COMPARISON, VIA THE SEESAW SIMULATOR, OF THREE SAWING SYSTEMS FOR PRUNED LOGS

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(Received for publication 23 January 1989; revision 5 April 1989)

ABSTRACT

Data from 89 real pruned **Pinus radiata** D. Don logs, representing most of the pruned log types currently being traded in New Zealand, were used in a comparison of sawing systems. Each log was "sawn" three times in the SEESAW simulator to provide results from No Taper Cant, Half-taper Cant, and Half-taper Live sawing.

Total conversion to sawn timber and volumes of clearwood recovered were very similar under all systems but the form in which this timber was produced differed markedly. Half-taper Cant sawing proved the best system for most purposes because it produced the fewest pieces and the most desirable distribution of widths. No Taper Cant sawing gave the second best result and is recommended as a good system for mills which do not have a half-taper sawing capacity. Half-taper Live sawing gave the poorest result with a 43% increase in the number of pieces produced and 47% of clears grades recovered in narrows less than 100 mm wide.

Keywords: pruned logs; sawpatterns; sawing simulation; SEESAW; timber grade recovery; log conversion.

INTRODUCTION

Although artificially pruned sawlogs have been readily available to sawmillers (particularly in New Zealand) for some time, there is a worldwide dearth of published information on how these logs might be most efficiently converted. Here, millers have arrived at their own techniques largely through trial and error, and partly through informal communication amongst themselves and with other interested parties (including Forest Research Institute researchers).

The first New Zealand research explicitly investigating a range of sawing options for artificially pruned logs was recently undertaken by Cown *et al.* (1988). Three hundred pruned logs from two compartments in Kaingaroa Forest were sawn in batches of 25 at the Timber Industry Training Centre sawmill. Those results were presented as indicative rather than definitive because unwelcome mill and operator variation was recognised and acknowledged; there were also problems with the matching of log batches due to largely undefined variation in defect core sizes. As a consequence, the approach taken here aimed to eliminate mill variables and provide accurate description and definition of each individual log sawn.

The vagaries of using a real mill over several shifts were avoided here by using the impossibly perfect sawmill, the SEESAW simulator. SEESAW (Garcia 1987; Park 1987; Todoroki 1988) is a completely interactive visual pruned log sawing simulator which uses data collected from indivdual real pruned logs as input. All plant variables may be preset and totally controlled. However, because SEESAW is interactive there are still margins for operator error. These are minimised by the facility to "uncut" and correct any mistakes detected while processing a particular log. They were further minimised in these studies by using only one operator, namely myself, to ensure consistency across all simulations. A further advantage in this type of simulation is that a much wider range of pruned log types may be analysed in one study. In this study the real log database was comprehensive enough to represent most sizes and qualities of pruned logs currently available to New Zealand sawmillers.

When designing this study, it was decided that results should be based on two types of analyses – the first to examine the conversions of individual logs across the quality range, and the second to analyse the total sawn produce when all samples were regarded as one large batch. Indices by Park (1989a) were used to assist in the former; individual log size and shape were expressed by Conversion Potential factor (CP) and pruned log quality (i.e., potential for producing sawn clearwood) was defined by Pruned Log Index (PLI).

No attempt is made here to analyse and compare the methods and practices of specific sawmills. Normal mill constraints are numerous and variations on basic principles proliferate. While sawing simulation can be effectively used to synthesise real mill and market situations that approach would defeat the purpose here and limit the results to just a few examples. Rather, the approach taken was to examine basic sawing systems. The term sawsystem, as used in this paper, is defined as a method of positioning and breaking down a log. (The edging of flitches was standardised for all sawsystems investigated.) Most of the pruned log sawing methods currently applied in New Zealand mills are variations on one of the three basic sawsystems examined and compared in this paper.

A criticism of sawing simulation is that no real mill can perform as well as a simulator. This is correct but does not prevent an objective study of basic differences in log conversion under alternative sawing systems. How these results may relate to real mills is a separate issue which is addressed briefly at the end of this paper and in depth in a companion paper (Park 1989b).

Objectives

The objectives of this study were to simulate the sawing of a large range of pruned logs under three distinct sawsystems – No Taper Cant, Half-taper Cant, and Half-taper Live – and compare results in terms of:

(i) Total conversion to sawn timber;
(ii) Conversion to clears grade timber;
(iii) Number of pieces produced;
(iv) Width distributions of all timber produced;
(v) Clear length distributions.

DATA

Data on 89 real pruned *Pinus radiata* sawlogs were drawn from the SEESAW "log library". Pruned Log Index provided the basis for sample selection and the objective was to ensure an even distribution of logs across the available quality range. These data were in two sets and had been acquired by two means. Set 1 consisted of 74 logs "reconstructed" from past sawing studies and represented a range of log sizes and silvicultural regimes from four sites in the South Island and two sites in the North Island. Set 2 consisted of 15 pruned logs from trees which had been cross-sectionally analysed and represented a further three types of silviculture from two sites in the North Island and one site in the South Island. Summaries of the six subsets comprising Data Set 1 and the three subsets comprising Data Set 2 are given in Table 1. For the purpose of these studies, Data Sets were combined to provide a balanced distribution of most of the pruned *P. radiata* log types available to New Zealand sawmillers at present. All logs were either 4.9 or 5.5 m long, and spanned the PLI range 1.5 – 8.5 with sizes in the range s.e.d. 271 – 552 mm, defect cores 173 – 372 mm, sweep 1 – 15 mm/m, taper (excluding butt flare) 3 – 32 mm/m.

METHODS

Sawing Simulation

Each of the 89 "library" logs was sawn three times in the SEESAW simulator, once under each of the sawsystems described below. A three-knee carriage with movable knees was defined with distances from knee centres, front to back, 2400 and 1800 mm respectively. Headrig sawkerfs were set at 3 mm and edger sawkerfs at 6 mm.

All sawing was on size and all produce was in 25-mm-thick boards. Sawing exclusively to 25 mm was adopted in order to allow a fair comparison across all sawlog sizes and minimise potential disadvantages to the smaller logs in the data set if a range of thicknesses was allowed. Relatively small logs, if well-pruned, may produce high percentages of log volume as clears grade timber but obviously not in large dimensions. On the other hand, large well-pruned logs may produce high volumes of clears in either large or smaller dimensions. While cutting to one thickness does not reflect the likely range of product from commercial sawmills, it removed a source of variation and simplified analyses, without jeopardising the main objective.

Similarly, edging and docking practices were completely standardised for all logs under each of the three sawsystems. All produce was edged to maximise grade with the range of recoverable widths being 50, 75, 100, 150, 200, 250, and 300 mm (50 mm was the least preferred width and this size was cut only when there was no other option for recovering clearwood). Cant sizes (produced under Sawsystems 1 and 2) varied with defect core sizes and the allowable range of cant depths was set as 100, 150, 200, 250, or 300 mm. Docking was for wane only, as opposed to docking for grade improvement, and the minimum recoverable length was set at 1.8 m.

Timber grades recognised in these simulations, in order of preference, were:

(1) Defect-free clear
(2) Clear one face

TABLE 1–Summary of sample logs

Location of sample point	No. of logs	Age (yr)	No. of pruning lifts	Final-crop stocking (stems/ha)	Range of				
					Pruned log index	Defect core size (mm)	Small-end diameter u.b. (mm)	Sweep (max. displ. at mid log) (mm)	Taper index (mm/m)
DATA SET 1 (Derived from sawing studies)									
Ranklebum Cpt 5	13	26	2	288	2.6–7.1	190–287	299–439	15–58	8–32
Herbert Cpt 21	14	26	3	308	2.9–8.3	188–304	307–440	11–48	3–32
Golden Downs Cpt 95	12	25	3	950	2.1–4.1	213–270	271–339	8–58	3–11
Golden Downs Cpt 116	11	22	3	345	3.7–5.4	173–234	289–333	8–50	7–11
Patunamu Cpt 3	14	28	2	123	2.8–7.9	205–297	308–491	7–60	7–23
Mangatu Cpt 1	10	21	2	335	1.5–3.9	220–343	303–434	7–54	6–16
	74	21–28	2&3	123–950	1.5–8.3	173–343	271–491	7–60	3–32
DATA SET 2 (Derived from cross-sectional analysis)									
Ngaumu (various*)	5	28–29	2	200–380	2.5–6.8	239–323	372–502	30–84	4–15
Rai Valley Cpt 9	5	32	2	296	2.2–5.1	315–372	380–546	29–71	6–15
NZFP (Woutu Block)	5	32	3	253	4.5–6.7	249–332	360–552	15–67	8–17
	15	28–32	2&3	200–380	2.2–6.8	239–372	372–552	15–84	4–17

* Logs were selected from a stratum comprising six stands.
Note: Log lengths are all either 4.9 m or 5.5 m.

(3) Shop – 70% of the piece in clearcuttings 1 m or longer
(4) Factory – 50% of the piece in clearcuttings at least 0.6 m long with further increments of 0.3 m tallied for grade determination
(5) Knotty excluding pith
(6) Pith; knotty boards with pith in.

NOTE: Grades 1 and 3 have direct equivalents in the current National Timber Grading Rules, NZS 3631 : 1988. Grade 4 is directly equivalent to NZS 3631 : 1978 Factory grade. Grade 2 approximates current NZS Select grades; Grade 5 approximates Merchantable and Grade 6 approximates Box.

Sawsystems

Examples of the three sawsystems used are given in Fig. 1 and sawing methods are described below.

"No Taper Cant" – flat cant sawing with natural offset

The knees of the carriage were kept in a straight line for all cuts. The log was positioned to minimise the spread of the defect core as observed on the end view shown by the simulator. Swept logs were positioned either horns up or horns down. Opening cuts on faces 1 and 2 were both "free" and were placed to remove just enough slab to ensure a board would be made from the next flitch. One or two flitches were taken from the opening face to produce a flat and then the log was turned down. Flitches were cut from the second face until the defect core was exposed for between half and all its length. The log was then turned through 180 degrees so that face 2 was against the knees of the carriage. Cant size was decided on by observing the X-ray view of defects and the opening cut on the third face was determined by counting back in increments of 28 mm (board thickness + sawkerf) from the proposed cant edge. After cutting the wing flitches the resulting cant was turned down with the flat end (face 1)

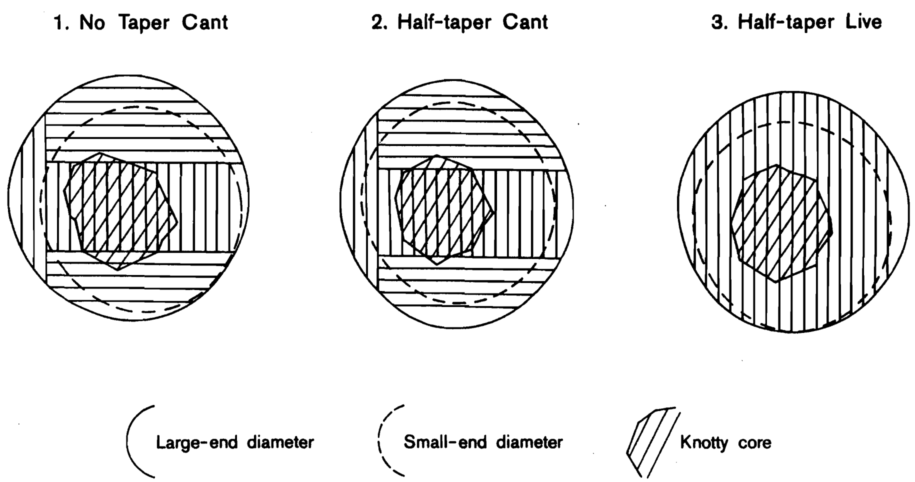

FIG. 1—Examples of saw systems (from simulated sawing of Log 653).

against the knees of the carriage. The opening cut on the remaining rounded face, face 4, was determined by counting back in 28 mm increments from face 1. The cant was then sawn through and through.

"Half-taper Cant" – flat cant sawing with taper split

Logs were sawn as under system 1 with the exception that the front knee on the carriage was moved out until the central axis of the log was parallel to the saw before placing opening cuts on faces 1 and 2. The carriage knees were realigned for subsequent sawing of faces 3 and 4. This meant that the effect of log taper was halved for all faces sawn and that the central axis of the log was approximately parallel to the saw for all cuts made. It also made initial log positioning less critical and easier. Except when severely swept, logs were positioned randomly because realignment using the movable knees compensated for most irregularities. The positioning of very swept logs varied depending on the type of sweep and over-all log shape.

"Half-taper Live – through and through sawing with log centred

The log was positioned to minimise the spread of the defect core in the directions lateral to the saw. This meant that any sweep was positioned either horns up or horns down on the carriage. The front knee of the carriage was moved out until the central axis of the log was parallel to the saw. The opening cut was made, as for the other sawpatterns, to face a board from the next flitch and the log was cut through and through until the pith was encountered. The log was then turned 180 degrees so the flat side was against the knees which were brought back into a straight line. The opening cut on the second face was determined by counting back from the squared face in 28-mm increments and the remainder of the log was cut through and through.

These sawing simulations differed from real sawing in one major aspect. Because of the construction of the SEESAW simulator, the operator could see the extent and positioning of the defect core at all times and, most critically, before opening the log. Because this must inevitably influence initial decisions, it was decided to make full use of such X-ray vision rather than introduce uncontrolled bias by trying to ignore what was before the eyes. It may also be argued that such information will be available to real sawyers (or controlling computers) when internal log scanning devices become commercially viable. This preknowledge is judged to have assisted No Taper Cant sawing the most and to have hardly affected Half-taper Cant sawing at all. Half-taper Cant sawn logs were nearly all randomly positioned and the over-riding factor was alignment by the central axis of the log, not the size and position of the defect core. Further into the sawing process, preknowledge of defect core gives little advantage over the signals available to an experienced sawyer. He takes note of the pith position obvious at either end of logs and recognises grain deviations on the sawn face indicating that defects are being approached. The major difference between SEESAW simulations and real sawing, in respect to determining cant size and cant positioning, is not what decision is made, but how early it is made. Of course, errors made in simulations may also be corrected whereas real sawing decisions are irreversible.

Data Analyses

Data were analysed using two basic methods. The first derived relationships using results from individual logs in order to examine effects across the whole range of pruned log quality. The second analysed distributions of total produce from all 89 logs (i.e., regarded results from each simulated sawsystem as a batch).

Individual log analyses

Results from individual logs were used to derive relationships between log potential and two types of log conversion.

Total conversion to sawn timber: The potential of each log for total conversion was determined by calculating Conversion Potential factor (CP) (Park 1989a); CP is derived from measurements of log size and log shape. The percentage of log volume converted to sawn timber under each sawing system was regressed against CP. These relationships were then plotted, compared, and tested for differences.

Conversion to clears grade timber: The potential of each log to produce clears grade timber was determined by calculating Pruned Log Index (PLI) (Park 1989a); PLI is derived from measurements of log size, log shape, and the size of the defect core. For each of the sawing systems, percentages of log volume outturned firstly as defect-free clears, then as combined clears grades (defect-free clears plus clear one face), were regressed against PLI. Each set of relationships was then compared as above.

Batch analyses

Combined results from all 89 logs were used for comparisons of over-all width and length distributions produced by each of the three sawsystems investigated.

RESULTS

Individual Log Analyses

Models for all conversion relationships shown in Fig. 2, 3, and 4 are given in Table 2. The r^2 and residual standard error values also included in the table show all were a good fit. The 95% confidence limits on all equations are less than $\pm$ 1% for the expectation (means).

Total conversion to sawn timber

Relationships between CP and total conversion are shown in Fig. 2. Conversions ranged from 55% to 70%, showing the wide range of log types included. There was very little difference between sawsystems and none was significant at the 95% confidence level.

Conversion to clears grade timber

Relationships between PLI and the percentage of round log volume converted to defect-free clears are shown in Fig. 3. Production in this grade ranged from 0% to 43% and, although there is a trend for slightly higher production from Half-taper Live sawing, differences between models from the three sawsystems were not significant at the 95% confidence level.

TABLE 2–Conversion relationships (n = 89)

y (conv. %)	Sawsystem	X	Model	Coefficients a	b	c	r^2	Res.S.E.
Total sawn timber	(1) NT Cant	CP	$y = a + bx$	–3.695	22.36		0.83	0.17
	(2) HT Cant			1.499	20.89		0.85	0.15
	(3) HT Live			0.4220	20.90		0.84	0.15
Defect-free clears	(1) NT Cant	PLI	$y = a + be^{-cx}$	81.92	–94.90	0.1003	0.92	0.31
	(2) HT Cant			101.0	–111.6	0.07703	0.90	0.36
	(3) HT Live			73.45	–88.59	0.1372	0.89	0.40
Combined clears grades*	(1) NT Cant	PLI	$y = a + be^{-cx}$	75.01	–83.47	0.1333	0.93	0.30
	(2) HT Cant			72.22	–78.06	0.1399	0.90	0.34
	(3) HT Live			59.06	–69.80	0.2203	0.90	0.35

CP = Conversion Potential factor } (Park 1989a)
PLI = Pruned Log Index. }
* Defect-free clears + clear one face grades.

Similarly, the relationship between PLI and combined clears grades, i.e., defect-free clears plus clear one face is shown in Fig. 4. Here the apparent trend in favour of Half-taper Live sawing when defect-free clears alone were considered, is minimised. Percentages of log volume converted to combined clears grades ranged from 8% to 48% and there were no significant differences between sawsystems at the 95% confidence level.

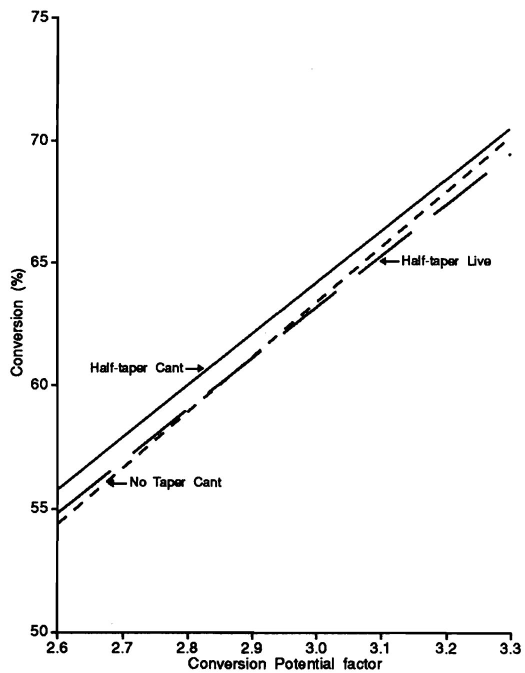

FIG. 2—Total conversion to sawn timber.

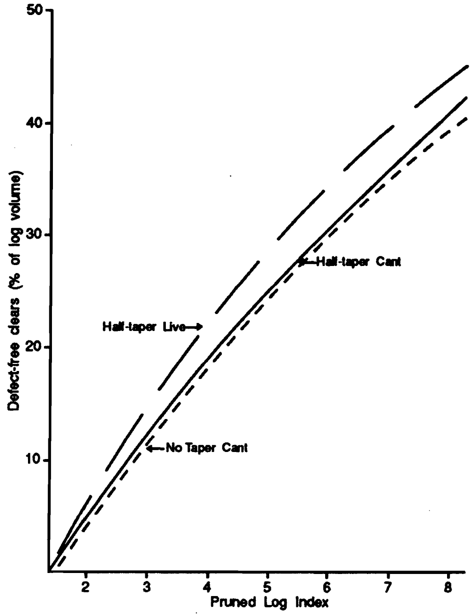

FIG. 3—Conversion to defect-free clears.

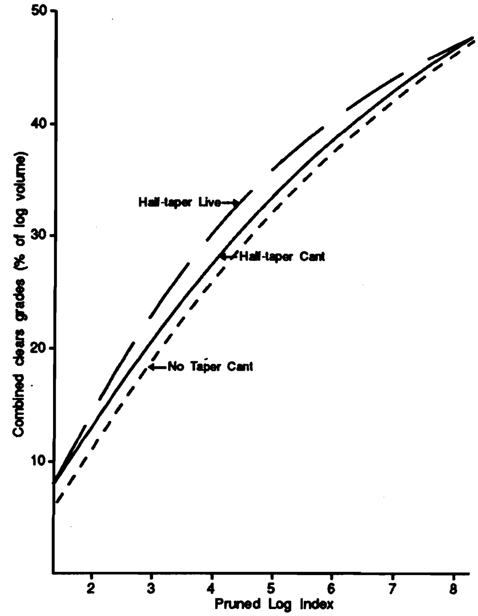

FIG. 4—Conversion to combined clears grades (clear + clear one face).

Batch Analyses

Grade recovery by number and volume of boards

Grade distributions, sawn volumes, and number of boards produced under each of the three sawsystems are summarised in Table 3. As Half-taper Cant sawing produced the lowest number of boards but the highest volume of sawn timber it is taken as the standard here against which to compare the other two sawsystems. The major interest is in the grand totals (all produce) and in combined clears grades.

In total recovery, No Taper Cant sawing produced 8% more pieces but 2% less volume, while Half-taper Live sawing produced 42% more pieces and 2% less volume.

In combined clears grades, No Taper Cant sawing produced 5% more pieces but 5% less volume, while Half-taper Live sawing produced 43% more pieces for a 6% increase in volume.

TABLE 3—Grade recovery by number and volume of boards

Sawsystem		Pith	Knotty	Factory	Shop	Clear one face	Clear	Total
(1) NT Cant	Number	277	277	229	90	341	1380	2594
	Volume (m^3)	7.27	6.65	5.15	1.77	4.38	14.29	39.51
(2) HT Cant	Number	237	269	196	74	349	1283	2408
	Volume (m^3)	6.81	7.32	4.91	1.43	4.87	14.82	40.16
(3) HT Live	Number	226	336	336	195	488	1844	3425
	Volume (m^3)	5.96	6.35	4.24	1.71	4.11	16.84	39.21

Recovery by width classes

For purposes of comparison three width classes were defined:

narrows = 50 and 75 mm (least preferred)
standards = 100, 150, and 200 mm
wides = 250 and 300 mm (most preferred)

Total timber recovery by these width classes, from each of the three sawsystems, is summarised in Table 4: Half-taper Cant sawing produced the best mix of widths. Width distributions from No Taper Cant sawing were also satisfactory but with 10% fewer wides, most of which fell down into standards. However, for most purposes, width recoveries from Half-taper Live sawing were unsatisfactory; 20% fewer wides were produced and most of the fall-down was to narrows rather than standards. One-third of all timber produced from the Half-taper Live sawing of this 89-log batch was in narrows.

TABLE 4—Total timber recovery by width classes

Sawsystem		Width classes			Totals
		Narrows (50 & 75 mm)	Standards (100, 150, & 200 mm)	Wides (250 & 300 mm)	
(1) NT Cant	Volume (m^3)	4.91	25.27	9.33	39.51
	Percentage	12.4	64.0	23.6	100
(2) HT Cant	Volume (m^3)	4.55	22.30	13.31	40.16
	Percentage	11.3	55.5	33.1	100
(3) HT Live	Volume (m^3)	13.19	20.87	5.15	39.21
	Percentage	33.6	53.2	13.1	100

When combined clears grades are isolated (Fig. 5) the implications of differences between widths produced by Half-taper Live sawing and the other two flat-sawing systems become more obvious; 47% of all Half-taper Live sawn clears were in narrows as opposed to 22% and 25% from Half-taper Cant and No Taper Cant sawing respectively.

Clear lengths

Clear lengths are defined here as defect-free clears and completely clean clearcuttings $\geq$ 0.6 m (although no defecting for grade was undertaken, the simulation system provides information on the clear lengths that are available, albeit some of these may be contained wthin lower grade boards.) Total production of available clear lengths $\geq$ 0.6 m from all sawsystems was similar, i.e., between 74% and 77% of sawn volume. However, the distribution by lengths of these clears differed.

For the purpose of comparison, three clear length classes were defined:

shorts = 0.6 – 2.3 m (least preferred)
randoms = 2.4 – 4.7 m
(full length) longs = 4.8 – 5.4 m (most preferred)

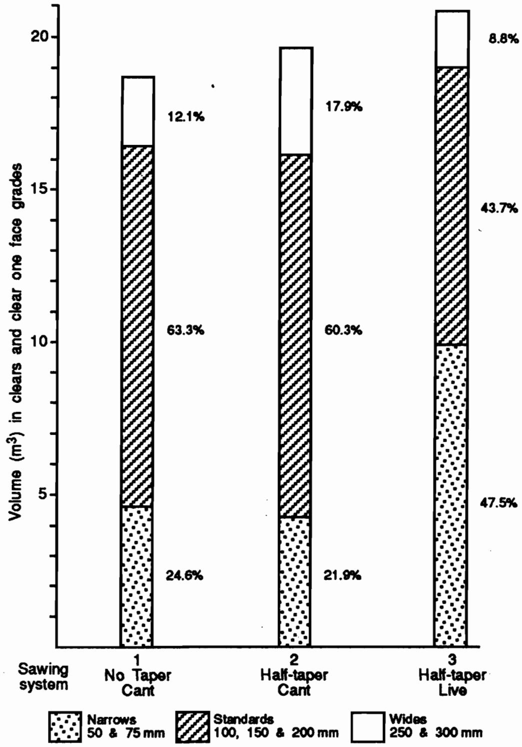

FIG. 5—Volumes recovered in combined clears grades differentiated by three width classes.

Clear lengths by these three classes, produced by each of the sawsystems investigated, are listed in Table 5 and compared in Fig. 6. While distributions of clear lengths were satisfactory under all systems, Half-taper Live sawing, when taken as the standard, produced 16% more full length clears than Half-taper Cant sawing and 27% more than No Taper Cant sawing.

TABLE 5–Distributions of clear lengths (defect-free clears + clearcuttings)

Sawsystem		Clear length classes			Totals
		Shorts (0.6–2.3 m)	Randoms (2.4–4.7 m)	Full length (4.8–5.4 m)	
(1) NT Cant	Volume (m^3)	11.66	9.16	8.64	29.46
	Percentage	39.6	31.1	29.3	100
(2) HT Cant	Volume (m^3)	11.77	7.86	9.98	29.62
	Percentage	39.7	26.5	33.7	100
(3) HT Live	Volume (m^3)	10.27	7.99	11.86	30.11
	Percentage	34.1	26.5	39.4	100

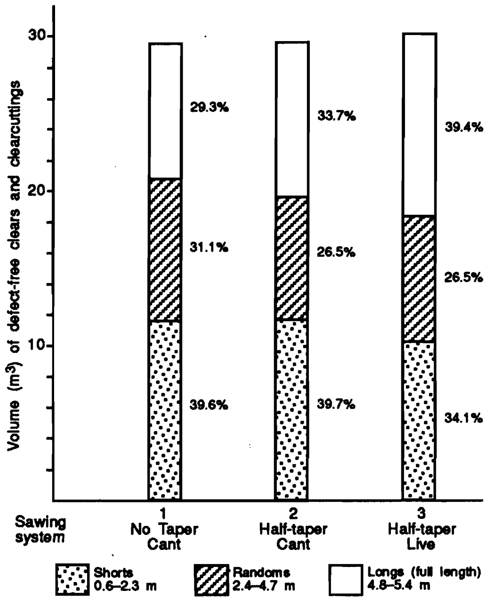

FIG. 6—Volumes of defect-free clear lengths produced differentiated by three length classes.

CONCLUSIONS

Comparison of these three sawsystems by sawing the same 89 logs in the SEESAW simulator led to the following conclusions:

(1) There are no significant differences in conversion rates;

(2) There are no significant differences in volumes of clears grades recovered;

(3) There are major differences in the dimensions and numbers of pieces produced between flat sawing (i.e., No Taper and Half-taper Cant) and Half-taper Live sawing systems;

(4) Half-taper Live sawing this wide range of logs produced an undesirable proportion of narrows (47% of clears grades recovered were less than 100 mm wide);

(5) Half-taper Live sawing increased the number of pieces by 43%;

(6) Half-taper Live sawing produced significantly more full length clears (16% more than Half-taper Cant and 27% more than No Taper Cant sawing);

(7) Half-taper Cant sawing was the best option. It was the easiest to execute, produced the best mix of widths in clears grades, and a satisfactory distribution of clear lengths;

(8) No-taper Cant sawing was the second best option but produced 10% less clears grade wides and 13% less full length clears than Half-taper Cant sawing.

DISCUSSION

This project addressed the problem of comparing sawsystems for pruned logs from a limited viewpoint. No attempts have been made to include either economic evaluations or comprehensive market considerations. These are separate and complex subjects in their own right. Rather, the approach here was to examine physical out-turn, in terms of total timber sawn and clears grades produced, across the currently available range of pruned log qualities. The purpose was to identify basic differences and provide positive guidelines on how pruned logs should be sawn. As normal mill constraints were also ignored, the author's interpretation of what is "best" may not apply to a specific situation. However, sufficient information has been given to provide strong indicators of what could be expected if the principles of each sawsystem were adapted to produce "order book" sizes. It is also conceded that no mill is likely to be sawing the full range of pruned logs at any one time, but Fig. 2 to 4 can be used to interpret what could be expected from limited ranges of logs.

Results from these sawing simulation exercises were clear cut. Careful sawing of pruned logs under any of the three systems tested will yield virtually the same conversions and grade distributions by volume. However, the form in which the sawn timber is produced will vary significantly between Half-taper Cant and No Taper Cant, and even more markedly between these two and Half-taper Live sawing. The order of preference for most purposes is Half-taper Cant, No Taper Cant, and Half-taper Live a very definite last. This order of preference is not universal and the reader is reminded of the study constraints and limitations described in the Methods section. My own considerable experience in implementing all of these sawing systems in real mills on a wide range of pruned logs is also drawn on here to maintain a balanced perspective.

Half-taper Cant sawing is dependent on the central axis of the log being aligned with the saw for all cuts and consequently demands a carriage with independently movable knees. At present only a minority of New Zealand mills have suitable carriages, but those who have adopted this method of pruned log conversion are unanimously well satisfied and only rarely resort to any other method of log breakdown (including full taper sawing – not tested here). A major advantage with Half-taper Cant, in addition to results given here, is that initial placement of a log on the carriage is easier and less critical. Log irregularities can be compensated for by intelligent use of the movable knees. This means that, most of the time, any face of the log can be made into the best opening face and the correct placement of initial cuts is also easier. (Even under SEESAW simulation, log setup was easier and faster for Half-taper Cant sawing than for the other two systems.)

Results given here from No Taper Cant sawing were not very inferior to those from Half-taper Cant; but, for practical purposes, this may be misleading. No Taper Cant benefited most from the SEESAW operator's preknowledge of the defect core. In real life it takes a very experienced sawyer to emulate all the correct first-time decisions needed to optimise log placement on the carriage and cant placement within the log when No Taper Cant sawing. While sizes produced from real No Taper Cant sawing will differ little from these simulations, it is likely that clears grade recovery will suffer more than in real Half-taper Cant or Half-taper Live sawing. Nevertheless,

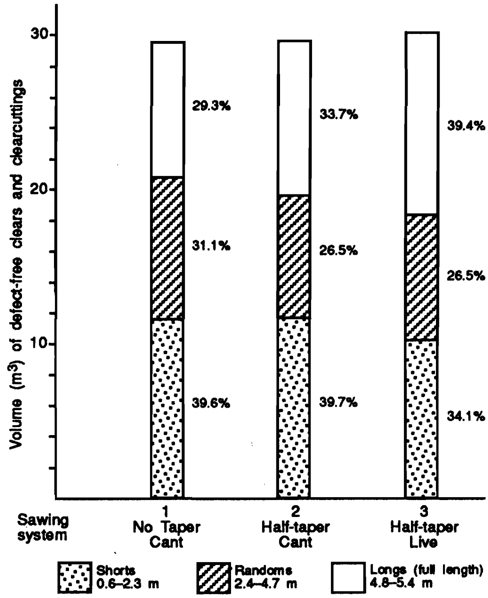

FIG. 6—Volumes of defect-free clear lengths produced differentiated by three length classes.

CONCLUSIONS

Comparison of these three sawsystems by sawing the same 89 logs in the SEESAW simulator led to the following conclusions:

(1) There are no significant differences in conversion rates;

(2) There are no significant differences in volumes of clears grades recovered;

(3) There are major differences in the dimensions and numbers of pieces produced between flat sawing (i.e., No Taper and Half-taper Cant) and Half-taper Live sawing systems;

(4) Half-taper Live sawing this wide range of logs produced an undesirable proportion of narrows (47% of clears grades recovered were less than 100 mm wide);

(5) Half-taper Live sawing increased the number of pieces by 43%;

(6) Half-taper Live sawing produced significantly more full length clears (16% more than Half-taper Cant and 27% more than No Taper Cant sawing);

(7) Half-taper Cant sawing was the best option. It was the easiest to execute, produced the best mix of widths in clears grades, and a satisfactory distribution of clear lengths;

(8) No-taper Cant sawing was the second best option but produced 10% less clears grade wides and 13% less full length clears than Half-taper Cant sawing.

DISCUSSION

This project addressed the problem of comparing sawsystems for pruned logs from a limited viewpoint. No attempts have been made to include either economic evaluations or comprehensive market considerations. These are separate and complex subjects in their own right. Rather, the approach here was to examine physical out-turn, in terms of total timber sawn and clears grades produced, across the currently available range of pruned log qualities. The purpose was to identify basic differences and provide positive guidelines on how pruned logs should be sawn. As normal mill constraints were also ignored, the author's interpretation of what is "best" may not apply to a specific situation. However, sufficient information has been given to provide strong indicators of what could be expected if the principles of each sawsystem were adapted to produce "order book" sizes. It is also conceded that no mill is likely to be sawing the full range of pruned logs at any one time, but Fig. 2 to 4 can be used to interpret what could be expected from limited ranges of logs.

Results from these sawing simulation exercises were clear cut. Careful sawing of pruned logs under any of the three systems tested will yield virtually the same conversions and grade distributions by volume. However, the form in which the sawn timber is produced will vary significantly between Half-taper Cant and No Taper Cant, and even more markedly between these two and Half-taper Live sawing. The order of preference for most purposes is Half-taper Cant, No Taper Cant, and Half-taper Live a very definite last. This order of preference is not universal and the reader is reminded of the study constraints and limitations described in the Methods section. My own considerable experience in implementing all of these sawing systems in real mills on a wide range of pruned logs is also drawn on here to maintain a balanced perspective.

Half-taper Cant sawing is dependent on the central axis of the log being aligned with the saw for all cuts and consequently demands a carriage with independently movable knees. At present only a minority of New Zealand mills have suitable carriages, but those who have adopted this method of pruned log conversion are unanimously well satisfied and only rarely resort to any other method of log breakdown (including full taper sawing – not tested here). A major advantage with Half-taper Cant, in addition to results given here, is that initial placement of a log on the carriage is easier and less critical. Log irregularities can be compensated for by intelligent use of the movable knees. This means that, most of the time, any face of the log can be made into the best opening face and the correct placement of initial cuts is also easier. (Even under SEESAW simulation, log setup was easier and faster for Half-taper Cant sawing than for the other two systems.)

Results given here from No Taper Cant sawing were not very inferior to those from Half-taper Cant; but, for practical purposes, this may be misleading. No Taper Cant benefited most from the SEESAW operator's preknowledge of the defect core. In real life it takes a very experienced sawyer to emulate all the correct first-time decisions needed to optimise log placement on the carriage and cant placement within the log when No Taper Cant sawing. While sizes produced from real No Taper Cant sawing will differ little from these simulations, it is likely that clears grade recovery will suffer more than in real Half-taper Cant or Half-taper Live sawing. Nevertheless, in my opinion No Taper Cant sawing is still preferable to Half-taper Live for most purposes because differences in grade will be more than compensated for by satisfactory width distributions.

Although Half-taper Live sawing produced a plethora of narrows and increased the number of pieces by almost 50%, it still has a place. It is a quick system for mills with a flexible multi-saw edger. It also allows logs to be semi-converted and conveniently stored as flitches for later re-edging in the same plant or another one. Should the demand be for long narrow clears, then live sawing may become the preferred option. The issue of quarter-sawn *versus* flat-sawn material was not addressed in these studies, but Half-taper Live sawing is the only one of these three systems which will produce a high percentage of quarter-sawn clear pieces.

The performance of all three systems was enhanced by sawing in the impossibly perfect sawmill where sawing variation was nil and every operator error could be rectified. Studies (*see Park* 1989b) have shown that a real mill is performing very well in terms of conversions and clears recoveries if these are within 5% of benchmarks established by SEESAW simulation.

ACKNOWLEDGMENT

The assistance of April Mortimer in collating and analysing results is gratefully acknowledged.

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