PROFITABILITY OF SECOND LOG PRUNING

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ABSTRACT

Pruning of a second log length (in addition to a butt log) was carried out over 3030 ha of State plantations in 1959-70 but only over 0.4 ha in 1971-72. Change in log form following thinning and pruning and the potential of radiata pine (**Pinus radiata** D. Don) to be grown to 60 cm d.b.h. in 26 years on a site index of 29 m have recently been demonstrated. This, and results from grade studies, suggest that the profitability of second log pruning should be re-examined. Profits of $72/ha land expectation equivalent are made at 7% interest, after allowing costs of $39.5/ha for each of two pruning lifts of 5.5-8.5 and 8.5-11 m, for trees of the size and age given. Uninodal second logs should remain unpruned. Profitability is naturally sensitive to all cost, return and silvicultural variables.

Second log pruning of short rotation sawlogs is a special, simple case in which the comparison between pruned and unpruned logs of the same age is valid, as the rotation and other treatments stay constant. Pruning profitability should normally be calculated by comparisons with the most profitable alternative regimes.

INTRODUCTION

Second log in this paper refers to the log-height class from 5 m ± 0.3 m to 10.3 m ± 0.6 m; that is, the log-height class immediately above the butt log, in 4.5 or 5 m lengths. An early reference to the pruning of the second log (Bridge, 1959), while dealing largely with the technique of the operation, stated "Pruning . . . (above) 18 ft (5.5 m) has long been considered desirable, silviculturally as well as commercially. Expected costs and . . . arrears of (other) primary silvicultural work, have combined to prevent it . . . (becoming general)". Again, ". . . there is evidence that it is economic to prune radiata pine as high as 26-28 ft (8-11.5 m) to obtain a second log free of knots. Considerable attention has been given to equipment for this operation" (New Zealand Forest Service, 1963). Later, "The recent development of an elevator and platform . . . has provided a ready means to raise pruning on a large scale to between 30 and 40 ft (9 and 12 m). . . . There is every reason to expect that the comparatively modest cost of this work will be handsomely recouped by the enhanced value of the sawlogs containing a high proportion of clear wood" (New Zealand Forest Service, 1964). In 1965, results were reported from a study of 12 logs—the Waierua study—which "would have an increased value due to (all) pruning of about £200 per acre ($988 per ha) . . ." (New Zealand Forest Service, 1965). In view of this enthusiasm, the extent of such pruning actually done is interesting.

Table 1 shows the extent of this operation in State forests in the 1960s; large areas were also pruned to a second log in private forests, notably in Northland and the Bay of Plenty. The records show discrepancies, which is surprising in view of the expense and the limited scope of second log pruning operations.

TABLE 1—Areas second log pruned in State forests (ha)

Conservancy		Pre-1962	1963	1964	1965	1966	1967	1968	1969	1970	1971 & 1972	Total (1)	Total (2)
Radiata pine													
Auckland		244	367	159	4			5				779	772
Rotorua		285	134	80	75	31	44	17	9	6		681	515
Wellington		216	23	2				2	2		½	245	61
Nelson			5	24	55	28	71	53	7	13		256	136
Westland								40	1			41	52
Canterbury		339	26	19		114	64	55				617	576
Southland			5	4	15	5	11	1				42	36
Totals		1084	560	288	149	178	191	173	19	19	½	2631	2148
Other species (3)													
Auckland	O	74	15	3		4						96	144
Rotorua	D		5									5	7
	C		6	(5)								6	53
(4)	O	(9)											9
Wellington	C			113								113	109
	O												10
Nelson	C						189	22				211	
	O		1									1	
Canterbury	O									1		1	2
Southland	O		6	9		2		2	2			21	22
Totals		74	33	125		6	189	24	2	1		454	356

(1) Totals of yearly amounts, from New Zealand Forest Service Annual Reports.
(2) Totals as given in New Zealand Forest Service Annual Report 1972.
(3) C = Corsican pine; D = Douglas fir; O = Others.
(4) Probably pre-1963, not recorded in New Zealand Forest Service Annual Report 1963.
(5) Probably 40 ha were pruned in 1964, as running total increased to 53 in 1965.

An initial period of second log pruning in the early 1960s was logically concentrated on radiata pine (*Pinus radiata* D. Don)—the fastest growing species. The location of the pruning was less logical; large areas were pruned in Auckland and Canterbury, where the lower site qualities reduce pruning profitability. Little second log pruning was done in Auckland after 1964 and in Canterbury the operation was reduced after 1966 because of the modest growth rate and the presence of resin pockets (Clifton, 1969) in the timber from that district. Almost no second log pruning is now done in New Zealand State forests.

PAST WORK IN NEW ZEALAND

Developments in methods were initially rapid, and in addition to the two-ladder technique (Bridge, 1959), the Morris pruning platform (Reid, 1963) was developed by Forest Service staff. Analysis of the benefits and possible profits was less pronounced. In 1959, it was estimated that a 25.5 cm knotty core at Ashley on 5 m second logs of 53 cm mid-diameter would result in additional clear timber whose value ". . . is likely to make the 30c pruning cost a very paltry sum" (Bridge, 1959). Profitability calculations were hampered by absence of actual grade results from such pruning.

Theoretical analysis of full log length clearwood yields from radiata pine was based on a top height/d.b.h. curve from permanent sample plot results, and on taper tables for unthinned stands (Fenton *et al.,* 1963). A restricted knotty core and a substantial final tree (over 51 cm d.b.h.) were required. As pruning at tree heights of over 18 m would result in cores greater than 25 cm diameter, second log pruning would have to be relatively severe to restrict the core size.

Actual grade results became available (Fenton, 1968) from Waierua, where 11 trees, 38 years old and 61 cm mean d.b.h., had been well pruned by the owner. Despite the 24% yield of full length clears, together with 45% of Factory and Dressing grades (N.Z. Standards Inst., 1970), the enhanced grade yields would not have covered pruning costs of $44.5 for each lift when compounded at 5% to age 40, and a loss of $89/ha would have resulted from the pruning. A major reason why second log pruning was not more profitable was the already high (23-25%) yield of Factory grade from untended radiata pine (Fenton and Sutton, 1968); the pruning of second logs had a lower grade enhancement than butt log pruning. A further reason for low profitability was the long (36-40 yr) rotations then considered necessary to obtain large diameters; Ashley rotation, for example, was envisaged as 45 years (Bridge, 1959). Costs were naturally high when compounded.

Three recent developments, together with the Waierua grade results, now affect second log pruning profitability—first, more precise information on volume above the butt log in heavily thinned stands of radiata pine (Fenton *et al.,* 1971); second, the potential of the species to be grown to a large diameter on short rotations (Fenton and Sutton, 1968); third, a standard method of calculating realisations per log and of assessing pruning profits.

EFFECT OF CURRENT FINDINGS

Log Volume Distribution

The actual second log volumes obtained from mean trees of 60 cm d.b.h. from heavily thinned stands were 5-10% greater (Fenton *et al., 1971)* than those projected from taper tables for unthinned stands (Duff, 1954). Hence recovery of sawn timber of high grade is likely to be greater than projected earlier (Fenton *et al.,* 1963). It had been previously stated "To determine if the generalised case is applicable to local conditions . . . it would be necessary to use local data to test if differences are significant. This applies to height/d.b.h. relationship; occlusion rate; taper and tree size" (Fenton *et al.,* 1963). Results obtained so far for second-rotation pumice land areas suggest a favourable change in stem taper follows thinning to 544 stems/ha at a height of 12 m and to 173-198 stems/ha at 27.5 m. The data are still limited and butt and second log form at low stockings require further study.

Grade Results

Second log grade results are now available from several tended stands, including one study—Waierua—where second logs were pruned. Results are given in Table 2 for sawing predominantly to 1 in. (2.5 cm) boards.

TABLE 2—Second log grade outurns

Study		Age (yr)	Log s.e.d. i.b. (cm)	Tree d.b.h. o.b. (cm)	Log vol. (m^3)	Grade % Box	Merch.	Dress.	Factory	Framing	Clear
Kaingaroa Cpt 1045	(1)	42	44.0	64	0.95	70	4	1	27	1	
Waierua	(2)	38	43.5	62	0.88	20	10	18.5	27		24.5
Waiotapu Cpt 28	(3)	26	42.5	60	0.90	22	26	12.5	34	5.5	

(1) Fenton, 1967; 30 unpruned logs
(2) Fenton, 1968; 11 pruned logs
(3) Fenton **et al.**, 1971; 15 unpruned logs

The Waierua second logs were 5% greater in small end basal area than those from Compartment (Cpt) 28, Waiotapu, and some allowance in grade would have to be made in estimating pruned second log grades from trees of 60 cm d.b.h. Against this, the cubic volume calculated from Smalian's formula for the Waierua sample was 0.88 m^3 whereas Waiotapu Cpt 28 was 0.90 m^3 from Newton's formula and 0.88 m^3 from Smalian's, so the grade outturn of the Waierua sample could reasonably be used for projections of logs of the same volume and pruning treatment. The sawmill conversion factors were 57% (Waierua—based on Smalian's formula) and 62% (Cpt 28, Waiotapu —based on Newton's formula); these differences are about 8% and would have a corresponding positive effect on realisation and profitability. The timber lost in conversion of the Waierua stand may all have been of low grade, however, with an inflated percentage recovery of better quality timber.

Realisations

Tables 3 and 4 show two simplified realisation calculations for unpruned (Cpt 28 Waiotapu) and pruned (Waierua) second logs. The basis for the export clear price is taken from an Australian price for finger-jointed clears; the realisation calculation is as for the profitability studies (Fenton, 1972a). The effects of log cartage, slab credit, cost of milling, and mill profit allowance are constant for the pruned and unpruned classes and have been omitted; what is significant is the difference in the two final figures/m^3. Any one of the cost or return items shown in Tables 3 or 4 naturally affects profits; all the tables show is a basis for comparing log values at clearfelling. The statements would have to be extended to a value at stump if further data show differences in sawing, log hauling and loading, and logging costs are likely to result from second log pruning.

TABLE 3—Timber realisations—unpruned second logs at 25-26 years. Grades from Cpt 28 Waiotapu

Export sales Grade	Size (in.)	%	Price (1) $/100 bd ft		Domestic sales Grade	Size (in.)	%	Price (2) $/100 bd ft	
Clears		0.0			Merchantable	4 × 1	6.0	5.12	
Dressing	4 × 1	6.0	9.30			8 × 1	8.0	6.35	
	10 × 1	6.5	10.25			12 × 1	12.0	7.78	
Factory	6 × 1	15.0	8.10		Box	4 × 1	7.0	4.15	
	10 × 1	19.0	10.80			9 × 1	15.0	4.45	
					Frame I	4 × 2	3.5	7.62	
		46.5		4.49	Frame II	4 × 2	2.0	6.52	
Less 46.5% of Mill handling		0.70							
Transport		0.50					53.5		3.10
Wharfage		0.25			Less 7½%; 2½% trade and cash discounts			0.30	2.80
		1.45			Plus DIF 0.06/100 bd ft			0.03	2.83
				—0.67					
	Net export sales			3.82					
	Domestic sales			2.83					
	Total			$6.65/100 bd ft at mill					

Conversion factor 53.7% = $15.14/m³ at mill

(1) Price at port F.O.B. (2) Price at mill DIF = Differential in rail freight allowance

Timber sizes and prices have been retained in Imperial units in these realisation statements

TABLE 4—Timber realisations—pruned second logs at 25-26 years. Grades from Waierua

Grade	Export sales: Size (in.)	%	Price (1) $/100 bd ft		Grade	Domestic sales: Size (in.)	%	Price (2) $/100 bd ft	
Clears	All	24.5	14.31[3]		Merchantable	4 × 1	2.0	5.12	
Dressing	4 × 1	9.0	9.30			8 × 1	3.0	6.35	
	10 × 1	9.5	10.25			12 × 1	5.0	7.78	
Factory	6 × 1	12.0	8.10		Box	4 × 1	6.0	4.15	
	10 × 1	15.0	10.80			9 × 1	14.0	4.45	
		70.0		7.91			30.0		1.55
Less 70% of Mill handling		0.70			Less 7½%; 2½% trade and				
Transport		0.50			cash discounts			0.15	1.40
Wharfage		0.25			Plus DIF 0.06/100 bd ft			0.02	1.42
		1.45		—1.02					
	Net export sales			6.89					
	Domestic sales			1.42					
	Total			$8.31/100 bd ft at mill					

Conversion factor 53.7% = $18.93/m^3 at mill

(1) Price at port F.O.B. (2) Price at mill (3) Price from Melbourne, price for finger-jointed clears (Fenton, 1972a)

DIF = Differential in rail freight allowance

Rotations

It had previously been assumed that rotations would be at least 36 years for sawlog regimes, and the profitability of this regime has been calculated (Fenton, 1972b). The short rotation (26 yr) proposals (Fenton and Sutton, 1968) are far more profitable (Fenton, 1972a); they did not originally specify second log pruning. The new data on log form, the applicability of the results from the Waierua sample, and the short rotation aim of a final tree d.b.h. of 60 cm, not the 57 cm of the 36 yr rotation (where diameter growth potential is sacrificed for a production thinning yield of pulp logs), suggest re-examination of second log pruning.

PROFITABILITY OF PRUNING

Costs

The cost given in 1959 of 3s or 30c/tree (Bridge, 1959) was for the entire 5.5 to 11 m lift. Two lifts of 5.5-8.5 m and 8.5-11 m at 14 and 17 m top height were considered necessary in profitability calculations (Fenton, 1972a) and were allowed at \$39.5/operation/ha on 198 stems/ha. There would also be additional administrative costs, but these are omitted here.

The direct costs/ha at three interest rates for a 26-yr rotation (to give a 60 cm tree on site index 29 m) are given in Table 5, both in discounted terms to year of origin of the stand, and compounded to rotation age.

TABLE 5—Second log pruning costs/ha

Pruning lift (m)	Age (years)	Cost (\$/ha)	Discounted cost(1) 5%	7%	9%	Compounded cost(2) 5%	7%	9%
5.5-8.5	10	39.5	24.25	20.08	16.68	86.22	116.61	156.83
8.5-11.0	12	39.5	22.00	17.54	14.04	78.21	101.85	132.00
Total \$/ha		79.0	46.25	37.62	30.72	164.43	218.46	288.83
Cents/m³(3)			27	22	18	98	130	172

(1) Discounted to year stand is established
(2) Compounded to year of clearfelling
(3) Assuming 0.85 m³/log, on 198 stems/ha

Returns

The extra return obtained, and the profits/ha, are given in Table 6; the data can be used to show the break-even margin necessary—130 cents/m³ at 7%. In practice, a greater differential would be required to cover the pruning administration costs omitted here. The realisation calculations in Tables 3 and 4 can be re-worked to test the effect each price or grade outturn or other variable has on net realisation; the cost half of the equation can be similarly adjusted. If the pruning costs need adjusting, they can be multiplied by:

$$\frac{\text{new cost}}{\text{old cost of \$39.5}}$$

TABLE 6—Second log pruning margins—26-yr rotation

A. At rotation age (26)					
	Extra return(1)		Profit at interest rate		
			5%	7%	9%
	cents/m³	379	281	249	207
	$/ha	638	474	419	349
B. Discounted to year of establishment					
	Return discounted			Profit at interest rate(2)	
$/ha (viz land	5%	7%	9%	5%	7%	9%
expectation value)	179	109	68	133	72	37

(1) The differential between the values/m³ in Tables 3 and 4
(2) The extra return less the costs from Table 5

Qualifications

It must be stressed that this calculation of pruning profitability is unusually straightforward, as the unpruned alternative is produced in the same rotation and from otherwise equal management. In other cases, the calculation of pruning profitability must be made by comparisons with the best alternative unpruned regime (Fenton, 1968), which may well have a shorter rotation, so comparisons should usually be made in discounted terms (as land expectation values). This can be illustrated by supposing, as is feasible, that the severe schedule required for second log pruning slows down increment in the following 10-14-yr period, and that to produce trees of 60 cm d.b.h. now takes 28, instead of 26, years. The profitability comparison is then superficially made on the discounted costs of pruning, as in Table 5, and the discounted benefits—which are reduced by a further 2 years from those given in Table 6.

$/ha	Return discounted			Profit		
	5%	7%	9%	5%	7%	9%
26-yr rotation	179	110	68	133	72	37
28-yr rotation	163	96	57	116	58	26

This, however, fails to allow for the fact that *all* plantation costs are increased by a further 2 years, and the benefits of $116, $58 and $26/ha at 5%, 7% and 9% interest would have to exceed the extra costs of prolonging the rotation.

In discounting terms, additional administrative costs would have to be added for years 27 and 28, and the full discounted returns from all log-height classes reduced by a further 2 years' interest. The neglect of this principle, among other things, led to the claims of an extra $988/ha benefit from two log length pruning (New Zealand Forest Service, 1965), as a comparison was made with an unpruned sample grown on the same rotation. The comparison should be made with the most profitable alternative regime, whether pruned or not.

DISCUSSION

Within the limits of present data, it appears to be profitable to prune 26-yr rotation sawlog regime stands to 11 m at interest rates of at least 9%. Further investigation may determine other pruning heights. For example, 8.5 m pruning would enable a short 3 m butt log to be sawn which would accommodate the most tapered part of the pruned length (and where pruning can be timed and executed most precisely), with a 5.5 m log of good form above. Alternatively, mixes of veneer bolt (2.6 m) and sawlog lengths could be produced. The severe pruning may itself have favourable effects on log form.

If this finding of profitable second log pruning holds, the "short sawlog rotation" regime is modified by additional 5.5 to 11 m pruning of all second logs which are not already uninodal. (The only strictly uninodal log sawn from Cpt 28 at Waiotapu was worth as much as the average pruned realisation given in Table 3, as it was largely of Factory grade). Overall grade outturn would improve further. If sufficient trees with uninodal second log branching frequency were available the pruning would not be worthwhile on present prices. It should be stressed that the first result of successful pruning is Factory grade (Fenton *et al.,* 1971; Fenton, 1967).

Projections made for South African radiata pine (using 6.5% interest rate, pruning at 14.6 and 17 m to a final height of 10.7 m, and achieving a final 51 cm d.b.h. tree at age 40) showed second log pruning was financially justified (Van Laar, 1965). Later work in South Africa (Bosman, 1968) showed that pruning to 10.7 m on high quality sites was more profitable than butt log pruning on low quality areas. This study included an allowance for saving in trimming cost at clearfelling, a factor which has not been quantified here. Projections for South Australian radiata pine (using 4% interest rate and a rotation of 50 years) were primarily concerned with assessing the likely volume of higher grades produced (Lewis, 1965). Similar qualifications for costs, timing, grade production and conversion factors applied to these overseas, as to the local, figures.

CONCLUSIONS

Pruning profitability should be calculated by comparisons between the alternative, most profitable regime and should not be based only on comparisons between a pruned or unpruned log of the same age. The calculation of second log pruning profitability for the short rotation sawlog regime (Fenton and Sutton, 1968) is, therefore, a special case, as the comparison between pruned and unpruned log applies within the same rotation and other treatments stay constant.

Pruning of the second log of radiata pine, if multinodal, is profitable at interest rates of at least 9%, if pruning is early, rotations for trees of 60 cm d.b.h. are 25-26 years, and current price margins and costs apply. It carries a relatively high degree of management risk.

Profitability assessments should be made for any pruning operations when they vary from the qualifications given above.

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