.9	–573.6	0.3094	0.90	729.6
MILL B								
Conv. to Clear (all lengths)	PLI	Split taper	Y = a + b.exp(–cX)	99.57	–111.0	0.06519	0.81	21.24
		Full taper	Y = a + b.exp(–cX)	57.92	–67.52	0.1267	0.91	12.23
Conv. to Full Length Clear	PLI	Split taper	Y = a + bX	–6.826	2.703		0.70	10.32
		Full taper	Y = a + bX	–4.483	2.518		0.67	28.69
Conv. to Clr + Clr 1 Face (all lengths)	PLI	Split taper	Y = a + b.exp(–cX)	62.38	–71.86	0.1705	0.90	7.708
		Full taper	Y = a + b.exp(–cX)	65.82	–70.84	0.1199	0.90	13.75
Conv. to Full Length Clr + Clr 1 Face	PLI	Split taper	Y = a + bX	1.951	2.530		0.43	27.74
		Full taper	Y = a + bX	–2.754	2.711		0.59	46.19

APPENDIX 2 cont.

Y	X	Sawing system	Model	Coefficients			r^2	RMS
				a	b	c		
Total Conversion	CP	Split taper	$Y = a + b/X$	118.7	–184.7		0.53	6.954
		Full taper	$Y = a + b/X$	125.5	–215.8		0.59	8.173
Gross Log Value—$/m³(r)	PLI	Split taper	$Y = a + b.\exp(-cX)$	633.6	–595.7	0.1887	0.85	837.5
		Full taper	$Y = a + b.\exp(-cX)$	641.2	–509.3	0.1317	0.89	857.7
MILL C								
Conv. to Clear (all lengths)	PLI	Split taper	$Y = X/(a + bX)$	0.1701	0.01035		0.70	17.83
		Full taper	$Y = a + bX + cX^2$	–3.331	4.573	–0.07582	0.82	19.20
Conv. to Full Length Clear	PLI	Split taper	$Y = a + b/X$	43.85	–181.1		0.46	43.04
		Full taper	$Y = a + b.\exp(-cX)$	48.56	–59.12	0.09312	0.56	35.65
Conv. to Clr + Clr 1 Face (all lengths)	PLI	Split taper	$Y = a + b.\exp(-cX)$	70.05	–38.70	0.06334	0.46	17.76
		Full taper	$Y = a + bX$	28.68	1.437		0.50	18.53
Conv. to Full Length Clr + Clr 1 Face	PLI	Split taper	$Y = a + bX$	24.02	1.212		0.34	20.29
		Full taper	$Y = a + bX$	24.54	0.6998		0.10	38.05
Total Conversion	CP	Split taper	$Y = a + b/X$	120.5	–184.6		0.62	4.215
		Full taper	$Y = 1/(a + bX)$	0.03929	–0.006942		0.53	6.782
Gross Log Value—$/m³(r)	PLI	Split taper	$Y = a + bX$	391.2	12.76		0.57	868.3
		Full taper	$Y = a + bX$	321.6	14.99		0.63	1103.

Notes: n = 18 for all equations
RMS = residual mean square