

DIRECTIONAL FELLING OF "OLD CROP" RADIATA PINE ON STEEP COUNTRY

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ABSTRACT

Directional felling is an accepted harvesting practice on the west coast of North America. Among the advantages claimed for it are less breakage, increased volume recovery, increased value recovery, and greater daily hauler production.

Breakage from conventional felling of unmanaged P. radiata stands has been shown to be a significant cause of losses in recovery on steep country in New Zealand.

To determine if breakage could be reduced, two areas were conventionally felled and two directionally felled on steep slopes in Tauhara Forest. Piece length, piece volume, pieces per cycle, and daily hauler production were recorded for each of the four areas. No attempt was made to record log values produced from each area.

Average piece length was 3 to 6 metres (14 to 36%) greater on the directionally felled areas. Average piece volume was about 5% greater. Average volume per cycle was 2% greater on one and 42% greater on the other directionally felled area. Hauler productivity increased by up to 50%.

The feller estimated it took him twice as long to directionally fell as it did to conventionally fell. Directional felling is both more difficult and dangerous and thus requires very skilled fellers to ensure that felling is carried out effectively and safely.

INTRODUCTION

When conventionally felling "old crop" radiata pine in New Zealand trees are generally felled downhill. Directional felling is the felling of trees in a direction and manner that has been pre-determined by the feller as being the most suitable for reducing breakage but within the combined constraints of safety, terrain, tree characteristics, economics, and the logging system used. The felling pattern adopted is usually across the slope or uphill.

Overseas Experience

Over the past two decades, as the timber resource on the west coast of North America diminished, felling techniques have

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changed. The volume and value lost through felling breakage concerned many forest managers in the Douglas fir and cedar areas. Felling downhill with the lean or across obstacles such as other fallen trees, stumps, etc., was common practice. Techniques of directionally felling trees to minimise breakage were therefore developed and successfully put into practice.

Proponents of directional felling on steep country claim the following apparent advantages over conventional felling:

- (1) Reduced damage in the form of fractures, splitting, shakes, and fibre-pull (Wackerman *et al.*, 1966; Barnacle, 1970; Conway, 1974; Anon, 1976; Sorensen, 1978).
- (2) Increased volume recovery ranging from 10 to 30% which in turn ekes out the resource and spreads fixed costs — *e.g.*, roading over a larger volume (Bryant, 1923; Brown, 1949; Henley and Estep, 1974; Dykstra and Froehlich, 1976; Groben, 1976; Powell, 1977; Hirt, 1978).
- (3) Increased wood value attained through the flexibility of being able to select preferred log lengths and types from an unbroken tree (Brown, 1949; Wackerman *et al.*, 1966; Groben, 1976).
- (4) Increased mean piece size which leads to greater daily production and lower extraction costs.
- (5) Trees are aligned allowing easier selection of trees to be stopped, easier breaking-out and extraction, and larger cycle volumes (Wackerman *et al.*, 1966).
- (6) Extraction distances are shorter for uphill hauling since trees felled across the slope or uphill do not slide downhill as far as with downhill felling (Anon., 1977).
- (7) Less debris is left behind because of less breakage. Site preparation and establishment costs are thus reduced (Groben, 1976; Anon., 1977). The cutover also looks aesthetically better (Groben, 1976).
- (8) Less soil movement by sideslope or uphill felling as there is less tendency for logs to disturb soil as they slide downhill (Groben, 1976; Anon., 1977).
- (9) Some directional felling techniques are safer than conventional felling as the feller is away from the tree butt at the final felling stage. The breaker-out's task may also be safer when working with trees which are in an orderly rather than in a random pattern. (Conway, 1974; Groben, 1976; Anon., 1977; Hirt, 1978).
- (10) Stream protection costs may be reduced; the need for more landing changes due to leaving buffer strips or the

cleaning of resultant debris from conventional felling out of streams is reduced by use of directional felling techniques (Dykstra and Froehlich, 1976).

Weighed against these advantages are:

- (1) A higher danger risk — trees which weigh many tonnes and hit the ground with great force may have to be forced away from their natural lean.
- (2) Higher felling costs owing to increased equipment requirements and lower feller productivity (Groben, 1976; Dykstra and Froehlich, 1976; Anon., 1977).
- (3) More difficult planning — more fellers are required owing to lower feller productivity (Anon, 1977).
- (4) The wind is more critical to efficient directional felling and fellers may have fewer days available for work (Groben, 1976).
- (5) Greater skill is required by the feller.

Tree Characteristics

McRae (1977) pinpointed the key tree characteristics affecting the ease with which trees can be directionally felled. They were:

- Tree weight
- Tree diameter
- Location of centre of gravity
- Green timber bending strength
- Tree lean

Wackerman *et al.* (1966) would add crown shape and decay to this list.

Limited work on crown shape and tree lean of radiata pine on steep slopes in New Zealand confirms the logic behind New Zealand fellers preferring to fell downhill. N. Mythen (pers. comm.) found that trees generally lean downhill* and R. Bedingfield (pers. comm.) found that crowns were larger on the downhill side. Although this pattern can sometimes be altered by the prevailing wind, it can be said that any attempt to fell radiata pine in any direction other than downhill will be generally both more dangerous and difficult.

New Zealand Experience

Until recently "old crop" radiata pine trees on steep country were, as stated above, felled downhill with the lean. In almost all cases this results in stem breakage.

*The average lean was about 5°. Very few trees had an abnormal lean, with the highest being 20°.

Lees (1969) found for the clearfelling of 34-year-old radiata pine on average slopes of 25° the average diameter at the point of first break was about half of diameter breast height. Where trees were felled uphill, however, the diameter at the point of breakage was "very much less" (approximately 15 cm less).

Manley (unpublished results available on request) reports that for "old crop" radiata in Kaingaroa Forest the height to the first break point was about two-thirds of total tree height. Break height decreased (and break diameter increased), however, as slopes became steeper. Although the breakpoint is expressed in different forms by these authors the expressions are equivalent.

The mean piece size arriving at the landing after conventional felling and cable hauling, expressed as a percentage of mean tree size, decreases as tree size increases (Murphy, 1979). The mean piece size has been found to be 80 to 90% of mean tree size for trees below 1 m³ volume and drops to 50 to 60% for trees above 4 m³. For example, in one study where the mean tree size was 4.5 m³ before felling, after felling the mean harvested piece size was only 2.6 m³. For the same study, however, it could be said that the mean piece size was considerably less than 2.6 m³ since pieces left as wastage were not included. A wastage assessment after extraction showed that although 89% of the standing volume was extracted to the landing this comprised only 24% of the pieces over 1.2 m length left on the ground after felling. Only a few of the very small pieces were extracted to the landing.

Studies like those mentioned above showed that breakage in "old crop" radiata pine was indeed significant on steep country. The lack of information on likely gains from directional felling over conventional felling of radiata pine in New Zealand was just as evident. For this reason the Forest Research Institute Harvesting Group in early 1978 initiated a study on directional felling in Fletcher Forests Limited, Tauhara Forest. The study was limited in that it was designed only to show differences in piece volume and logging productivity. The value of logs derived from directionally and conventionally felled areas was not measured.*

*Where applicable Fletcher Forests have now introduced directional felling on steep country as a permanent practice. Since introduction they have noted a significant increase in value recovery owing to greater long-log recovery.

Stand and Topographic Details

The study was carried out mainly in compartment 123 in Fletcher's Tauhara Forest but information from an earlier study in compartment 34 has also been used (Table 1) (Murphy, unpublished results available on request).

TABLE 1: STAND AND TOPOGRAPHIC DETAILS

Compartment	Felling Pattern	Stocking (stems/ha)	Mean d.b.h. (cm)	Height (m)	Tree size (m ³)	Average Slope (°)
34	C-"A"	188	—	—	4.53	20
123	D-"A"	329	62.7	41.2	4.45	6*
123	C-"B"	253	58.0	40.1	3.43	20
123	D-"B"	263	57.2	40.2	3.54	20

C-"A" = Conventionally felled area A

D-"A" = Directionally felled area A

*The writer considered it reasonable to compare breakage on the 6° slope area with that of the 20° slope area since the former was directionally felled across the slope. Trees felled across the slope fall through an arc of 90° whether the slope is 6° or 60°.

Experience and Methods used by the Feller

The feller had had over eighteen years' experience in bush-work and was classed as a very experienced feller. At the time of the study he had little experience in directional felling but was willing to try though he thought it would take more time.

The trees in the directionally felled areas were felled across the slope to reduce breakage during felling. No attempt was made to fell to reduce breakage during extraction. On directionally felled area "A" wedges and axe were used. A hydraulic jack was used with success on directionally felled area "B".

The hauler used was a Madill two-drum machine with a 27 m tower rigged as a running skyline. Conventional "B" and Directional "B" were both tip-hauled. Directional "A" was butt-hauled and conventional "A" was both butt- and tip-hauled.

All areas were felled by the one feller.

Length of Pieces

The length of pieces arriving at the landing was significantly higher for directionally felled areas than for conventionally felled areas (Table 2). The increase in the mean length of pieces was larger for directionally felled area "A" than for directionally felled area "B" but this may have been due to the larger tree size.

TABLE 2: LENGTH OF PIECES ARRIVING AT THE LANDING

Felling Pattern	Mean Piece Length (m)	No. of Pieces Measured	Standard Deviation	Level of Signif. (%)
C-"A"	17.30	964	9.57	0.1
D-"A"	23.59	84	9.16	
C-"B"	18.62	783	10.10	2
D-"B"	21.23	111	11.58	

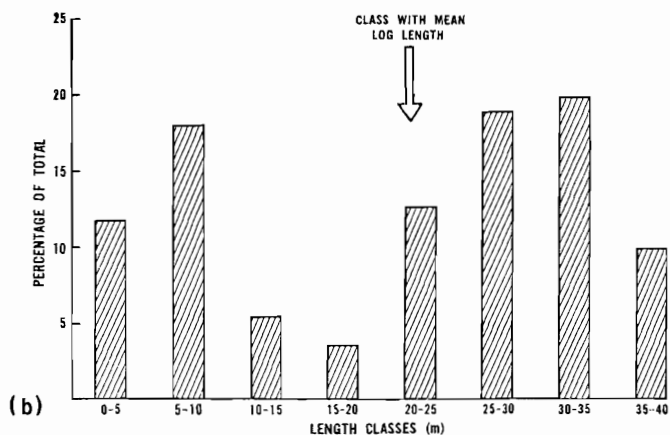
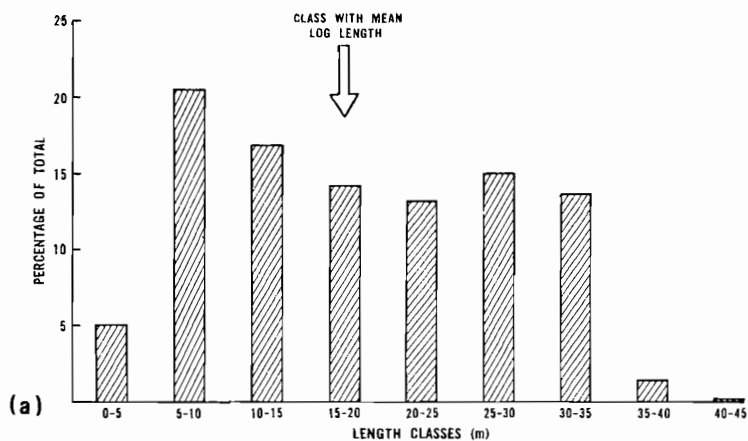


FIG. 1:

- (a) Distribution of lengths: normal felling pattern area B.
 (b) Distribution of lengths: directional felling pattern area B.

Examination of Fig. 1 shows that the distribution of lengths is also different for the two felling types. Over 60% of the logs in the directionally felled area were over 20 m in length while slightly over 40% were over 20 m in the conventionally felled area. The increase in log lengths should allow considerably more opportunity for obtaining the maximum value possible from the stand.

Piece Size

Not unexpectedly, the mean piece size also was found to be greater for directionally felled area "A" than for the conventionally felled area (Table 3). A 5% increase in volume was found. This is less than has been claimed overseas for directional felling but it can be expected that old crop radiata pine would have a smaller decay problem than overmature Douglas fir or cedar and thus be less likely to break.

Although the increase in piece volume was not statistically significant at the 10% level, it was nevertheless a real increase in piece size since it was associated with a 36% increase in log length (significant at the 0.1% level).

Piece size was not measured in directionally felled area "B" so no comparison could be made.

TABLE 3: MEAN PIECE SIZE ARRIVING AT THE LANDING

<i>Felling Pattern</i>	<i>Mean Tree (m³)</i>	<i>Mean Piece (m³)</i>	<i>Difference (m³) (%)</i>	
C-"A"	4.53	2.42		
D-"A"	4.45	2.55	0.13	5.4

Pieces per Cycle

The mean haul volume for the directionally felled area "A" was slightly larger than for the conventionally felled area. However, the mean number of pieces per cycle had dropped for unknown reasons (Table 4).

There is more interest, however, in the difference between the two "B" areas. In the directionally felled area there was almost one piece more per cycle arriving at the landing than for the conventionally felled area. An assumed increase in mean piece size of 5% (resulting from longer piece lengths) coupled with the increased number of pieces per cycle would in this case mean a 50% increase in cycle volume.

TABLE 4: PIECES PER CYCLE

<i>Felling Pattern</i>	<i>Mean Cycle Volume (m³)</i>	<i>Mean No. of Pieces per Cycle</i>	<i>Level of Signif. (%)</i>
C-"A"	5.85	2.42	n.s.
D-"A"	5.96	2.33	
C-"B"	N.A.	2.32	0.1
D-"B"	N.A.	3.29	

A comment made by the head breaker-out on cutting to length at the stump may answer why more pieces per cycle were stropped for the directionally felled area "B". He did not like stropping trees which had been cut to length because "the logs lay flatter to the ground — are harder to get the stropps around — and take longer to strop". The same would apply to the smaller pieces resulting from conventional felling. On the other hand, the longer pieces from directionally felled areas would be more likely to be held up by slash and stumps. Better tree alignment may have also contributed to the increased number of pieces per cycle.

Daily Hauler Production

Figure 2 shows the increase* in daily production which occurred after logging directionally felled area "B". Daily production increased by about 40 to 50% in the directionally felled area. This was due to larger pieces (resulting from longer pieces), more pieces per cycle, and more cycles per day.

A similar pattern was found by a large forest company recently when carrying out trials on two-stage logging on steep country. If only long logs were extracted, hauler production increased by up to 50% (W. Evans, pers. comm.).

The feller estimated that he spent twice as much time per tree felling directionally than conventionally. As has been shown in earlier work (Murphy, 1979) the cost of the felling phase accounted for less than 4% of the harvesting cost. Doubling the felling cost to achieve a 50% increase in production is sound logging.

*A similar pattern occurred for directionally felled area "A" but not all of the increase in production can be attributed to the directional felling technique since extraction distances were shorter than for the conventionally felled area.

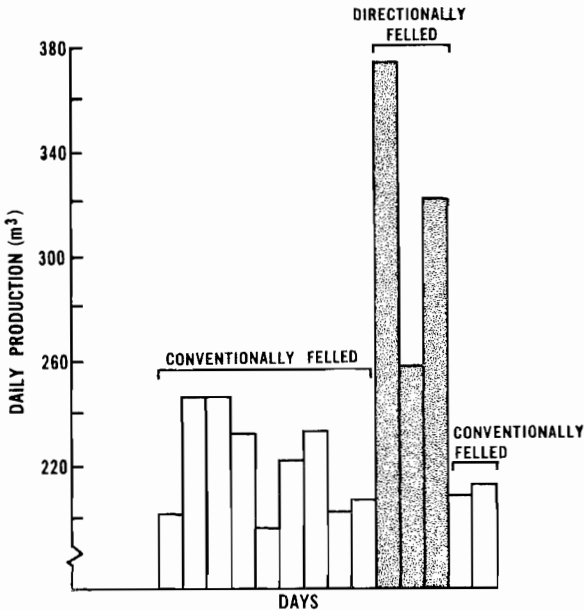


FIG. 2: Daily hauler production.

Relevance to "Old Crop" Stands

Although this study was limited it did indicate that directional felling may:

- (a) Increase piece lengths by 3 to 6 metres.
- (b) Increase average piece volume by about 5%.
- (c) Increase hauler productivity by up to 50%.
- (d) Reduce extraction costs significantly.
- (e) At least double felling costs.

If directional felling is to be successfully and safely implemented into New Zealand forestry practices, fellers need to be well skilled in conventional felling techniques and specifically trained in directional felling techniques. They must also be aware of the effect they have on subsequent harvesting, processing, and forestry operations.

Relevance to Managed Stands

To decide upon the likely success of directional felling to new crop managed stands one must first have an idea of what the trees will look like. We can expect that they will be smaller (because of the shorter rotations), shorter, fatter, and branchier (due to the wider spacings) than old crop stands. One could expect that increased branchiness would help to cushion the impact of felling

and reduce breakage. Also, as stated before, breakage decreases with decreasing tree size and one could expect less breakage from the smaller trees. Increases in volume may thus not arise from directional felling.

The main advantage of directional felling in managed stands, if indeed one does arise, may be related to a redistribution of log lengths such as was indicated in Fig. 1b. Flexibility in selecting high value logs may be especially important if a premium exists for long log lengths.

In early 1981 the FRI Harvesting Group will carry out a comparison of conventional and directional felling in a managed stand on steep country. The comparison will be made on the bases of breakage, value, extraction productivity, and costs. Some of the above queries should thus be answered.

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