APPLICATIONS OF THE SEESAW SIMULATOR AND PRUNED LOG INDEX TO PRUNED RESOURCE EVALUATIONS – A CASE STUDY

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ABSTRACT

Methods presented for evaluating pruned sawlogs are based on accurate and detailed individual log measurements. The measurements provide data both for the calculation of Pruned Log Index (PLI), which is an absolute measure of pruned log quality, and for sawing simulations. The prime objective in pruned sawlog evaluations is to determine accurately the potential of logs to produce clears grade timber. Sawing simulations, using sample log data, provided better estimates of pruned sawlog potential than could be derived from a timber grade study in a real sawmill. The SEESAW simulator was used to design a standardised sawpattern (STD SP) which maximised recovery in clears grades. SEESAW was then used on a range of logs from the database to provide optimum STD SP results on clears grades recovery. Upper benchmarks for STD SP were set by deriving relationships between PLI and those simulated sawing results.

Twenty pruned **Pinus radiata** D. Don logs from Waratah in the central North Island were sawn to STD SP at the Timber Industry Training Centre sawmill. Sawing results and data from those logs were used in validations of SEESAW and the upper benchmarks. The Waratah logs were also used to provide an example of how a straightforward evaluation of pruned sawlog samples should be carried out. This included a demonstration of how the benchmark relationships established between PLI and SEESAW results can substitute for the continual use of the simulator and reduce the time taken for data analyses from days to minutes.

Keywords: pruned sawlogs; timber grade recovery; sawing simulation; Pruned Log Index; SEESAW.

INTRODUCTION

A co-operative venture was set up between the Forest Research Institute and a group of forest growers to develop methods for evaluating the pruned component of stands prior to log sales. Its main aims were to provide both buyers and sellers of pruned logs with adequate descriptions of log quality and assessments of potential grade out-turn and value, with the emphasis being on potential production of clears grades. As internal log scanning is still far from being a commercial reality, systems of sampling pruned logs, defining their quality, and predicting conversions, grades, and values were investigated. Fuller details of the aims and objectives of the 1986 Pruned Log Evaluation Cooperative, including the approaches taken to sampling, will be given by Somerville *et al.* (in prep.).

Agreement was reached that a detailed individual log approach was preferable to batch sampling. Then the task of deriving methods for evaluating crops of pruned sawlogs was divided into six main components:

(1) Crop stratification;
(2) Stand sampling;
(3) Data acquisition;
(4) Definition of pruned sawlog quality;
(5) The design and implementation of a standardised sawpattern;
(6) A standardised method of deriving sawing results.

Items 1 and 2, crop stratification and stand sampling, will be covered in detail by Somerville *et al.* (in prep.). This paper deals with the examination and subsequent adoption of techniques to define and interpret the sawing potential of pruned logs sampled, i.e., items 3–6 above. Techniques were tested, modified, and finalised during the first case study which was on a collection of pruned stands from Waratah in the central North Island.

Two methods of acquiring detailed data on individual logs were well established and consequently adopted. These were the cross-sectional analysis system of Somerville (1985) and the sawing study method of Park & Leman (1983). The newly derived Pruned Log Index (PLI) (Park 1989a) was proposed as the most appropriate measure of pruned sawlog quality. It was agreed that a Standardised Sawpattern (STD SP), which would maximise clears grades, should be designed and tested in a sawing simulator, and then implemented in a real sawmill to appraise real situation practicability and performance. This sawpattern was to produce standard sizes but could disregard all other commercial constraints. Finally, it was proposed that results from sawing simulation should become the recognised standard rather than "actual" results from any real sawmill. Acceptance of this proposal was difficult for many members of the Cooperative and, as yet, remains unacceptable to many parties who were not involved. Consequently, it has been decided to present this paper in two parts. Part 1 is dedicated to proving the case for simulation; Part 2 shows how the pruned sawlog evaluation techniques developed should be implemented.

Real sawing studies are not the ultimate technique for evaluating pruned logs. If they are used in this role the prime objective must be log data acquisition rather than a one-off grade out-turn result. Although real timber grade studies are carried out with much tighter controls than normally apply in most mills, results are inevitably influenced by decisions made by study personnel and the performance of the mill on the day. Few of the inconsistencies or mistakes made can be corrected later and logs can be sawn only once to provide an "actual" result. The key to unbiased evaluations of pruned sawlogs is an accurate definition of their potential under one or more tightly controlled sawing systems. This can be consistently achieved only through modelling or sawing simulation. Such simulations may define, for a given log or batch of logs, upper benchmarks which are unlikely to be achieved by any real mill. The difference between simulated benchmark results and what a particular mill achieves, or should expect to achieve, has been addressed in depth by Park (1989c), and the difference between the real conversion of these logs from Waratah and the simulated benchmark for the same sawpattern is shown in Part 1 of this paper.

The sawing simulator used here was SEESAW Version 2.1. The prototype SEESAW program (Garcia 1987) has been constantly modified and further developed by C. Todoroki over the past two years. Version 2.1 was our working model for 6 months and was the last intermediate stage before Version 3 (Todoroki 1988).

DATA

The pruned resource evaluation on the Waratah block (Somerville *et al.* in prep.) was carried out over an area of 122 ha which encompassed 1 year's proposed cut. Within this area seven *P. radiata* stands were defined. The first log sample, and that which was to be analysed by sawing, comprised sets of five pruned butt logs from randomly selected mid-dbh trees from four of the stands. These 20 logs provided basic data for this paper and are summarised, by individual log, in Appendix 1. Log length ranged from 3.7 to 6.1 m, s.e.d. 416–502 mm, defect core 267–363 mm, and PLI 3.8–7.9.

A set of 18 pruned logs was also selected from the SEESAW "log library". These logs had been sawn or cross-sectionally analysed in previous studies from seven other sites around New Zealand. They were selected from the "library" to provide an even spread across the then available range of PLI, i.e., PLI 1.5–9.0. Log lengths were all either 4.9 or 5.5 m, s.e.d. 299–552 mm, and defect cores 220–325 mm.

PART 1: APPLICATIONS AND VALIDATION OF THE SEESAW SIMULATOR

Objectives

(1) To design and implement a standardised sawpattern (STD SP) for pruned sawlog evaluations.

(2) To set an upper benchmark for STD SP using the SEESAW simulator on a range of "library" logs.

(3) To saw samples of pruned logs from Waratah to STD SP at the Timber Industry Training Centre (TITC) sawmill in order to provide an "actual" result and acquire new log data.

(4) To replicate the sawmill results on the logs from Waratah using SEESAW (a validation of the SEESAW simulator).

(5) To replicate STD SP benchmark results by "best sawing" of the Waratah logs in the SEESAW simulator (a validation of the STD SP upper benchmark – *see* (2) above).

Methods

The methods described below have been numbered to match the objectives described above.

(1) The standardised sawpattern, STD SP, was designed by experimenting with a range of pruned log types in the SEESAW simulator. The approach was based on results from a previous analysis of three sawing systems using the simulator (Park 1989b) and also on this author's experience with pruned logs in real sawmills. The former identified a Half-taper sawing system as the best for this purpose, and the latter had demonstrated advantages in mixing thicknesses recovered and making sizing cuts, when necessary, in the knotty zone of pruned logs rather than compromising the best placement of opening cuts on all faces in the clearwood zone.

(2) The 18 pruned logs selected from the SEESAW "library" were used to define the upper benchmark for the new STD SP. This benchmark was the level set across the range of pruned log types for conversion to combined clears grades, i.e., defect-free clears plus clear one face, under ideal simulation conditions. SEESAW was set with a 3-mm sawkerf for log breakdown and 5-mm sawkerfs for edging; overcut was zero. Each of the 18 logs was "sawn" to the STD SP and percentages of round log volume out-turned as clears grades were related, by nonlinear regression analysis, to Pruned Log Index (PLI). It has previously been shown (Park 1980) that any satisfactory predictor of clears grades will also predict gross pruned sawlog values with similar accuracy. Gross log value ($\$/m^3(r)$) is the value of all sawn timber and wood residues recovered from a cubic metre of log. As an example, a relative price list (Appendix 2) was used to generate values from the SEESAW simulations and $\$/m^3(r)$ from each log was also related to PLI using non-linear regression analysis.

(3) The 20 logs from Waratah, comprising four subsets of five logs each, were sawn at the TITC sawmill to the STD SP. All cuts made on the headrig were directed by me. Headrig sawkerf was 3.5 mm and edger sawkerfs 5 mm. The study was carried out using the methods of Park & Leman (1983) which, in addition to yielding actual sawing results, provided data for calculation of PLI and for scale reconstruction of each log and preparation as input to the SEESAW simulator (as described by Park 1987). Timber produced at the mill was graded twice, firstly to the current National Rules, and then to grades recognised by the SEESAW simulator. The latter are used for all results presented here.

(4) The first of two simulations, Simulation A, carried out on these "rebuilt" Waratah logs, aimed to replicate the real results from TITC mill. This would constitute a second validation of the SEESAW simulator; the first, under a different and simpler sawpattern, has been given by Park (1987). The most important aspect was to test how well SEESAW could replicate the original distributions of timber grades recovered. Because of the amount of information given to the SEESAW operator prior to commencing simulations, volumetric recoveries would have to be similar unless the log representations in the simulator were seriously in error. Sawkerfs were set in SEESAW to match those measured at TITC. For each log the SEESAW operator was given the location of the opening cut, the number and thicknesses

of flitches sawn from each face, the size of the cant, and details of any sizing cuts that had been made. Also given were the order and thicknesses of pieces recovered from the cant and the full dimensions of every piece recovered from the wing flitches. All mistakes and poor decisions made in the real sawing of these logs were carefully replicated in this simulation. Comparisons of simulated *versus* real sawing were made firstly by comparing volumes by grade recovered from each subset of five logs, and then by comparing the relationships of PLI with conversion to clears grades.

(5) The second simulation carried out on the Waratah logs, Simulation B, aimed to produce the best possible result from sawing them to the new STD SP. For this sawkerfs were set as in (2) above and the SEESAW operator completely ignored all sawing information gathered at TITC mill. Each log was taken on its merits and cut to best advantage within the prescription of STD SP.

Results

Equations for all relationships presented in this section, together with r^2 and residual standard error values showing goodness of fit, are listed in Table 1.

TABLE 1–Relationships derived for conversion to clears grades and gross log values
Model $y = a + be^{-cx}$ $x = PLI$

y	n	a	b	c	r^2	Res.S.E.
A. CONVERSION (%) – defect-free clears						
SEESAW benchmark	18	185.7	−195.6	0.03489	0.94	0.86
TITC mill	20	60.50	−63.74	0.09242	0.50	1.18
Simulation A	20	41.65	−78.34	0.2540	0.78	0.85
Simulation B	20	69.34	−94.11	0.1455	0.92	0.62
B. CONVERSION (%) – combined clears grades (clear & clear one face)						
SEESAW benchmark	18	61.21	−75.14	0.2359	0.92	0.99
TITC mill	20	44.84	−122.8	0.4681	0.80	0.70
Simulation A	20	46.86	−111.7	0.4137	0.75	0.88
Simulation B	20	73.60	−77.69	0.1474	0.80	0.84
C. GROSS LOG VALUE ($/m³(r))						
SEESAW benchmark	18	271.1	−239.4	0.2418	0.96	2.09

N.B.: No graphs are presented for relationships from Block A.

(1) Standardised sawpattern – STD SP

With the sawpattern developed in the SEESAW simulator (Fig. 1), logs are flat sawn using a half-taper system which allows the central axis of the log to be approximately parallel to the saw for all cuts. All faces are free-cut to maximise clearwood recovery and two sizing cuts are allowed, if needed – the first to size the cant from the third face, the second to complete the sawing of the knotty core within the cant. On all faces, 25-mm flitches are cut from the outside until a clear face 150–200 mm wide is exposed over at least two-thirds of the log length; then 40-mm flitches are taken.

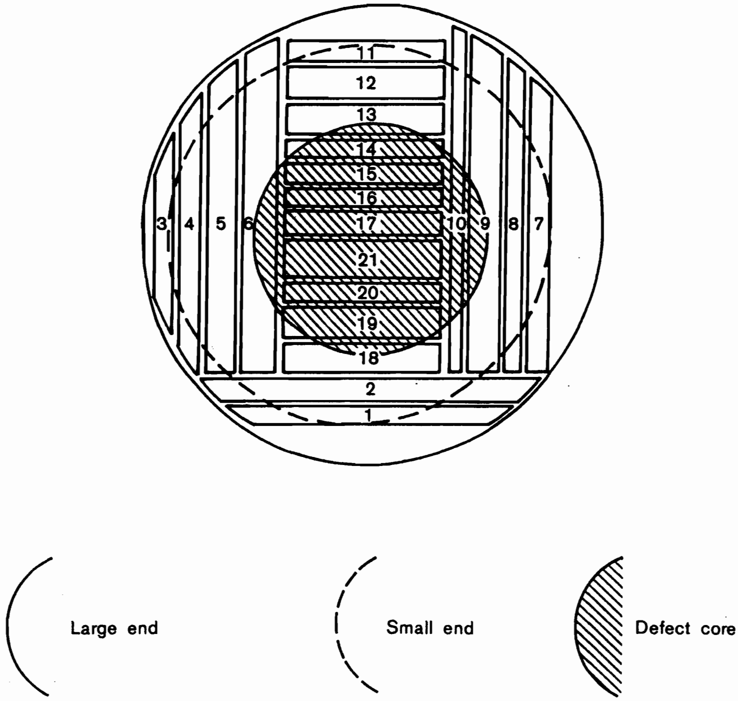

FIG. 1—Example of the standardised sawpattern - STD SP.

Cant depth depends on the size and positioning of defect cores and any of the following cant depths are allowed: 100, 150, 200, 250, or 300 mm. The clearwood-bearing ends of cants are similarly free-cut to 25 and 40 mm but the bulk of the knotty core is sawn to 25 mm to assist accuracy in defect core reconstructions and measurement. This is achieved by cutting from one end until the knotty core is encountered and then reverting exclusively to 25-mm boards until the pith is encountered. The cant is then turned through 180 degrees and cut similarly from the other end. One 50-mm piece or one 40-mm piece may be taken from this last knotty section of the cant in the interests of minimising, or precluding, the second sizing cut. Wing flitches are edged to maximise grade and allowable widths are 50, 75, 100, 125, 150, 200, 225, 250, and 300 mm. The least preferred width is 50 mm and this size is only to be recovered when other options on grade or volume are severely limited. Boards from the cant are not considered for further re-edging unless more than one third of the length contains wane. Docking on all pieces is for wane only.

(2) STD SP benchmark results from SEESAW simulation

The tight relationship between PLI and conversion to combined clears grades, as found by the simulated sawing of 18 "library" logs to the STD SP, is shown in Fig. 2. This has set the upper benchmark for STD SP. The similarly tight relationship between gross pruned log values, generated from the price list given in Appendix 2, and PLI is shown in Fig. 3.

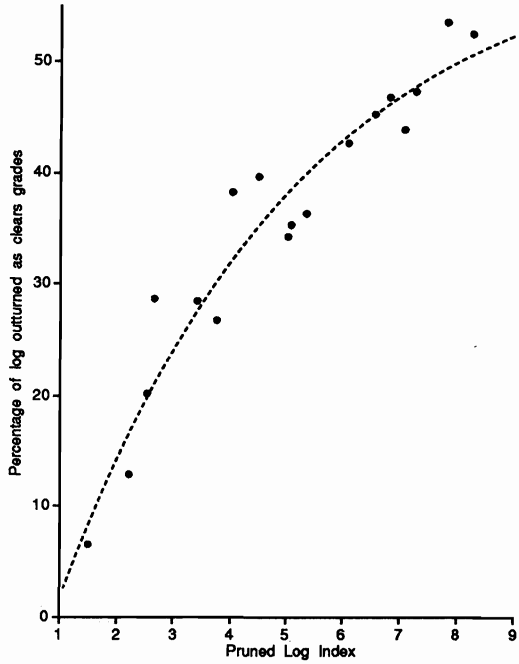

FIG. 2—Benchmark relationship between PLI and conversion to combined clears grades - derived from 18 "library logs".

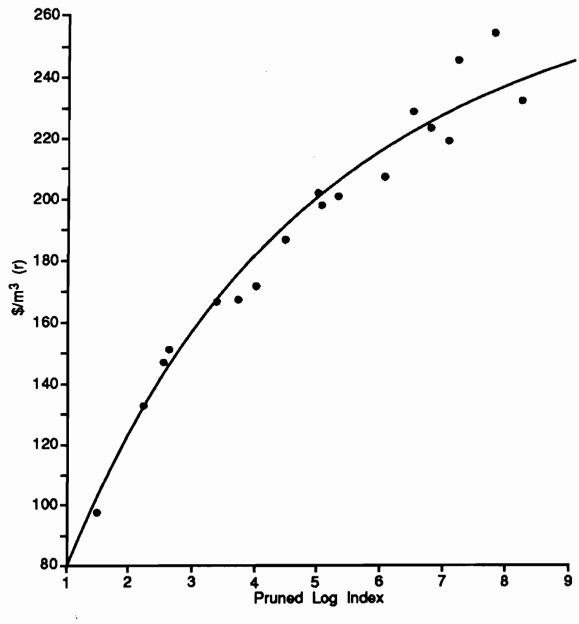

FIG. 3—Benchmark relationship between PLI and gross log values ($\$/m^3(r)$).

(3) Simulation A – Replication of TITC mill results from Waratah logs

Results from sawing the 20 Waratah logs to the STD SP in the TITC mill and then replicating mill plant and practice in SEESAW are presented and compared in two ways. Firstly, in Fig. 4 mill and SEESAW recoveries from each sub-set of five logs are paired for comparison. Each result shows total volume recovered as sawn timber and the contributions made to this by each of the six grades recognised. This closely matched pairing of results from the four five-log samples is a second validation of SEESAW and shows how well real mill results can be replicated.

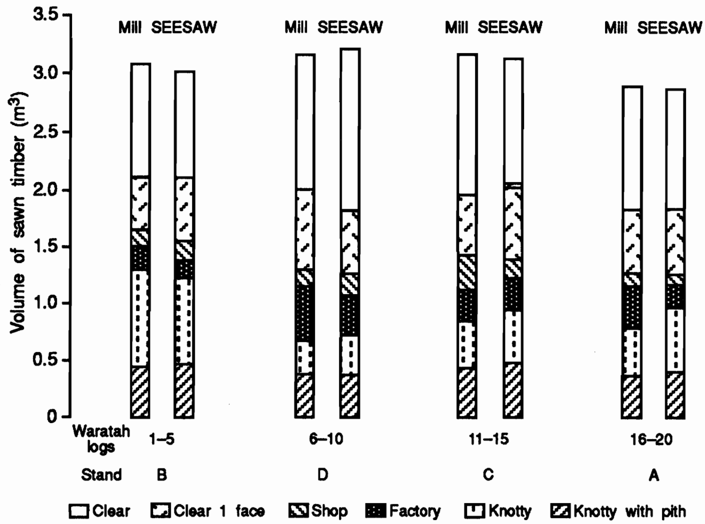

FIG. 4—Comparison of actual (TITC sawmill) and simulated (SEESAW simulation A) recoveries by volume and grade for each subset of five Waratah logs.

In the second comparison, clears grade recoveries from individual logs, expressed as percentage of round log volume, are related to PLI. The plot of points and relationship derived from the mill sawing are shown in Fig. 5a and equivalent results from simulation in Fig. 5b. While the distribution of individual points varies a little between Fig. 5a and 5b, the relationships derived are virtually identical (*see* Section (5) below).

(4) Simulation B – Waratah logs "sawn" to best advantage under STD SP

Conversions to clears grades under this best simulated sawing of the 20 logs from Waratah are plotted in Fig. 6. The fitted curve is both steeper and at a higher level than the relationships shown in Fig. 5 for the same sawpattern on the same logs. This curve from Simulation B does not differ significantly, over the range of PLI it covers, from the benchmark set using "library" logs (*see* Section (5) below.

(5) Comparison of all sawing results

All PLI relationships derived are plotted together in Fig. 7. The upper pairing of benchmark and Simulation B relationships and the lower pairing of curves from real

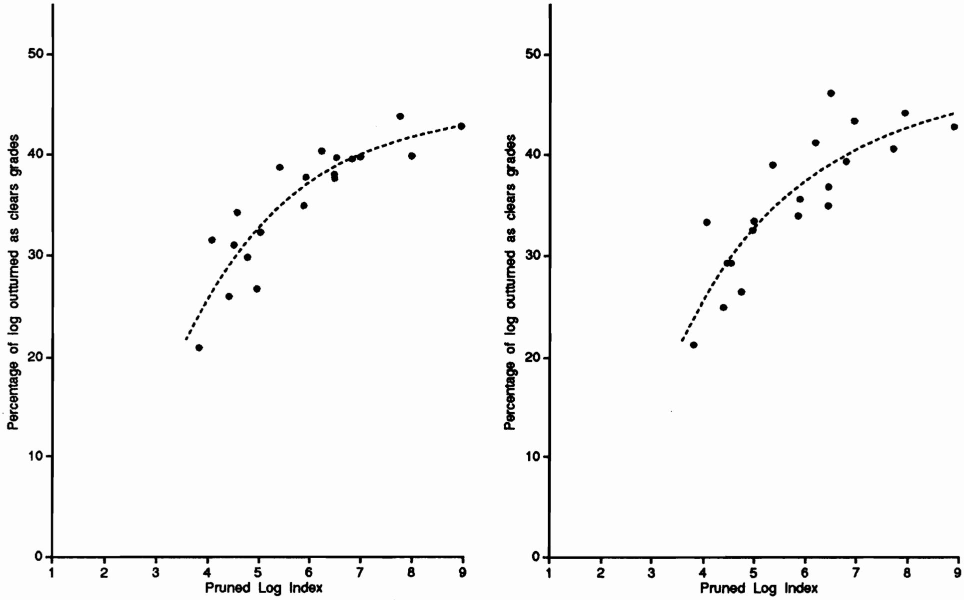

FIG. 5—(a) Conversion to combined clears grades from actual sawing at TITC sawmill.

(b) Conversion to combined clears grades from SEESAW simulation A which aimed to replicate mill results.

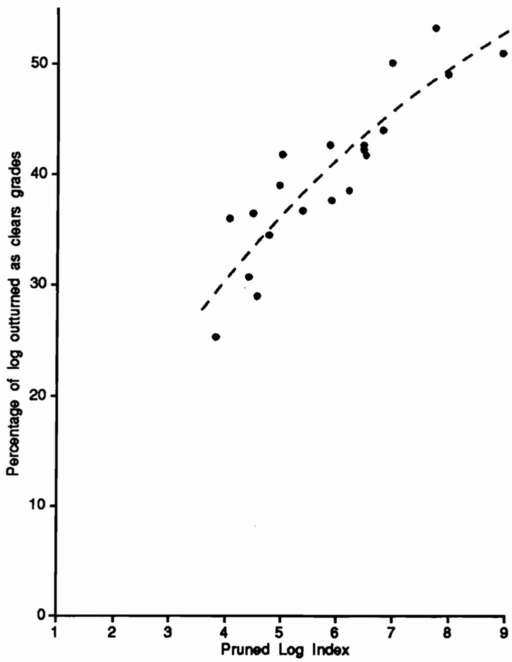

FIG. 6—Conversion to combined clears grades from SEESAW simulation B where logs were cut to best advantage.

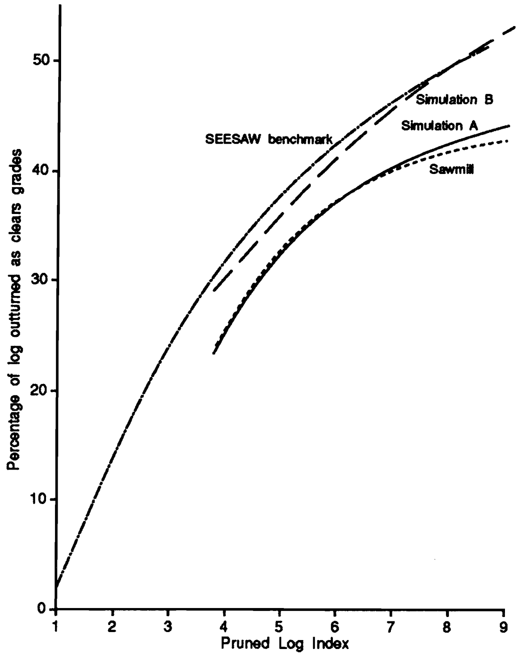

FIG. 7—Comparison of conversion to combined clears grades from benchmark simulation, Waratah simulations A and B, and real sawing of the Waratah logs.

sawing and Simulation A show a very satisfactory performance by the SEESAW simulator. The Figure also serves to demonstrate, firstly, how SEESAW benchmark results and best simulations on any new sample logs should be very similar and, secondly how clearwood recoveries from real sawing, or accurate simulations of real sawmill practice, will fall below SEESAW benchmarks. Conversions to clears grade timber from the TITC sawmill were 5% below the benchmark on the poorest logs sampled and dropped away to 9% less on the best logs. This is not a particularly good performance by a small mill of this type. Other studies (Park 1989c) have shown that efficiently operated small sawmills can come well within 5% of the SEESAW benchmark. Had the grades produced at TITC mill been the only criterion by which these logs were judged, the best of them would have been significantly undervalued.

Conclusions

(1) STD SP is a practical and effective method of converting pruned sawlogs for the purpose of evaluating clearwood potential.

(2) PLI is strongly related to both out-turn in clears grades and gross pruned log values.

(3) Results from real mill sawing are subject to greater variation than simulation results and will undervalue logs if mill performance in conversion and clearwood recovery is substandard or poor.

(4) SEESAW simulation gives an accurate and unbiased appraisal of pruned sawlog potential.

(5) PLI is a consistently reliable measure of pruned log quality. The new samples from Waratah were correctly ranked against the original "library logs".

(6) Real mill sawing can be accurately replicated using SEESAW.

(7) STD SP benchmark results will be duplicated on new log samples if they are sawn to best advantage in the SEESAW simulator.

(8) As a consequence of (2), (5), and (7) it is not necessary to use SEESAW on each new log sample. Calculation of PLI provides immediate access to any benchmark results previously set by SEESAW simulation.

PART 2: EVALUATION OF PRUNED LOGS FROM FOUR STANDS AT WARATAH

This is an example of how a pruned resource evaluation should be carried out using the principles established in Part 1. The approach to sampling, and number of samples drawn, will vary according to the objectives. This exercise was part of a larger study (*see* Somerville *et al.* in prep.) where the bulk of samples were analysed by cross-sectional analysis, and sampling strategy was predetermined to ". . . broadly define pruned log quality on a stand basis". Consequently, mid-diameter logs only were sampled from each stand. (Where the total stand diameter range is to be examined for a complete evaluation of the pruned component, sampling includes the small and the large end of the range and as a consequence sample size is usually tripled.)

Objectives

(1) To evaluate five pruned logs from the mid-diameter range of each of four stands at Waratah in order to broadly define pruned log quality on a stand basis.

(2) To compare results from the four stands.

Methods

Five logs were selected from each of the four stands as described earlier under "Data". The methods of Park & Leman (1983) were used to measure log profiles, dismantle logs by sawing, and reconstruct and measure defect cores from the sawn produce. Using these measurements PLI was calculated for each log. Then the mean PLI together with 95% confidence limits was calculated for each group of five logs, i.e., stand sample. Results from each stand were then classified and compared on the basis of PLI values derived from previously established SEESAW benchmarks for STD SP sawing and the more general interpretation of PLI from Park (1989c).

Results

The PLI, calculated for individual logs, are listed in Appendix 1. The range overall was PLI 3.8–8.9 and the means of the five-log samples from each of the four stands investigated were Stand A 6.1, Stand B 4.7, Stand C 5.7, Stand D 6.7. STD SP benchmark predictions of clears grades recovery and gross log values for these mean PLI are given in Table 2.

TABLE 2–Evaluation of mid-diameter pruned *Pinus radiata* logs from four stands at Waratah

Stand	Mean PLI	Pruned log quality	Predictions from STD SP benchmarks		
			Defect-free clears (% of round log volume)	Combined clears grades (% of round log volume)	*Gross log values ($/m³(r))
A	6.1	"Good"	27.6	43.4	216
B	4.7	"Satisfactory"	19.7	36.4	194
C	5.7	"Satisfactory"	25.4	41.6	211
D	6.7	"Good"	30.9	45.7	224

* Grade benchmarks are permanent but Gross Log Values are dependent on changeable price lists, and are therefore temporary; $/m³(r) are based on the price list in Appendix 2.

The mean PLI, together with confidence limits at the 95% level, are also shown in Fig. 8 which includes the general classification of PLI values (from Park 1989c).

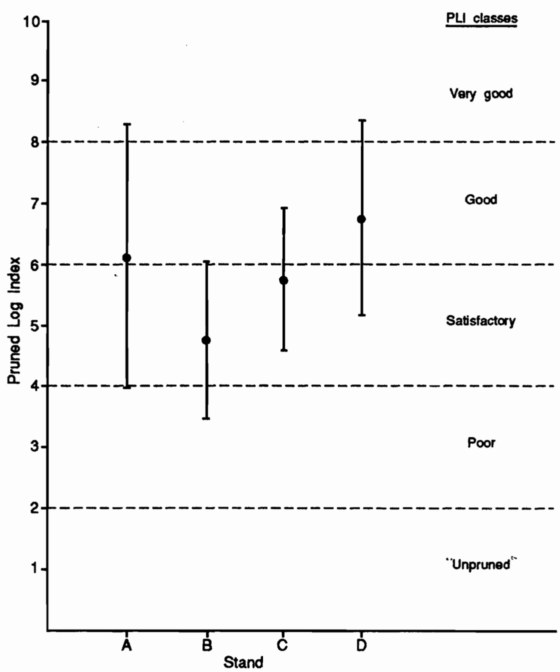

FIG. 8—Mean PLI with 95% confidence limits from stand samples.

Conclusions

(1) These four Waratah subsets were all classed as "satisfactory" to "good", which represented the top third of all pruned logs available to sawmillers at the time.

(2) Although results from all stands were similar, the comparisons in Table 2 and Fig. 8 suggest Stand B could be separated as not as good as the other three.

(3) Potential conversions to combined clears grades, interpreted from the STD SP benchmark, were from 36% to 46% of round log volume. (Clears grades recoveries in most sawmills would be about 5% lower than those figures.)

(4) Further analyses of these samples by SEESAW simulation would have neither improved upon nor altered the results presented.

DISCUSSION

These methods of evaluating pruned sawlogs are based on accurate and detailed measurements of individual pruned logs. The measurements provide data for both the calculation of PLI, which is an absolute measure of log quality, and SEESAW simulations. The prime objective is to determine accurately the potential of pruned sample logs to produce clears grade timber. This is initially established by simulated sawing to a standardised system designed to maximise clearwood recovery. Subsequent evaluations can be made more easily using the tight relationships derived between PLI and simulation results.

These studies have shown how sample logs can be "rebuilt" and input to SEESAW to provide better and less variable estimates of pruned sawlog potential than can be derived from a real sawing study. The great advantage in simulation is the removal of sawmill variation, thus allowing the universal application of results. SEESAW is the only simulator available which can accurately simulate grade recovery from individual pruned logs. The drawbacks with using SEESAW are, firstly, the time it takes to prepare sample log data as input and carry out one simulation and, secondly, the level of expertise required from the operator. On its own, SEESAW is an inappropriate tool for general and frequent pruned sawlog evaluations. However, the studies have also shown how the strong relationships established between SEESAW results and PLI can effectively substitute for continual use of the simulator. These relationships were used to establish STD SP benchmarks for clears grades recovery and gross log values (they could be and have been used to establish similar benchmarks for other sawing systems, e.g., Park 1989b). PLI predictions from those benchmark relationships are as accurate as the complete processing of each new set of sample logs in the simulator by an experienced operator. More importantly, this path reduces the time taken for data analysis from days to minutes.

Part 2 of this paper gave an example of how a straightforward resource evaluation of pruned sawlogs should be carried out. The exercise was relatively simple and direct use of the SEESAW simulator was not necessary. In that example log data were acquired by means of a sawing study. The same data could have been more easily and more cheaply acquired through log cross-sectional analysis in the forest, and this is the method most frequently used in current pruned resource evaluations.

Although a sawmill timber grade study and/or new SEESAW simulations are not necessary for routine pruned log evaluations they are still required in some circumstances. Some examples have been given by Park (1989c). Another example is when a dispute arises between grower and miller over the quality of pruned logs being supplied. In that situation a sample of logs in the mill yard can be measured, sawn by the mill's own method, then "reconstructed" to provide defect core measurements.

PLI may then be calculated to establish the quality of logs in the mill yard at the time. Should the log quality found coincide with the miller's view then options are either a further examination of the log source or an adjustment in log price. On the other hand, experience has shown that, when the finding on quality is in favour of the grower, sawmillers are often reluctant to accept results because their clearwood recoveries are below expectation. When this happens it may be necessary to convince the saw-miller by identifying why and where he is losing clearwood. Those questions can be conclusively resolved by examining the "actual" conversions and grades and then using the sample log data for a series of SEESAW simulations (including the mill's own saw system) similar to the exercises shown in Part 1 of this paper.

To date, the techniques described here have been used to provide the basis for seven separate pruned log sales.

ACKNOWLEDGMENT

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APPENDIX 1

PRUNED *PINUS RADIATA* BUTT LOGS SAMPLED FROM FOUR STANDS AT WARATAH

Log No.	Length (m)	dbh (mm)	s.e.d. (mm)	Sweep (mm/m)	Taper (mm/m)	Defect core (mm)	Volume (ub) (m^3)	PLI
STAND A								
16	4.3	552	461	3	8	313	0.782	4.98
17	3.7	630	517	9	16	267	0.930	8.90
18	4.6	610	502	4	10	309	0.996	6.43
19	4.9	572	443	8	11	299	0.852	5.87
20	4.6	601	484	8	8	348	0.899	4.45
STAND B								
1	5.2	552	416	10	13	301	0.854	4.03
2	4.9	570	472	7	11	286	0.949	6.44
3	4.9	554	463	10	10	322	0.924	4.53
4	5.2	588	461	11	19	323	1.044	4.94
5	4.9	575	455	8	13	363	0.932	3.80
STAND C								
11	4.9	576	466	5	12	277	0.948	6.94
12	4.6	638	474	8	15	304	1.006	5.35
13	4.9	630	493	6	13	322	1.108	5.83
14	4.6	583	466	2	4	260	0.856	6.18
15	4.9	577	464	11	11	335	0.887	4.38
STAND D								
6	4.9	572	483	5	9	299	0.965	6.78
7	4.9	600	479	6	7	296	0.964	6.47
8	6.1	578	467	6	10	326	1.220	4.74
9	4.9	569	452	9	12	225	0.918	7.94
10	4.6	577	444	5	11	234	0.847	7.71

APPENDIX 2

RELATIVE PRICE LIST
(Based on Waipa Wholesale Price List 1986)

Grade	Width	
	50–150 mm ($/$m^3$)	200–300 mm ($/$m^3$)
Pith	127	135
Knotty	135	150
Factory	172	199
No. 1 cuttings	270	301
Clear one face	318	344
Defect-free clear	398	441

Waste credit—sawdust and chips = $25/$m^3$.