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LONG LOG CUTTING IN THE BUSH FOR HAULER EXTRACTION: CUTTING STRATEGIES TO MINIMISE VALUE LOSS

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ABSTRACT

Increasingly in the future, the harvesting of New Zealand's plantation resource will expand on to steeper, and more difficult terrain, requiring the use of cable haulers. Harvest Planners are likely to try and keep landing sizes to a minimum as they adhere to both economic and environmental constraints.

Small landings may require that clear-felling aged Radiata pine be reduced in length by the fallers before it can be efficiently handled.

The cutting of the stem into sections rather than final log lengths is proposed to minimise the fallers task and to ensure final log-making is undertaken in a more suitable location. A general methodology to develop cutting instructions is presented and illustrated with four examples.

The effect of the stem sectioning approach on total log value is quantified. The results indicate that with the use of an appropriate strategy only about 1% total potential value is sacrificed.

INTRODUCTION

The processing of stems in the bush before extraction by cable systems is a relatively new experience in radiata pine harvesting in New Zealand but has been practised for some time in other countries. The Pacific Northwest region of North America is where New Zealand logging people often look to develop their ideas in logging techniques on steep country. Processing in the bush is a

Figure 1 - Cutting the stem into sections to improve handling will be a valid option in many settings.

widespread practise in this region and therefore of interest to New Zealand. But rather than directly copy this technique, the reasons why log length extraction is used in the PNW must first be understood, especially as some in the PNW would avoid this practise if it were possible. The reasons for log length extraction in the PNW are :

1. Natural stands contain a mixture of species and a wide range of tree sizes. Some trees by New Zealand radiata pine standards are very large. Cutting to length enables these stands to be reduced to pieces of a more even size. This means more efficient use of the extraction and loader units.

2. Many natural stands of the PNW contain substantial proportions of stem rot. Bucking in the bush enables the worst of this to be left behind.

3. Much of the hauler extraction is on steep terrain where road and landing construction is very expensive. Cutting to length enables landings to be kept small.

This latter reason is of most interest to New Zealand. Our harvesting will increasingly occur in areas where there will be significant constraints on landing formation.

Processing in the bush has, up to recently, been scantily researched in New Zealand. One of the first signs of interest was by G. Murphy in 1977 with "A pilot study of three log preparation alternatives for cable-logging" (FRI, Economics of Silviculture, Report No. 104, unpublished). This investigation concluded that processing to log lengths in the bush was not economic compared to the conventional tree length extraction. The study was, however, based on a large hauler (350 kW) and restrictions on landing size were not considered.

Measurement has shown that the smaller 071 Madill (200 kW) maintains an average haul size of approximately 3.5 - 4.0 tonnes (M. McConchie, FRI, pers. comm.). Cutting to length should enable a better balancing of the load size for this smaller machine to allow the haul size to be kept to the higher end of this scale.

Of more obvious concern is the need to be able to land logs on smaller skidsites. Skidsites may in the future not always be able to be constructed to sizes that are possible in most of the areas now harvested.

The objectives of cutting to length in the bush in New Zealand are therefore :

(a) to reduce the length of the butt piece, to enable it to more easily land on the skidsite;

(b) to reduce the weight of the butt piece, to allow the breaker-out the opportunity to attach the most appropriate load size for the site (amount of deflection) and the machine capacity.

DEVELOPING CUTTING STRATEGIES

Radiata pine at clearfell age of 30 - 35 years will produce a butt length* to the first break of approximately 25 - 30 metres, although there will be considerable variation of this length. It is this butt segment of the tree, containing about 99% of the tree's value, which must be reduced in length and weight.

How many cuts should be in this butt piece?

Under most cutting patterns the 25 to 30 metre length would be expected to produce 4 - 5 logs if a long length sort (8 - 12 m) is included in the mix, and 6 - 7 logs if only shorts are cut. Cutting all of these logs in the bush is likely to be unrealistic for any of a number of reasons, including the following :

(i) The task would put a greater workload on the faller, the most likely candidate to undertake the length cutting. A greater number of skilled fallers would be required, possibly more than are presently available.

(ii) Cutting such a large number of logs is unlikely to be satisfactory from a safety point of view, both for the fallers when they are cutting the logs and the breaker-outs when they are stropping in the bush. Falling is already a dangerous task without adding log processing problems.

(iii) Having to extract a large number of short logs is likely to have a serious effect on the productivity of the extraction system. It would take a considerable time to accumulate an optimal load for the machine.

(iv) Dropping short logs under the tower will lead to jackstrawing. This would complicate the job for the skidworker, who will still be required to unstrop and do a final trimming, and for the loader trying to sort and stack.

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* Butt length refers to the single piece of the stem from the base of the stem to first felling break.

(v) Many of the log types cut can be deceptively similar and require a surface coding for the loader operator to correctly segregate them. For example, a 5.3 m peeler and a 5.5 m pruned sawlog, or a 4.9 m complete pruned and a 4.9 m partially pruned sawlog, would be of different value and may go to different destinations but would look very similar. Paint labelling by the faller would be unlikely to survive the treatment logs receive during extraction, so the skidworker would have to remeasure and classify many of the logs for the loader operator.

If not 4 - 6 logs then how many?

The most simple option is to cut the butt piece in half, creating two sections of about 12 - 15 metres. Because of tree taper however, they would be of disproportionate volume. To make the two sections of a more even volume the cut should be made closer to 12 metres from the butt. This would mean the top log would be about 18 metres long. On small skidsites under a short tower 20 - 24 m is about the maximum limit of the effective processing area between the tower and the edge of the skidsite.

Cutting the butt piece into more than two long length logs begins to encompass the problem areas (i) - (v) outlined above.

Given that around 12 metres is the best place to cut the stem to even the weight distribution of the two pieces, what flexibility should be allowed around this position?

The minimum cut position should be at 10 - 11 metres. Shorter than this the top piece will be too long to land easily on the skidsite and the short butt log may cause problems in extraction.

The upper limit should be about 15 metres. Above this height the butt log would contain a disproportionate percentage of the volume. The maximum limit of 15 metres has further significance as it is the length of a standard loggers tape (although 25 m versions are available).

How should the faller decide where to cut within this 10 - 15 m zone?

All of the clearwood will be incorporated in the bottom third to half on the first long log so will not be affected by the cut position. The characteristics of the second log will, however, be set by the decision of where to place the cut.

The length of the clearwood zone is a key factor in determining the pre-emptive cut position. Two points must now be borne in mind :

1. The faller will make errors in detecting the end of the pruned zone.

2. Because of variation in pruning height and the length between branch whorls in Radiata pine, the clearwood zone will vary considerably between trees within the same stand.

Any decision rules must therefore have sufficient flexibility to cope with these influences.

The first decision the faller must make after felling the tree and perhaps trimming the butt is to locate the end of the pruned zone. This might be expected to vary from 2 - 7 metres. If a pruned log can be cut from this pruned length then the faller will have to add on another unpruned log length to reach the position for the pre-emptive cut, i.e.

Pruned log + unpruned log = 11-15 metres total length

The sort length specifications vary amongst regions and sometimes operations. Pruned logs tend to have wide length limits, to maximise recovery. Some of the variation in recovered pruned sawlog length observed in use are :

Some pruned sawlog length specifications

Minimum (m)	*Maximum (m)*
3.1	*7.6*
3.7	*7.0*
4.9	*6.1*

Unpruned log sort lengths also show considerable variation. In some regions only short sawlogs (less than 7 m) are cut while in others long length logs (up to 12 m) can be produced. Thus several sets of decision rules are necessary to cover the various options. In the following analysis the basis of the development of the fallers' cutting rules were :

1. Maximise clearwood recovery.
2. Produce long lengths where possible.
3. Produce preferred lengths where possible.
4. Allow maximum flexibility so log remanufacturing is not affected.
5. Rules set for the fallers must be simple.

CUTTING RULES FOR FALLERS

If the rules are to be simple, a minimum number of measurements should be expected of the faller. An easy system to follow is :

1. Estimate total length of the butt stem.
2. Measure the length of the clearwood zone.
3. Measure the distance from the butt to a critical diameter point (usually either 25 or 30 centimetres).
4. Measure from the butt to a cut position.

With this system the cutting position can be determined quickly as the total length estimate need not be accurate. The measurements to be made are sequential and only require the faller to move once along the stem. The key point is however, that the faller has available a prepared set of cutting instructions.

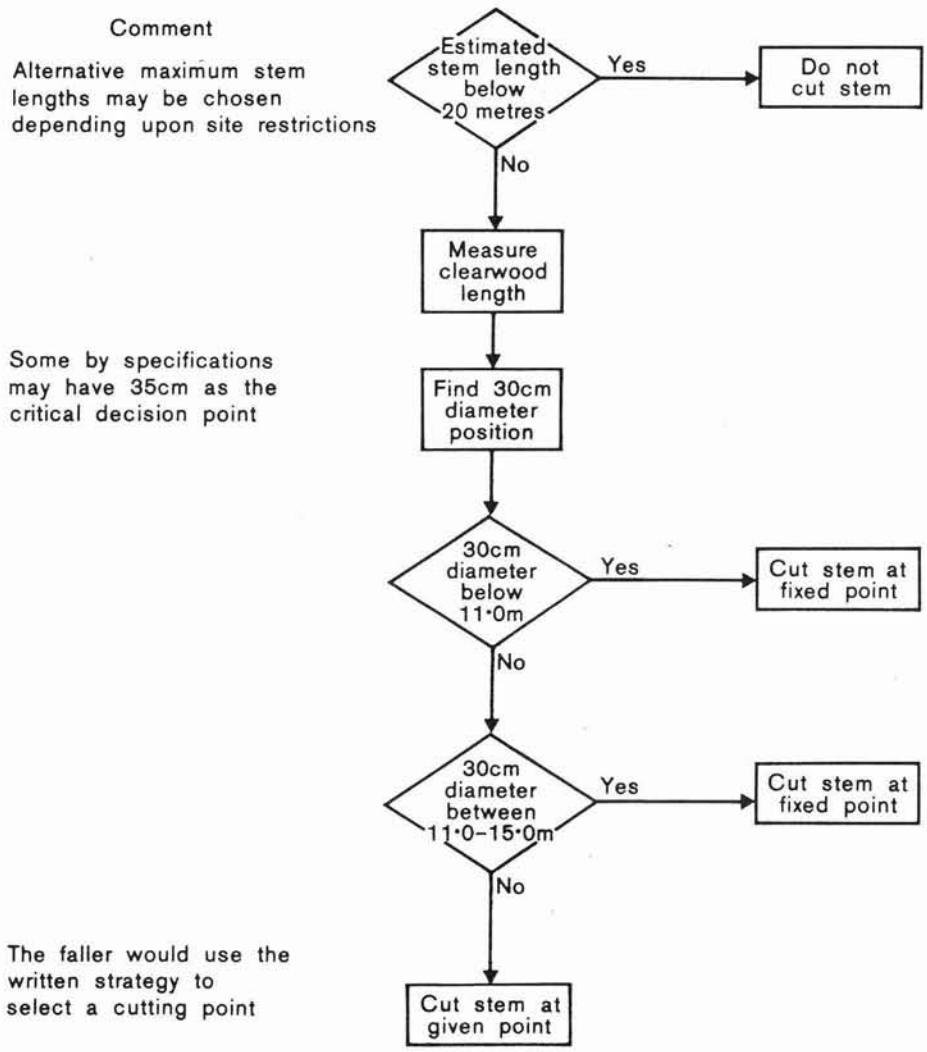

Figure 2 - Fallers decision path for log-making

Required log mixes vary considerably around the country so it is not feasible to build a set of cutting rules to fit them all in this report. However, a set of four examples is demonstrated, each with a different set of log sorts indicating a methodology which could be utilised to develop the fallers cutting strategy. The examples are :

Option 1 : a straightforward mix of both pruned and unpruned short sawlogs. The unpruned sort has a single preferred length.

Option 2 : The production of pruned peelers, as well as pruned sawlogs. Short unpruned sawlogs with two preferred lengths to be cut.

Option 3 : Both completely pruned and partially pruned sawlogs to be cut. Short unpruned sawlogs with lengths 4.9 metres and longer preferred.

Option 4 : Pruned sawlogs with both long and short unpruned sawlogs. Both unpruned sorts have preferred lengths.

TESTING OF THE CUTTING OPTIONS

A sample of 100 trees, each measured in detail after felling for dimensions and quality, was used to test the effects of the different cutting options. The sample was obtained during the logging of a 'transition' crop stand in Kaingaroa Forest.

The parameters of the sample trees are in Table 1. They indicate that the 100 tree sample represents a 'reasonably typical' pruned stand, (if such a stand exists), in terms of tree size, breakage characteristics and clearwood lengths.

TABLE 1 : PARAMETERS OF SAMPLE

	Average	Range
DBH (cm)	48	21 - 69
Tree height (m)	41	31 - 47
Volume to first break (m^3)	2.4	0.6 - 5.0
Length to first break (m)	26.8	16 - 33
Clearwood length (m)	5.4	2.2 - 8.0

The effects of the selected cutting strategy were analysed by using the value optimising program AVIS. Each stem was assessed for maximum value recovery as if it were processed completely on the skidsite, i.e. normal practise. Then the faller's cut following the above methodology was imposed upon the full stem and the resultant two sections were assessed again for maximum value recovery.

The effect on value of the faller's mimicked cutting decision was the difference between the two sets of derived values for the logs produced. This is presented as a percentage value loss directly attributable to the faller's cutting strategy. In practise varying levels of value loss could be expected as both skidworkers and fallers would make errors during log-making.

Since log values vary around the country a set of typical values were used (Table 2). The relativity between prices is more important in this type of analysis than the absolute prices.

TABLE 2 : ASSUMED PRICES FOR LOG SORTS

Log sort		$ Value	Relative value (pruned sawlog = 100)
P1	Pruned peeler	91.50	108
P1	Pruned sawlog	85.00	100
PL	Partial pruned sawlog	64.00	75
S2	Longs	73.00	86
L2	Longs	68.00	80
S2	Shorts	51.00	60
L2	Shorts	44.00	52
S3	Shorts	26.00	31
R	Pulpwood	15.00	18

All preferred lengths were given a 7.5% value premium

RESULTS

Option 1: Pruned Sawlogs Required

Pruned sawlogs - 3.1 - 7.6 m (0.3 m increments)
Unpruned sawlogs - 3.1 - 6.7 m (0.3 m) 6.1 m preferred

Fallers Cutting Strategy - Option 1

Stem length below 20 metres : do not cut
30 cm diameter below 11 metres : cut at 12.2 m
30 cm diameter 11.0 - 15.0 metres : cut at nearest 0.3 m mark

Clearwood zone	*Pruned sawlog*	*Unpruned sawlog*	*Cut position*
< 3.1 m	-	*6.1 + 6.1*	*12.2*
3.1 - 4.8	*3.1 - 4.6*	*10.1 (6.1 + 4.0)*	*13.2 - 14.6*
4.9 - 7.6	*4.9 - 7.6*	*6.1*	*11.0 - 13.7*

- ***Strategy value loss : 0.8%***

As well as varying in pruned height, trees will vary in size. Therefore the diameter grade break, usually 30 cm, will influence the faller's decision on 1/3 to 1/4 of all trees. Where the 30 cm diameter point falls between 11 and 15 m, the faller's pre-emptive cut should be at the nearest 0.3 m increment mark. If the 30 cm mark is below 11 m the cut should be made at a set point, in this example, 12.2 m. This will allow one 6.1 m unpruned log plus one log of a lower grade. The second log will be of low value so miscutting will not significantly affect value.

For the above combination of pruned log grades, there is an advantage in adding the 6.1 m preferred length to the pruned zone rather than the full length possible of 6.7 m. If the faller has over-estimated the pruned length and the skidworker detects the error, the skidworker then has a 0.6 m leeway before he must waste a segment at the end of the long length or cut two shorts.

Even though the cutting strategy for this option is relatively simple, the faller should be given an unambiguous statement of management's desires in the form of an instruction card. This gives both the faller and supervisor a written standard and ensures that both have understanding of what will be extracted from the bush. The important feature of this card is that it tells the faller where to cut rather than just listing a set of log specifications.

Simplified Example of the Faller's Cutting Card for Option 1

SIDE ONE

CUT FOR SAFETY FIRST	
If 30 cm mark greater 15 m	
Pruned height	*CUT AT*
0 - 3 m	*12.2 m*
3.1 - 4.8 m	*add 10.1 m*
4.9 - 7.6 m	*add 6.1 m*

REVERSE SIDE

CUT FOR SAFETY FIRST
If 30 cm fall in 11 - 15 m CUT TO NEAREST 0.3 m mark
If 30 cm falls below 11.0 m CUT AT 12.2 m

Option 2: Peelers Required

Peeler - 5.3 m
Pruned sawlogs - 3.7 - 7.0 m
Unpruned sawlog - 3.1 - 6.1 m (5.5 m and 6.1 m preferred)

Fallers Cutting Strategy - Option 2

Stem length below 20 metres : do not cut
30 cm diameter below 11 metres : cut at 12.2 m
30 cm diameter 11.0 - 15.0 metres : cut at nearest 0.3 m mark

Clearwood zone	*Pruned sawlog*	*Unpruned sawlog*	*Cut position*
< 0 - 3.6 m	-	*5.5, 6.1*	*11.0 or 11.6 or 12.2*
3.7 - 4.8	*3.7 - 4.6*	*10.1 (6.1 + 4.0[1] / 5.5 + 4.6[1])*	*13.8 - 14.7*
4.9 - 7.0	*4.9 - 7.0*	*5.5*	*10.4 - 12.5*

- ***Strategy value loss : 1.0%***

The faller should not make the allocation decision between peeler and pruned sawlog. This should be left to the skidworker who is in the position to check for defects such as slabbing, out-of-roundness and sweep. If the faller makes the allocation decision and the skidworker does not agree and re-cuts accordingly, considerable value could be lost.

Another factor is that logs can take some time to be extracted to the skidsite after they have been fallen for cable systems. Demand between sawlogs and peelers can change rapidly so it is prudent to leave this allocation as late as possible. Also supervisors, not unnaturally in difficult terrain, seldom examine closely the faller's activities but usually do place attention on the task of the skidworkers. The decisions involving the highest value portion of the tree should be made where a supervisor can readily inspect the results, i.e. the skidsite.

The same general philosophy holds for the cut position as in Option 1. Where no pruned logs are able to be obtained the cut position will be a standard length up the stem. The desire for two preferred lengths, 6.1 and 5.5 m allows a wider choice than in Option 1.

A set 10.1 m increment was used to add to the first set of pruned sawlog steps, 3.7 m to 4.6 m. There is a temptation to add other options, however, these cutting decisions should be kept relatively simple, so the faller keeps his mind on his main task of felling trees safely.

The last clearwood zone, 4.9 - 7.0 m, involves the addition of a standard 5.5 m length. It is possible that the option of adding a 6.1 m increment could also be included.

Note the faller does not judge if a 5.3 m peeler can be cut. He cuts for a sawlog, so if he decides :

Faller : 5.5 m pruned sawlog + 5.5 m unpruned = 11.0 m cut

and the skidworker judges a 5.3 m peeler could be produced, then 0.2 m waste will be produced. However, a higher standard of butt preparation is usually necessary for a peeler so the 20 cm waste will likely be cut from the butt.

The skidworker may choose to cut a log with longer clearwood zone into peelers, foregoing some clearwood recovery. Under these cutting decision rules he could allocate up to a 6.1 m pruned sawlog into a peeler grade before any volume loss.

Faller : 6.1m pruned sawlog + 5.5 unpruned sawlog = 11.6 m
Skidworker : 5.3 m peeler + 6.1 m unpruned sawlog + 0.2 m trim = 11.6 m.

Under most circumstances the relative value between peeler and pruned sawlogs would not permit more than 0.5 - 1.0 m of pruned material to be lost from a pruned sort into an unpruned sort.

Option 3: Partially Pruned Logs Required

Pruned sawlogs - 4.9 - 6.1 m (0.3 m increments)
Partially pruned sawlogs - 5.5, 6.1 m (min 2.1 m clearwood)
Unpruned sawlogs - 3.1 - 6.7 m (0.3 m) - logs 4.9 m+ preferred

Fallers Cutting Strategy - Option 3

Stem length below 20 metres : do not cut
30 cm diameter below 11 metres : cut at 12.2 m
30 cm diameter 11.0 - 15.0 metres : cut to nearest 0.3 m mark

Clearwood zone	*Pruned sawlog*	*Unpruned sawlog*	*Cut position*
0 - 2.0 m	-	-	*11.0 - 12.2*
2.1 - 4.8	*5.5 pp., 6.1 pp.*	*5.5, 6.1*	*11.0*
4.9 - 6.1	*4.9 - 6.1*	*6.1*	*11.0 - 12.2*

- ***Strategy value loss : 0.9%***

Partially pruned sawlogs add an apparent further complication to the cutting pattern. However, as this example shows, they do not necessarily pose additional problems for the faller.

As there is no distinct preference for unpruned logs, apart from those longer than 4.9 m, there is considerable flexibility for the faller to cut those stems where the clearwood zone is 2 m or less. Cutting at a 0.3 m increment between 11.0 m and 12.2 m would ensure a wide range of subsequent length options for the skidworker.

The next zone, 2.1 - 4.8 m, is where partially pruned sawlogs can be produced. If the faller makes the bush cut at 11.0 the skidworkers then have the option of producing :

1. 5.5 m partially pruned + 6.1 m unpruned; or
2. 6.1 m partially pruned + 5.5 m unpruned.

The next clearwood zone, 4.9 - 6.1 m produces the premium pruned sawlogs. The decision here is - what standard length to add? Choosing a mid-range figure of the 4.9 - 6.7 m preferred length gives security if errors have been made in finding the end of the pruned zone. Adding 6.1 m was chosen in this example to allow consistency with the other cut positions but 5.5 m might be another valid option.

The requested log sorts are such that none of the clearwood between 6.1 and 7.0 m will be recovered in either a pruned or a partially pruned grade. From 7 m on a pruned sawlog plus a partially pruned log could be produced, however, it depends on the relative values of pruned and partially pruned logs whether the following choice would be made.

Pruned length 7.0 m

(1) 6.1 m pruned sawlog + unpruned sawlog
(2) 4.9 m pruned sawlog + partial pruned sawlog

Partially pruned grades tend to command approximately 75% of completely pruned grade. Under that pricing structure the best option in terms of maximising value recovery is always number (2), cut a short pruned sawlog plus a partial pruned sawlog.

Option 4: Long Unpruned Sawlogs Required

Pruned sawlogs - 3.1 - 7.0 m (0.3 m increments)
Unpruned sawlogs - 8.6 - 12.2 m (0.6 m increments, 11.0 and 12.2 m preferred)
Unpruned sawlogs - 3.7 - 6.1 m (0.3 m increments, 4.9, 5.5 and 6.1 m preferred)

Fallers Cutting Strategy (1) - Option 4

Stem length below 20 metres : do not cut
30 cm diameter below 11 metres : cut at 12.2 m
30 cm diameter 11.0 - 15.0 metres : cut at nearest 0.3 m mark

Clearwood zone	*Pruned sawlog*	*Unpruned sawlog*	*Cut position*
0 - 3.0 m	-	*11.0, 12.2 m*	*11.0 or 12.2 m*
3.1 - 4.8	*3.1 - 4.6*	*+9.8*	*12.9 - 14.4*
4.9 - 7.0	*4.9 - 7.0*	*+5.5*	*10.4 - 12.5*

- ***Strategy value loss : 5.7%***

The cut position for those stems where a pruned log cannot be produced is straightforward, either at 11.0 or 12.2 m, to match the preferred long lengths. The next stage is for the clearwood zone, 3.1 - 4.8 m. A long length unpruned sawlog can be added to the pruned length. The length 9.8 m was chosen as it also enables a mixture of at least one preferred short length to be cut :

9.8 m = 6.1 + 3.7 -- or 5.5 + 4.3 -- or 4.9 + 4.9

to suit grade variations.

A preferred short length 5.5 m is added to the clearwood zone 4.9 - 7.0 m to give leeway for errors.

Following the above set of cutting instructions does, however, have a significant affect on value. Nearly 6% of the potential value is lost through cutting between 10.4 and 14.4 m. This is mainly due to the strategy's inability to produce the preferred long lengths 11.0 and 12.2 m.

Approximately half of the number of preferred long length logs can be cut due to the cutting instructions used above. If this is not acceptable then the allowable cutting zone would have to be increased so that at least a 11.0 m unpruned log can be obtained.

Effect of Long Logs of Strategy (1)

		Bush	*Skid*
Preferred logs	*12.2*	*15*	*24*
	11.0	*7*	*16*
		22	*40*
Other Longs		*24*	*27*
Total Value ($)		*3855*	*6579*

Fallers Cutting Strategy (2) - Option 4

Stem length below 20 metres : do not cut
30 cm diameter below 11 metres : cut at 12.2 m
30 cm diameter 11.0 - 15.0 metres : cut at nearest 0.3 m mark

Clearwood zone	*Pruned sawlog*	*Unpruned sawlog*	*Cut position*
0 - 3.0 m	-	*11.0 or 12.2*	*11.0 - 12.2*
3.1 - 4.8	*3.1 - 4.6*	*+ 11.0 if possible or + 9.8 m*	*12.9 - 15.6*
4.9 - 7.0	*4.9 - 7.0*	*+ 11.0 if possible or + 5.5*	*10.4 - 18.0*

- Strategy value loss : 1.3%

Adopting the policy of increasing the allowable length of the first long log to 18 m and attempting to recover at least one preferred long length, either 12.2 or 11.0 m, reduces the value loss from an unacceptable 6% to just over 1%.

The numbers of preferred long length logs increased considerably with the changed cutting strategy.

The disadvantage of this policy is to increase the average volume of the first section, but it still remains within acceptable limits in the sample used in the above analysis. In strategy (2) the mean volume of the first section is 1.6 cubic metres, with a maximum section value of 4.3 cubic metres.

Effect of Long Logs of Strategy (2)

		Bush	*Skid*
Preferred logs	*12.2*	*11*	*24*
	11.0	*36*	*16*
		47	*40*
Other Longs		*16*	*27*
Total Value ($)		*5747*	*6579*

SUMMARY

The reduction of the stem into shorter sections in the bush on steep country allows the stem length and weight of clearfell age radiata pine to be reduced, so allowing a commensurate reduction in hauler and landing size. Final log-making, however, because of its potential impact on profitability, should be undertaken where it can be most easily and effectively supervised and monitored. This means the final allocation process should either occur on the skidsite or at some central processing area. Fallers can then be allowed to concentrate on their main task, felling, while others in safer working conditions can concentrate on maximising value recovery.

The examples above show that with some thought, logical and simple cutting instructions can be given to the faller that will minimise value loss and maximise the flexibility of later cutting options by cutting the tree into sections rather than their final log grades.

Value loss from making a single cut of the stem into two sections appears to be about 1%. Although this analysis has been based on two sections, it is possible a three section approach may also be feasible.

Care has to be taken when formulating decision rules when long log assortments are included within the mix, or value losses could be excessive.

The supervisor should prepare simple cutting cards for the fallers giving guidelines as to where the pre-emptive cut in the stem should be made. These cards should be updated as required.

Figure 3 - Final log-making should be carried out in a safe, accessible location so maximum attention can be paid to quality.

Having the faller use a set of cutting instructions which a supervisor has developed to match the required log mix at the time instead of a randomly positioned cut will save approximately $25,000 per year per crew using the reduction of the stem into shorter sections in the bush. While this figure is derived using the 100 tree sample and one set of log values, it indicates that it is worthwhile for the crew supervisor to spend a portion of his time before harvesting begins to review the fallers' cutting policy and develop a new one if necessary.

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