LOGGING INDUSTRY RESEARCH ASSOCIATION

NEW ZEALAND

PROJECT REPORT

ORGANISED FELLING

P.R. 28

1986

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MAY, 1986

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ACKNOWLEDGEMENTS

I wish to express my thanks and gratitude to :

The British Forest Commission for the time taken to show me work they were undertaking in the area of improved felling presentation during a tour of Britain in 1982, and for allowing the results of that work to be quoted within this report.

The Trustees of the David Henry Scholarship and N.Z. Forest Products Ltd for awarding me a scholarship which financed most of the expenses incurred during the above tour. That provided the initial insight and motivation for this three year research and development programme.

The numerous bushmen, contractors, companies and suppliers of machinery who assisted during the development and testing of the technique.

Finally, the LIRA staff member Bill Liley for assistance in developing and testing the technique, and for the work done in editing this report during my absence overseas.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

SUMMARY

Organised felling is a system of felling for thinning *Pinus radiata* stands in New Zealand. The system requires a disciplined approach to felling in which trees are directionally felled to facilitate easiest extraction. Once felled the stem is thoroughly delimbed and the limbs that fall on the extraction track or cover parts of other logs to be extracted are removed. Limbs removed should be placed against the butt of crop trees likely to incur damage during extraction.

This system of felling results in the logs to be hooked on being clearly visible. It also substantially improves the working environment of both the faller and the breakerout. Increases in the utilisation of available volume have been shown to result from the system. An increase in the amount of work required by the faller, principally in clearing slash, reduces the faller productivity. This decrease suggests that if the organised felling system was to be used an extra faller would be needed.

After some preliminary trials in New Zealand, organised felling was compared with conventional felling in two trials in thinning operations :

- a hauler thinning operation
- a skidder thinning trial

Machine productivity was in most cases substantially increased when extracting wood from organising felling versus conventional felling. The most dramatic increase occurred in a skidder extraction trial where daily productivity incręased by as much as 67%. Even with an extra faller, the cost/m^3 was still 27% and 40% lower than for conventional options.

Organised felling has proven to be well within the learning capabilities of the average faller already employed in Radiata thinning. Although not yet substantiated, it is considered an ergonomically more desirable methods, i.e. resulting in less back strain and generally less fatiguing.

The transition from conventional to organised felling will not take place without a commitment from all those concerned, nor without the sharing of the rewards obtainable.

1. INTRODUCTION

The most commonly used method of felling and trimming in Pinus radiata thinning in New Zealand is motor manual. Typically, most radiata thinning gangs have two, three or four fallers, a machine operator and a low to medium kilowatt rated rubber tyred skidder, or a small crawler tractor. Considerable research effort has been invested in improving the productivity of the extraction machine through increasing travel speeds, changes in rigging configuration etc. Often the largest part of the daily cost of such a gang is manpower cost, which may account for 50% or more. It was reasoned that increases in efficiency of the the fallers could have a dramatic effect on the profitability of a thinning gang.

Conventional falling and trimming employs chainsaws of 60 cc or more, (often up to 90 cc), equipped with guide bars from 40 cm (16 inches) to 50 cm (20 inches). Additional felling aids are rarely seen and most frequently the tree will be felled in the direction in which it leans. Trimming is typically carried out using the tip of the bar while the operator walks along the log. The strain placed on the operator, especially in the back region, makes the technique ergonomically harmful. Not only does it place considerable stress on the operator, who also yields a relatively low quality trimming standard, but little or no thought is given to removing slash to improve either the fallers own environment or that of the breakerout. Due to lack of attention to directional felling concepts, trees are often felled so that they are virtually impossible to extract without incurring considerable damage to residual crop trees. Finally, the Logging Industry Accident Reporting Scheme has indicated a high incidence of chainsaw accidents caused because of this trimming technique.

There has been research and development in improving faller techniques for more than a decade. Changes have been made only slowly and with a noticeable reluctance. Much of this work has suffered from the "it won't work in New Zealand" syndrome. Recent progress includes the formation of the Logging Industry Accident Reporting Scheme, the availability and use of protective clothing (especially legwear), and the slow trend to using smaller saws equipped with shorter bars.

Organised felling, although based on principles developed overseas, has been refined by a New Zealander for thinning radiata. The initial rationale for the work came from observation of organising felling approaches in Britian. Considerable technique modification was necessary to apply it to radiata thinning.

A disciplined, systematic approach to felling and trimming is required for fallers adopting the organised felling system. That commitment will result in significant increases in extraction machine productivity, and improved utilisation of, the machine operator, breakerout and faller's time. Through improved use of felling aids the faller will spend less time dealing with hangups, trees will be better aligned for extraction, and he will be less likely to cut himself.

This report describes the technique and presents results of a three year research development programme.

2. BACKGROUND

Specific research into organised felling for radiata thinning commenced in mid-1982. However related technique developments started at least ten years before that.

2.1 Nordfor

The first evidence of such research was in 1972 when N.Z. Forest Products Limited employed consultants from Nordforest AB, a Swedish consulting firm, to investigate their clear felling techniques. The group suggested that there were different techniques available which would improve the fallers work conditions. Lockie, (1974) compared the conventional felling with the Nordfor felling but couldn't identify any significant difference on the productivity of the two techniques. Subjective comments from operators suggested that the conventional technique was much better.

For all the changes demonstrated and recommended by Nordfor, (such as lighter saws with shorter bars to reduce operator fatigue), the only result from the exercise was a change in scarfing technique. Conventional scarfing involved putting in the bottom cut of the scarf first and then the top cut. This was reversed so that the top cut of the scarf was cut first. The faller could then look down the top cut and see when the bottom cut met it. The change gave better control over the direction in which the tree fell. NZFP made it a company ruling that the new scarfing technique be used to give better alignment for extraction and hopefully improve the extraction machine's productivity.

2.2 Swedforest Consulting AB

In 1980, with assistance from the Accident Compensation Commission, LIRA employed another Swedish consulting group, Swedforest Consultancy AB. Their brief was to develop and recommend safe felling and delimbing techniques, safe equipment, protective clothing and a training scheme for the recommended techniques. Field work was undertaken in the Rotorua area in February and March of 1980 and consisted of a survey of existing methods, equipment and use, and protective clothing and use.

The survey of existing methods and equipment showed that hangups in radiata thinning were numerous (LIRA, 1980). In one instance an operator was observed to have spent 80% of his time either getting down, studying or trimming up after the results of the hangups. Trimming techniques were to walk along the tree on flat country and beside the tree on steep country. Safety equipment was generally not used. Of the fallers surveyed (30) only 50% used ear protection, one faller used a visor, but no leg protection was in evidence.

To the consultants the survey also indicated that the methods used could be improved and made safer. Chainsaws used were too heavy and not equipped to an acceptable standard from a safety point of view. Felling aids were practically non existent, and the the only protective clothing commonly used was the hard hat and steel toe-cap boots.

The consultants duly developed a suitable method as specified in their terms of reference. The method has been well described (LIRA, 1980), and was very much based on the Swedish experience. The report suggests that a good method meets the following stipulations :

- it is safe for the operator and those around him;
- it is ergonomically correct and thus minimises fatigue;
- it is efficient;
- it gives good results from a quality point of view.

The Swedforest Consultancy exercise significantly influenced, and continues to influence, motor manual felling and delimbing in New Zealand. Some aspects which can be directly attributed to that are the development of New Zealand made protective legwear, the formation of the New Zealand Logging Industry Accident Reporting Scheme, the slow but significant swing to lighter chainsaws utilising shorter bars, the increased use of felling aids, and the increased awareness of there being more than one way to fell a tree.

Slowly, but surely, management was beginning to recognise the asset it has in good fallers. One thing that did come to light from the Norfor and Swedforest visits to New Zealand was our inherent suspicion of anything that comes from overseas, often characterised by the comment "it might work in Sweden, but it won't work in New Zealand".

2.3 Britian

In 1982, while on a David Henry Scholarship tour of Scandinavia and Britain, (Gaskin 1982), the opportunity arose to view examples of superior felling presentation techniques in Britain. The basic techniques and equipment used were similar to those used in Sweden and demonstrated in New Zealand by the Swedforest Consultancy group. The main difference was that far more emphasis was placed on subsequent extraction of the produce. Several reports were obtained from the British Forestry Commission which describe in detail the techniques and effect on the productivity of fallers and extraction machines. Because these reports are not readily available they have been summarised below. They cover three extraction systems - skidder, forwarder and cable crane. While having been developed for clear felling, the basic principles are important and have been found to be quite easily transferable to New Zealand thinning operations.

2.3.1 Clear felling methods for winch skidder extraction

The report describes four basic clear felling methods - scoot felling, strip felling, bench felling and face felling. The objective of these four methods was to present concentrations of logs for extraction which were free of slash so that they could easily be hooked on to the skidder strops. The felling patterns were tested in a wide range of piece size, between 0.10 and 2.27 m^3. Strip and face felling were recommended where the average piece size exceeds 0.50 m^3, as in such a piece size it is not desirable for the faller to do too much man-handling of pieces. In any of the felling systems the option was available for the extraction machine to travel on slash thus reducing compaction and the likelihood of the machine getting stuck. These felling systems are illustrated in Appendix I.

The report concludes by saying that adoption of a systematic felling method can give better presentation of produce than is possible using conventional felling methods. The improved felling allowed increased skidder output. In discussing the bench felling technique they suggest increases in extraction output from 5.5 m^3/hour for conventional to 8.25 m^3/hour for bench felling.

Finally, providing that the particular method used is appropriate to the crop and ground conditions in any individual case, then any increased felling costs resulting from the more exacting specifications will be more than offset by decreased extraction costs.

2.3.2 Clear felling harvesting system, forwarder extraction

This report describes a clear felling harvesting system based on shortwood bench felling for subsequent forwarder extraction. Because of the lack of applicability to New Zealand, a full description of the system is unnecessary. However, its effects on extraction and faller productivity is worth noting.

A comparison of faller productivity was made between the shortwood system, and 'pole' (tree length) felling. In all piece sizes within which the comparison was made the time per tree for shortwood felling was signifcantly higher as shown below.

	$0.2\ m^3$ tree size	$0.95\ m^3$ tree size
shortwood	8.85 minutes/tree	27.5 minutes/tree
pole	4.84 minutes/tree	18.5 minutes/tree

In the following extraction phase a Chieftain Forge forwarder extracting the shortwood was compared to a Fallstone skidder extracting the pole length wood. Both machines were extracting over the same distance (150 m). In the smaller tree sizes ($0.2 - 0.5\ m^3$) there was little difference between the systems. However in a $0.65\ m^3$ tree size, the time to extract a cubic metre of wood by forwarder from shortwood felling was only 5.37 minutes, whereas for the Fallstone skidder with pole length the time was 7.18 minutes.

In concluding the report the authors note that when non- qualified costs are taken into account, the advantages of the shortwood system become such that it is undoubtedly the more efficient system. They also note that it is ergonomically better than the alternative and no more expensive in terms of overall harvesting costs.

2.3.3 Organised felling method for the presentation of shortwood for cable crane extraction on steep ground

This report has been summarised in more detail as the results obtained are dramatic. It was also this work and the results that provided the motivation and justification for a three year research and development project by LIRA.

The British Forestry Commission recognised that cable crane extraction outputs are influenced by three factors :

(i) The inwoods terminal time which commonly occupies between 30 and 60% of the total cycle time;

(ii) The roadside terminal time which may amount to between 25 and 40% of the cycle time; and

(iii) The average load volume extracted.

High inwoods terminal times are often the result of difficult hooking on conditions due to lack of separation of slash and produce. Movement over the felled area by the breaker-outs is slow, at times hazardous and the selection of loads for attachment difficult.

With those points in mind the project objectives were :

(i) To develop improved felling methods in tree length and shortwood working in order to maximise load size and reduce hooking on time for subsequent cable crane extraction; and

(ii) To compare outputs and total harvesting costs of tree length and short length systems.

The primary considerations in the development of a new felling method were that they were :

- safe and ergonomically acceptable;
- within the learning capacity of the average Forestry Commission faller;
- adaptable to meet changes and product specifications.
- workable in a wide range of species and tree sizes.

With regard to subsequent extraction, it must :

- allow for safe working for the winch and the winch crew;
- enable the use of multiple chokering systems to maximise load sizes;

- minimise breakout forces during side haul.

Description of felling method (Refer fig. 1)

Individual felling strips are marked out 15 m wide across a slope and potential bench trees, stopper trees and pulp stopper/stacking sites identified. The first bench is felled as soon as possible. Subsequent benches are felled as required. Benches are felled at approximately 90° to the contour, preferably uphill (essential in Douglas fir), trimmed as completely as possible, cross cutting points being marked during trimming.

The felling of crop trees commences at the bottom of the strip nearest the bench. Individual trees are then directed across the slope over the bench facing the crown in the slash zone. Work progresses in ranks of one to three feet to the top of the strip.

As individual trees are felled they are trimmed completely using the undersweep technique, the top cut off and the pole rolled into the timber zone to be supported by the stopper trees.

The poles are measured and cross cut in the timber zone, either individually or when two or three poles have accumulated. The saw logs remaining in place whilst the pulp wood is rolled over the log for subsequent stacking in the secondary timber zone.

Bench trees are cross cut when no longer required, and similarly stopper trees are felled and processed when no further produce is to be presented in that part of the timber zone.

The preferred direction of working in individual strips is from right to left when facing the slope (trees felled left to right). Where the lean of the trees dictates felling from right to left, then the trimming of crop trees must be carried out from tip to butt with the operator remaining on the uphill side of the stem. The first strip to be felled should be along the lowest part of the slope.

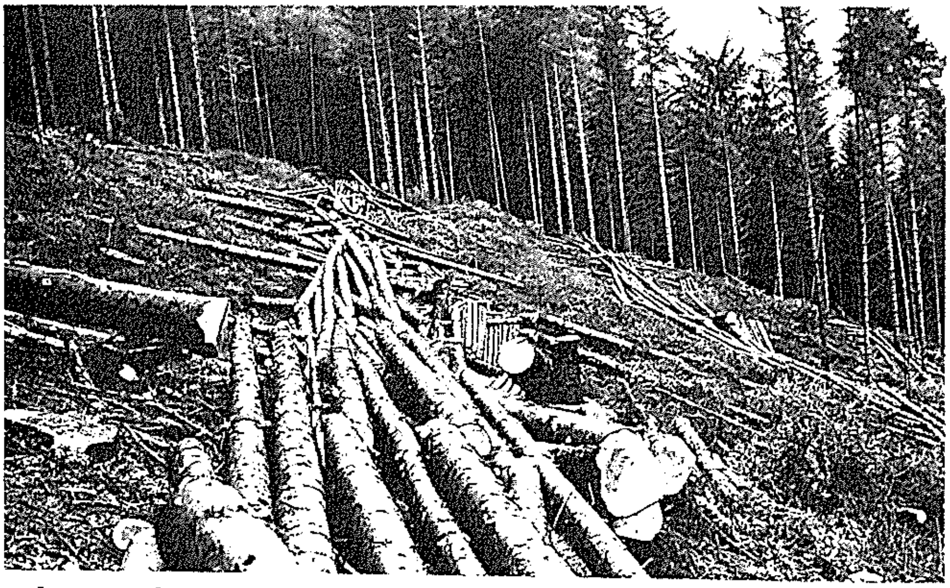


Fig 1 - Organised Felling Method for Presentation of Shortwood for Cable Crane Extraction on Steep Ground

Effect on Productivity

The effect on productivity can best be described by the following table.

TABLE 1 - Effect of Contour Felling on Faller and Extraction Productivity (British Forestry Commission)

PECIES		NORWAY SPRUCE		DOUGLAS FIR		SITKA SPRUCE	
elling							
ean tree volume	- m^3	0.33		1.71		0.60	
elling method		Contour(2)	Conv.(3)	Contour	Conv	Contour	Conv.
ime per tree	- SMs (1)	12.48	17.93	21.47	27.56	18.56	25.67
ime per m^3	- SMs	37.82	54.33	12.56	16.12	31.07	47.78
elling cost per m^3	- $	7.99	11.48	2.65	3.41	6.56	10.10
xtraction							
ime per m^3	- SMs	10.58	15.42	6.56	7.78	9.56	12.07
ost per m^3	- $	6.25	9.12	4.46	5.28	5.66	7.14
elling and Extraction							
ost to Roadside	- $	14.24	20.60	7.11	8.69	12.22	17.24
stimated Cost Saving by Contour Method	- $	6.35		1.58		5.02	
	- %	31		18		29	

1) SMs = Standard minutes with allowances added
2) Contour felling
3) Conventional felling

The table compares the felling and extraction costs to roadside for shortwood contour and conventional felling. Cost information (1983) has been converted from pounds sterling to N.Z. dollars based on the exchange rate at the beginning of 1985.

Safety and Ergonomic Considerations

In common with all organised felling methods, contour felling carried out correctly imposes on the operator a disciplined and ordered approach to the planning and execution of each days work. On steep slopes the involuntary movement of trees and produce during processing is a constant potential hazard but one which is significantly reduced in this method by demanding that all work on the felled tree is carried out from the uphill side. The creation of secure timber zones against stopper trees or stumps eliminates the risks of uncontrolled downhill movement of produce during both the felling and extraction phases. By moving produce from the trimming area (slash zone) as work proceeds, the greater part of the fallers working day is spent on clear or slash covered ground, rather than amongst the mixture of slash and often unstable produce which regularly results from conventional working. The extraction teams' working conditions are similarly improved and additionally the orderly slash free zones of timber reduce the incident of unpredicted load reaction during extraction.

The ergonomic advantages of the contour felling method are considerable. An improved working condition is achieved during trimming through raising of the crop trees on benches. All movement of produce is downhill aided by gravity, and a higher proportion of the fallers movement during felling, trimming and crosscutting is along the contour rather than up and down hill.

Training Installation and Supervision

During the study a certain number of workers were trained in the contour method in order to assist with studies. The limited experience gained indicated that where the faller was competent in directional felling and the use of requisite aid tools, he would become conversant with the method in two to three days. However, the importance of an adequate period of consolidation immediately following training must be stressed. It is recommended that first line supervisors also take part in the worker training of this method in order to be able to provide the necessary guidance and encouragement during the consolidation period.

These three reports from the Work Study Unit of the

British Forestry Commission, plus information gained during the David Henry scholarship tour, provided the philosophy and rationale for LIRA's commitment to this project.

2.4 INITIAL NEW ZEALAND EXPERIENCE

The first opportunity to begin preliminary research into the organised felling concept in radiata thinning occurred in mid-1982. It was undertaken as part of an evaluation of the Holder A60 Cultitrac skidder (Gaskin and Gleason, 1982).

The stand used for this work was in Lake Taupo Forest and was having the first production thinning, from 850 stems per hectare down to 250 stems per hectare. The average extracted piece size was $0.20m^3$.

Three fallers felled for the machine. One faller made an attempt to organise the felling face so that the produce was left clear of slash. This meant that the heads of the logs to be attached to strops were clearly visible. The other two fallers made no attempt to clear any slash until they had the full drag prepared, then a rough attempt was made to clear some slash from the heads of the logs to be hooked on. The illustration below shows clearly the results of slash removal from the organised felled area and illustrates the ease with which logs could be located for hooking on.

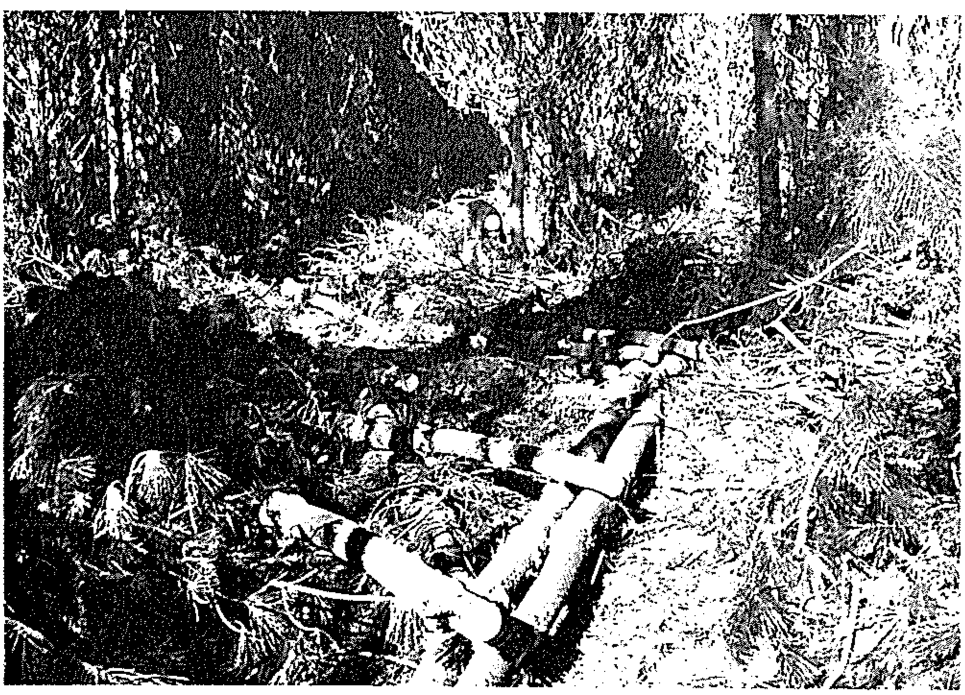


Fig 2 - Initial New Zealand attempts at organised felling in radiata thinning

The cutter practising the organised approach also, where required, positioned logs to improve the breakout phase. This positioning was done simply by moving the head of the stem into line.

Time studies were carried out on the fallers and the results are summarised in the table below. It was interesting to note how much the fallers doing the conventional felling were influenced by the development of the new technique. This is high-lighted by the "clear slash" and "position" elements in the table. The times quoted are in centi-minutes with no refuelling, rest or smoko allowance included.

Table 2 - Comparison of Fallers' Times, Conventional and Organised Felling, Lake Taupo Forest

Mean Felling Cycle times in centi-minutes

Element	Conventional	(No. of Observations)	Organised	(No. of Observations)
Walk and assess	0.62	(50)	0.46	(56)
Clear butt	0.61	(48)	0.62	(61)
Fell	0.68	(77)	0.70	(69)
Trim	2.31	(75)	1.34	(67)
Clear slash	1.94	(59)	1.18	(64)
Position tree	0.31	(4)	0.28	(45)
Total Cycle	6.47	.	4.58	

The significant difference in time per tree is unexpected and could best be explained by the different levels of motivation between the cutters and, although not quantified, a reduction in time spent on hangups by using a more disciplined approach to falling and an improved working environment brought about by slash removal.

Analysis of the machine cycles extracting from both types of felling clearly indicated that improvements in machine productivity were possible. The breakout or bush phase of the cycle took 4.1 minutes per drag for conventional felling where an average of 5.5 trees were hooked on each drag. The same bush cycle for organised felling took 3.1 minutes per drag where an average of 6.5 trees were hooked on. It was reasoned that it didn't need an Einstein to work out that there were big production gains possible through using organised felling.

The machine cycle is fully analysed in the following table.

Table 3 - Analysis of Machine Cycle Extracting from Conventional and Organised Felling

Element	Mean Time in minutes		
	Conventional (1)		Organised (2)
Travel empty		1.27	
Position	0.61		0.57
Strop on	1.93		1.69
Winch in	0.60		0.53
Reposition	0.13		0.24
Excess trim (3)	0.83		0.04
Travel loaded		2.16	
Skids (4) unhooking, fleeting etc		3.74	
Delays - personal/ production		1.24	
Number of pieces per drag	5.50		6.50
Average haul distance		113m	
Average cycle time	12.51		11.48

Notes
(1) 46 Observations
(2) 29 Observations
(3) Excess trim occurred after breakout where the faller did a clean up trim of the drag
(4) Includes unhooking, fleeting and clearing skids

Not only was the average machine cycle 1.03 minutes quicker, but there was also an extra piece per drag extracted from the organised felling wood. The 9% improved cycle time, and 18% increase in stems per drag, was sufficient incentive to commence full development and evaluation of organised felling techniques for thinning young p.radiata stands.

3. THE TECHNIQUE

3.1 Introduction

This section of the report covers a detailed description of the organised felling technique. Descriptions and examples are given for tree length extraction and short or processed length extraction. Aspects peculiar to various extraction units are also described.

It is assumed that operators are familiar with and competent in the performing of basic felling skills of directional felling and completely flush delimbing It is also assumed that they have an understanding of the requirements of the extraction machine for which they are felling.

3.2 Faller Planning

Forward planning is critical in all felling, and may mean the difference between profit and break even, or even loss. For organised felling, unless adequate time is spent on this sub operation the chances of the concept working are greatly reduced. There are two distinct parts to planning; stand assessment or familiarisation, and determination of extraction tracks. Before extraction tracks can be decided on, the faller must be familiar with the stand.

3.2.1 Stand Assessment

The faller should consider the following aspects of the stand.

Predominant Lean. This is mostly influenced by the prevailing wind direction but may be complicated by other factors. Topography is the most important of these, and on steep country there is usually no problem because the trees are all leaning downhill. On easy country, however, lean will often change, especially where there is a small sharp gully running through an area. Edge trees are likely to lean away from the rest of the stand as a result of lopsided crown development. Slumping in unstable soil types can lead to trees leaning in all directions.

Gaps in Stocking. The faller should check for pockets of windthrow which could cause problems in placing extraction tracks. The best direction for extraction tracks is through such natural features as gullies or gaps in the stocking and so the location of these should be identified.

Felling Aids. The stand should be assessed to determine what felling aids, e.g. wedges, felling lever, are appropriate. Selection of felling aids is influenced by many factors - tree size, the number of times the aids will be used, and most importantly what is available.

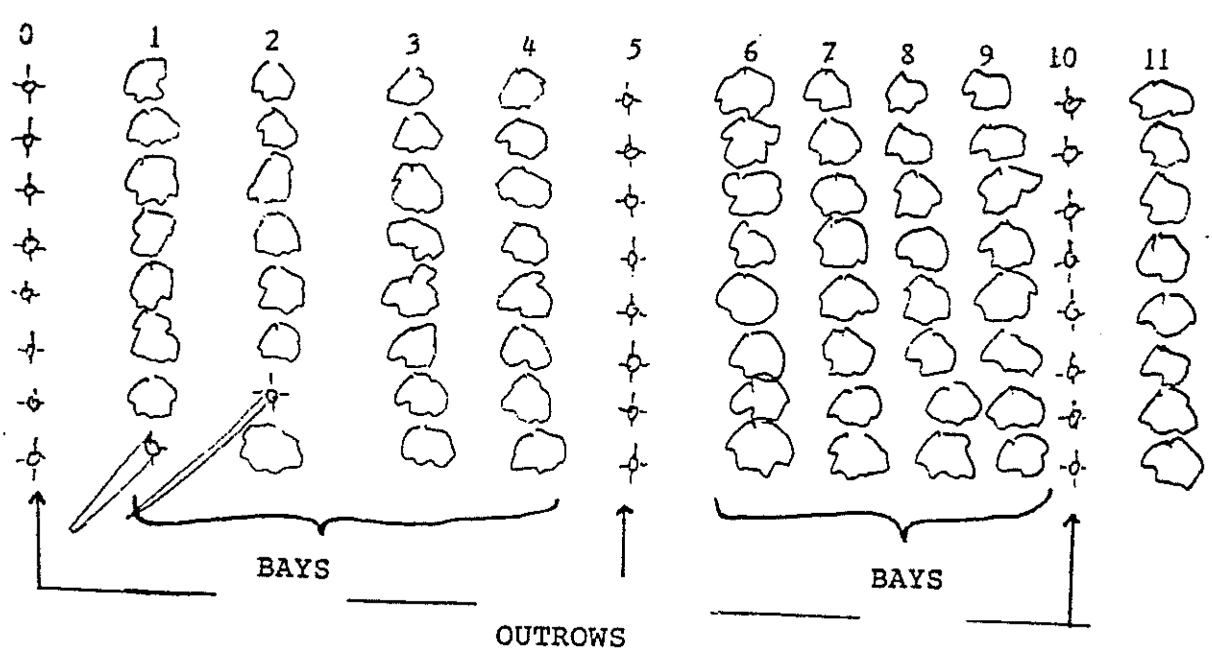
Management Aids. These should be made available to fallers but normally are not. They include such things as topographical maps, information on stocking, the average piece size, and more importantly for the selection of equipment - the range in piece sizes.

3.2.2 Extraction Tracks

OUTROW

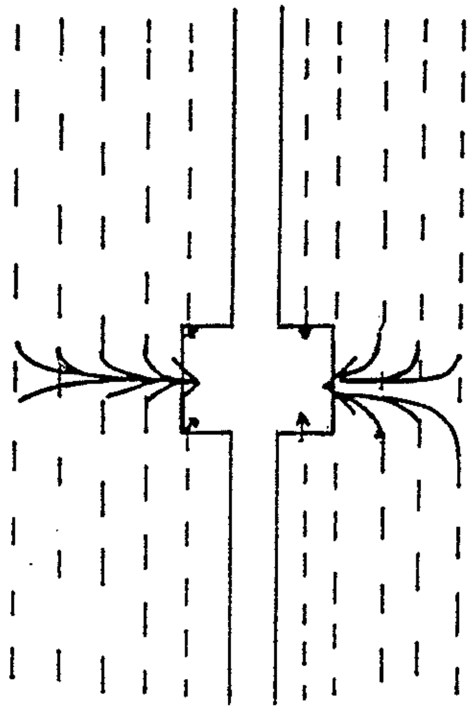
The simplest option is an outrow extraction system in which a row is selected and completely removed during thinning. The row then becomes the extraction track. Half the area to each side of that track (the bays) is then selectively thinned. The most common outrow system used in New Zealand is either fifth or seventh row outrow. The diagram below illustrates a fifth row cutrow system (fig 3).

Fig 3 - Fifth Row Outrow System



The outrows can be cut in sections along with the thinning of the bays. In the fifth row system depicted, two rows would be thinned either side of the outrow. Fig 4 illustrates what an area would look like for one landing.

Fig 4 - Relationship of outrow system to a landing



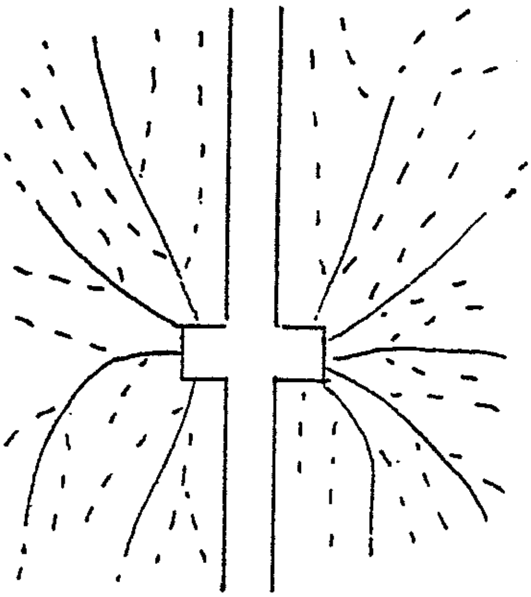
There are constraints with the outrow system. The topography should ideally be as flat as possible, or at least negotiable in all areas by the extraction machine. The stand must have been established from planted stock rather than by regeneration, and the rows of trees should be easily discernible. The forest manager must accept that he will lose a certain percentage of crop trees during outrow felling. The trade off is that it is an easy method for extraction thinning and often allows a lower cost than the random tracking method. A further advantage is that the faller has a very straightforward, well defined pattern of felling to work to, i.e. it requires less thought.

RANDOM

While outrow thinning is possibly the ideal from the logger's point of view, thinning in New Zealand more usually involves a random extraction track method. Tracks should be as straight as possible, but where bends are unavoidable they should be gradual. The track should start at the entrance of the landing and as it progresses into the stand will have numerous branches. Fig 5 illustrates this concept.

The primary track is marked in the solid line while secondary tracks are indicated by dotted lines.

In deciding where extraction tracks should go, natural features should be used, e.g. gullies or ridges, and natural gaps in stocking. From the forest manager's viewpoint random tracking extraction removes less crop trees - they are avoided by working around them. However with random extraction patterns more of the total forest area may be disturbed or compacted than with an outrow system. More thinking is also required from the faller if damage is to be avoided.



CORRIDOR

Outrow and random extraction tracks are used for tractor and skidder thinning. Where hauler thinning is contemplated a form of outrow extraction paths are used. Normally these extraction outrows are called extraction corridors. The extraction corridors are cut at right angles to the slope. It is critical that side slope is kept to a minimum or there may be severe damage to the standing trees on the downhill side. Corridors are spaced at 15 to 20 m intervals, depending on the topography, tree size, product mix and type of extraction unit used. Spacing must be flexible to allow for variations in contour.

Where the head of a gully is being worked, either uphill or downhill, the corridor spacing at the top of the hill is wider than at the bottom. Where a ridge is encountered, line length varies to compensate for that.

The easiest way to establish corridor direction is to use a compass bearing. Using the compass, two poles are placed at the bottom of each line for the faller to sight as he cuts the line out. Further sighting poles may be needed as he progresses up or down the hill. It is essential that he can line up the poles at all times.

3.3 ORGANISED FELLING - THE TECHNIQUE

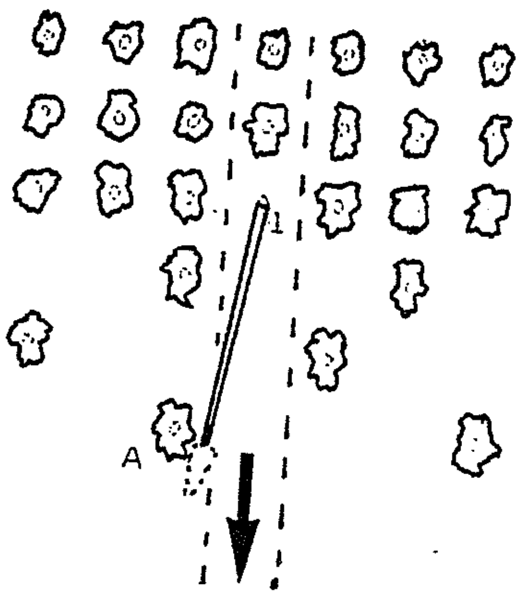
Organised felling is a disciplined approach to preparing logs for extraction. It requires that;

- the trees are accurately felled for best extraction alignment,
- the stem is thoroughly delimbed,
- slash is removed from the part of the tree to be attached to the strop,
- the extraction path is kept clear of slash,
- trees along the extraction path are protected from potential damage during extraction.

Organised felling works equally well in areas felled for butt or head extraction although the results in areas felled for head extraction are the most visually spectacular.

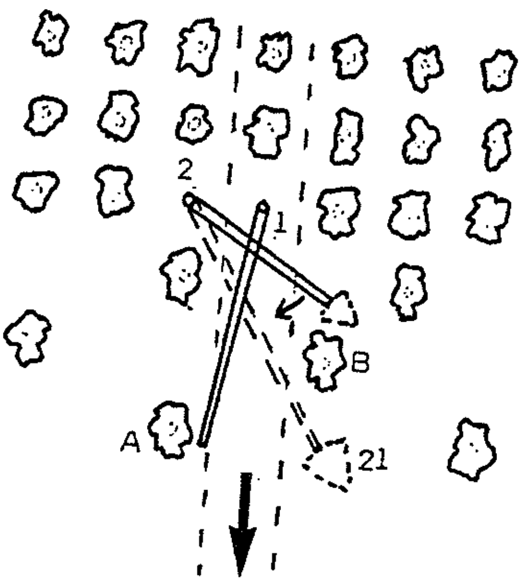
3.3.1 Felling for Head Extraction Using Ground Based Extraction Units

Fig. 7



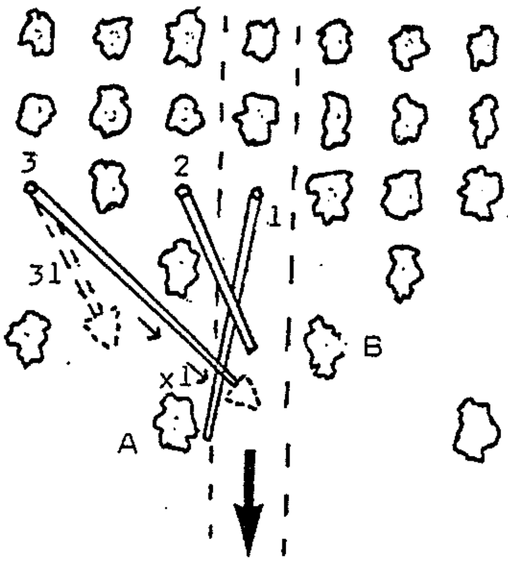
Having decided on and "marked" in the extraction track (the parallel dotted lines in Fig. 1), the first tree felled is that which is on or closest to the extraction track. This tree should be felled so that the head lands off the track. The tree is trimmed and branches that lie between the dotted lines should be removed to the left side of the stem. The head is cut up and stacked against the trunk of the crop tree (A). This will protect it from possible bark damage during extraction. If Tree 1 was short, it should be felled so that the head lands on the left of tree A and the tip swung on to the track manually. This would involve less work moving the head. Tree 1 now acts as a bench on which to fell subsequent trees to facilitate easier trimming or movement.

Fig. 8



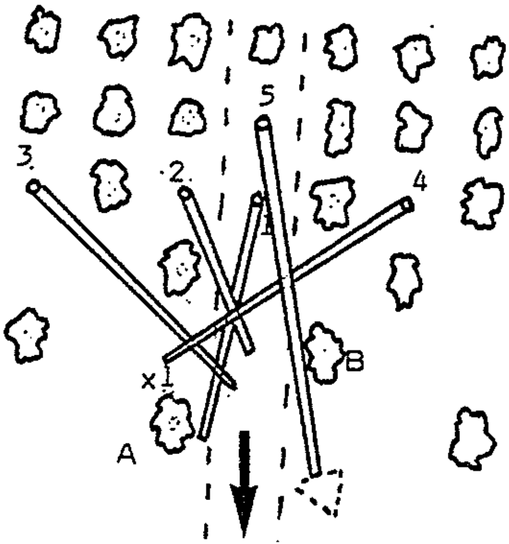
The faller can either continue falling trees on the track or start thinning the side. In Fig. 2 he has thinned the side tree 2, which is a short tree. It has been felled so that the head is well clear of the track and does not need to be moved. Again, all branches which lay on the track should be cleared. When the tree was headed off, he could swing it, using Tree 1 as a bench, in the direction of the arrow so it was better aligned for extraction. If tree 2 had been long, it could have been felled to the left of B as shown by the dotted outline 21. This would mean more branches to be removed from the extraction track. However, the head would be well clear and not need to be moved.

Fig. 9



When trees some distance from the track (such as tree 3) are felled, it is unlikely that the head will clear the track. In the case of tree 3, the head has landed on the track. When headed off, the head would be cut up and stacked against A in the area of x1. This will protect A from damage during extraction. If tree 3 had been short, it would have been felled as the dotted outline 31 indicates and dragged (using pulp hooks) so the tip lies across tree 1. The head would still be stacked against A at x1. With trees like 3, there is no need to remove branches that land off the track. Only branches close to the head would need to be moved and stacked against tree A.

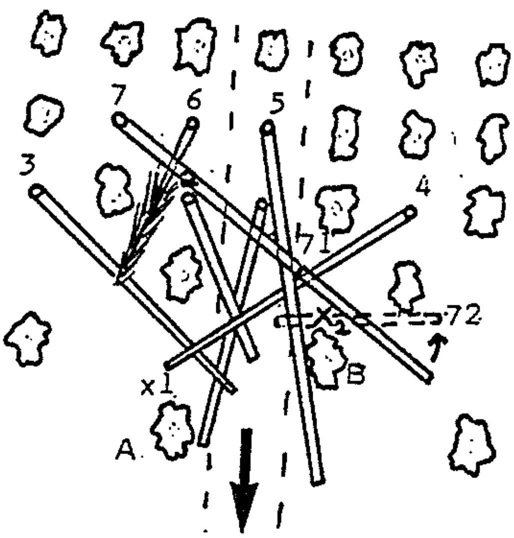
Fig. 10



Before the faller could fell tree 5 which is on the track, he would have to fell tree 4 as indicated. This would then provide a bench to fell 5 across. Tree 5 would be felled so the head lands on the right hand side of the track where it would not need to be moved. All branches falling on the track would again be cleared.

The sequences described above are then continued, ensuring that adequate bench trees are used. All slash is cleared from the extraction track and that cleared slash is stacked to protect crop trees.

Fig 11



Two features are illustrated in Fig 11. The first is the felling of dead and/or non-merchantable stems, (tree 6). If these are felled away from or parallel to the track as indicated, there is no need to move them as they should be well clear. If they occur on the track or have to be felled over the track, then slash falling on the track should be removed.

If the produce specifications enable short logs to be cut, the best way to fell tree 7 is as indicated. The tree is completely trimmed and headed off, leaving the head where it lies but removing the slash from the track. The slash should then be stacked against tree B at x2. Tree 7 is then crosscut at 71 and the short head piece is manoeuvred in the direction of the arrow so it lies in the position as indicated by the dotted outline 72. Felling 7 thus greatly reduces the slash removal than if it had been felled to the left of tree B.

The described technique is the same whether random extraction tracks or an outrow system is being used. The main points are :

(1) Keep the extraction track as free from slash as possible.

(2) Make sure adequate slash is placed around those crop trees likely to sustain damage during extraction.

(3) Make sure stems are trimmed as completely as possible.

(4) A little thought about head placement during felling will result in a significant reduction in the amount of slash requiring removal.

The four photographs on the next page illustrate the result of the organised felling approach for different ground based extraction techniques. All wood was to be extracted by head pull.

Fig 12 - Random thinning system using gully bottoms and spurs as extraction tracks. Age 18 radiata. Extraction by skidder.

Fig 13 - Random thinning system. Age 15. Extraction by rubber tyred skidder

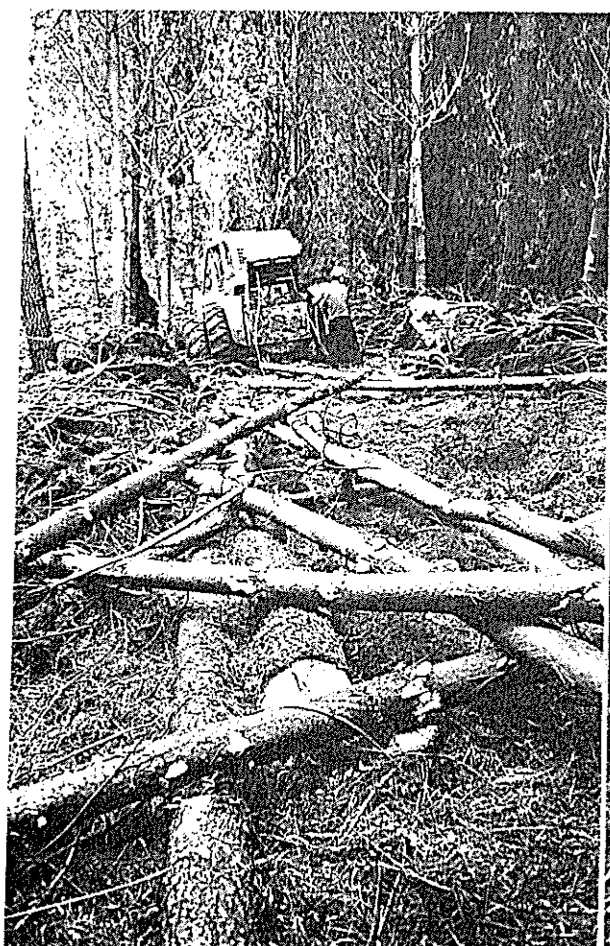


Fig 15 - Random thinning system extraction tracks determined by natural gaps and best line to landing. Age 13 radiata. Extraction by skidder and crawler tractor

Fig 14 - Outrow extraction thinning system. Age 13 radiata. Extraction by skidder

3.3.2 Felling for Butt Extraction Using Ground Based Extraction Units.

Organised felling for effective butt extraction differs little from that for head extraction. Ideally the extraction track is set off to one side and trees felled away from that track into the area previously thinned. If possible, the area into which the trees are felled should already have been extracted, i.e. the machine operates on a drag for drag basis. This is not always practical, and the technique illustrated assumes that the fallers are required to work up to one week ahead of the extraction machine.

Fig. 16

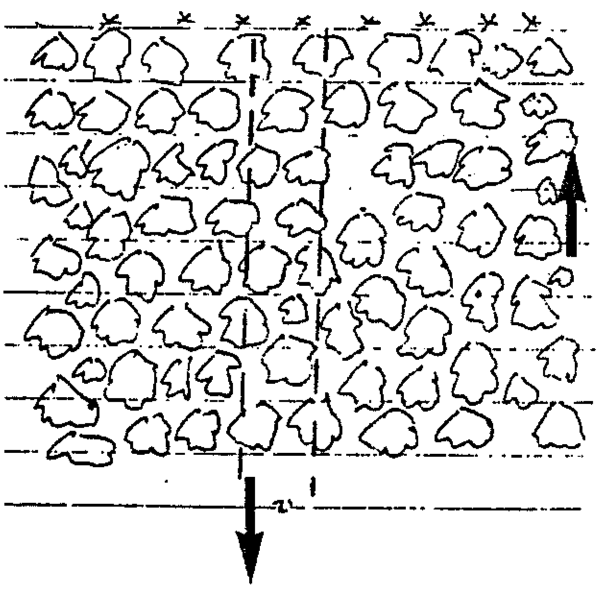
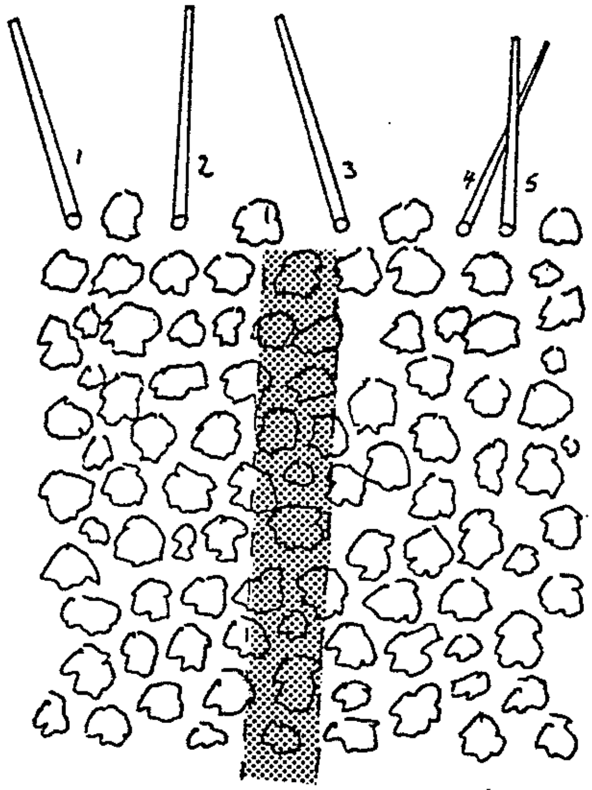


Figure (16) shows a stand to be thinned. The edge of the compartment is indicated by the line of ****s. A good predominant lean exists, indicated by arrow 1. This lean is consistent for the whole of the area. The topography is generally flat, and where the topography changes lean is not affected. The arrow 2 indicates the desired extraction direction. A selection thinning is required with the extraction track indicated by the dotted line.

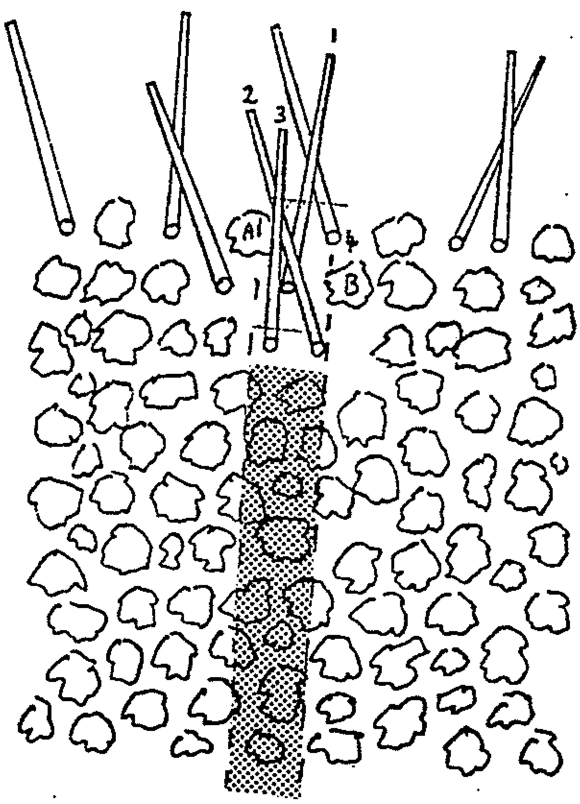
Fig 17



The faller starts work at the edge of the block with the first tree felled being one on the proposed extraction track. This tree is felled out into the open area and fully trimmed. As there are no other trees beyond this to be hooked on there is no requirement to remove any slash.

All the trees along the edge to be extracted out the track should be felled first. This serves to open up a reasonable work face. In felling these trees thought should be given to directionally felling them so they could be used as bench trees for subsequent trees. Note that tree 3 has been felled at an angle across the end of the extraction track so it can be used as a bench to support the next tree to be felled. Tree 4 was felled at an angle to support tree 5.

Fig 18

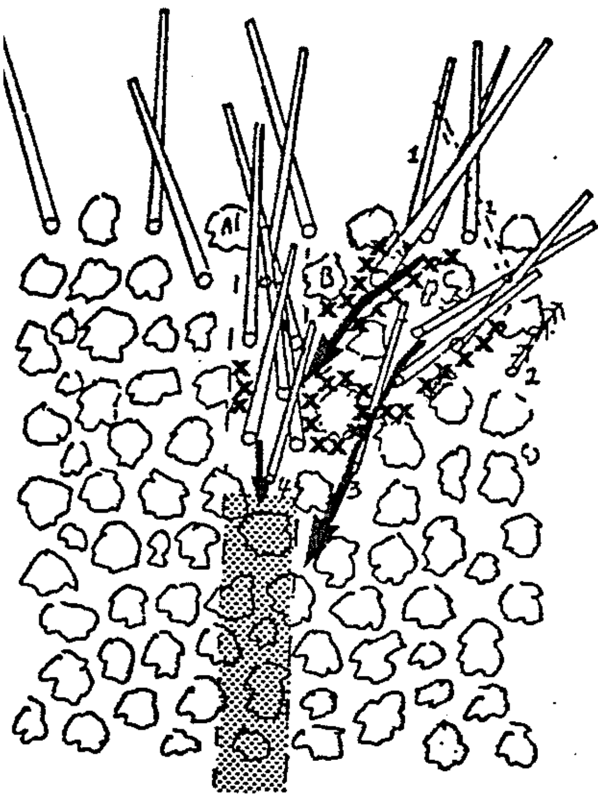


The faller has elected to start the thinning by cutting out his extraction track to give him a better idea of the direction required for extraction. Note that felling all the next three trees across a bench tree, made complete delimbing more straightforward.

Any slash occurring in the shaded sections of these three trees would be removed and placed around the butt of trees A and B thus affording them protection during extraction. It is important that any slash that fell over the butt of tree 4 is also removed so that the machine operator has clear access to hook on that tree during extraction.

The faller may be tempted to take more trees along the extraction track. This is not wise as once the sides are thinned it may be possible to fell some of the trees on the extraction track into the sides and thus considerably reduce the amount of slash removal required.

Fig 19



In Figure 19 the right hand side of the "face" and more of the extraction track has been thinned. If tree 1 had lain where it fell (as indicated by the dotted out line) it would have been difficult to extract. Using pulp hooks the faller manoeuvres it across the other logs to give it a better lie.

Tree 2, a waste tree, has been felled away from wood to be extracted so as to avoid any hindrance during breakout.

The head of trees 3 and 4 would have been stacked against the tree closer to them, C and B respectively. The slash build up is indicated by those areas shaded by XXX. Where slash build up occurs it should be concentrated into rows so that lines of extraction become clearly visible.

Lines of extraction are shown using the solid line with an arrow. These are more easily discernible if slash rows are clearly established and makes the machine operators job much easier.

The main features of organised felling for butt-pull are the same as those for head-pull. Consider the subsequent extraction operation and aim to make that as easy as possible. The photograph over page illustrates an area felled, out of phase, for butt-pull extraction.

In either butt or head-pull situations where there are trees that lean the wrong way which cannot be felled with the aids available, fell them for extraction by the opposite end. Another alternative is to fell them across the face and crosscut them so they can be extracted in two pieces with minimum risk of damage to the residual stand. There is sufficient tolerance in all New Zealand's thinning specifications to allow this to be done. Felling aids are available and are relatively inexpensive - have them at the felling face and ensure that they are used.

It is also advisable when trimming trees felled for head extraction to leave the branch stubs from the last whorl 3 or 4 centimetres long. That will prevent the strop sliding off the log.

3.3.3 Felling for Extraction by Hauler

Organised felling for hauler extraction follows the same procedures as for skidder or tractor extraction. The part of the log to be attached to the strop and the extraction row are both kept clear. Figure 20 illustrates the results of organised felling in a thinning operation where logs were being extracted in an intermediate length of 5 to 6 metres. Cutting the logs to length offers the faller even more flexibility, making the job of felling much easier.

Fig 20

Once the corridor has been marked in, as described earlier, then cutting should commence from the bottom of the hill and progress to the top. This takes advantage of the natural tendency of trees to lean downhill. The easiest approach is to first cut 10-15 metres of the corridor then thin both sides and repeat the sequence. This reduces the number of times the faller needs to walk up the hill. It is important that on steep slopes the tree remains attached to the stump during delimbing. This reduces the likelihood of movement during delimbing or at heading off. (Cut them off after though!)

If stems are being cut to length then the trees can be felled directly across the corridor, and once cut easily extracted without causing damage to residual crop trees. If stems are being extracted tree length then they should be felled as nearly parallel to the corridor as possible.

Ensure sufficient slash has been placed on the uphill side of the tree for downhill extraction, and on the downhill side of the tree for uphill extraction. Corridor spacing is important; the corridor should be spaced so that all trees to be extracted can be reached from the centre. Preferably stems to be extracted should have the section to be hooked on no further than one metre from the edge of the corridor.

4 EFFECT ON FALLER PRODUCTIVITY

In carrying out the organised felling approach the faller is required to do considerably more work in the form of clearing slash and a slower or more careful approach to felling. It would not be unreasonable to expect that the time per tree or time per cubic metre would be significantly increased, thus decreasing the fallers productivity. Two detailed studies have been undertaken comparing organised with conventional falling. The first study was in a hauler thinning system, and the second in a skidder thinning system. This section tables the results and discusses the two studies.

4.1 Hauler Thinning

An Igland hauler was used to extract thinnings from a stand in Kinleith Forest, N.Z. Forest Products Limited, (Liley,1984). The stand was 14 year old, regenerated radiata pine with an average d.b.h. of 20 cms. The stand was being reduced from, in excess of 1500 stems per hectare, to 350 stems per hectare. The average thinning tree size was .22 m3 with the average processed piece being .12 m3. Slopes encountered during the study ranged from 0° to in excess of 40°. The system departs from the typical hauler thinning system in that all wood was processed to 5.5 m lengths in the bush. The wood is removed to the edge of the road and stacked in front of the hauler. Load out was by self-loading trucks. This system didn't require any landings - merely a road with sufficient width to park the machine on.

Conventional felling consisted of felling an extraction corridor, thinning one side and then thinning the other side. Two fallers were employed and the resulting wood presentation could best be described as poor. No attempt was made to clear slash from the corridor, which meant that the breaker out was working with slash covered logs. Working conditions for the fallers were also very poor. The level of motivation of fallers practising the conventional felling was not good.

In an attempt to remove the complicating effect of motivation from the comparison, the cycle descriptions in Table 4 excludes such tasks as, fell dead or nonmerchantable, refuel, saw maintenance, rest and smokos. Only the actual worked time per tree is shown.

Table 4 - Comparison of Fallers Cycle Time, minutes

	Conventional		Organised
	Cutter 1	Cutter 2	
Element	Mean	Mean	Mean
Walk and Select	0.51	0.38	0.30
Clear Butt	0.32	0.48	0.36
Scarf	0.16	0.21	0.14
Back Cut	0.33	0.50	0.27
Trim	3.03	3.18	1.46
Clear Slash			1.45
Cross Cut	0.27	0.17	0.29
Manoeuvre			
Total Cycle	4.62	4.92	4.27
Tree Diameter (breast height)	24.13	22.09	19.10
Number of Observations	46	46	70

A full description of elements and break points is contained in Appendix II. It should again be reiterated that these results are highly individual. There is no way of accurately predicting what would happen if better motivated fallers had been used for the conventional felling. It does, however, highlight that with a little training various elements can be dramatically reduced, allowing time within the cycle for other work modes such as "clear slash" which will improve the environment for subsequent extraction.

The graph over page illustrates the difference between the three groups of data for the three more important elements - walk and select, trim, and total cycle time.

The graph is in the form of a 'box plot' of observed times. The median or middle observation is shown, plus the upper and lower quartiles. The quartiles are the limits of the upper and lower 25% of observation. Thus 50% of observations are contained in the boxes and give a simple indication of the variability of observations. The 'whiskers' extend out to the lowest and highest observations and thus show the full range of observations.

Figure 21 - Box Plot of Walk and Select (A), Trim (B), and Total Cycle (C)

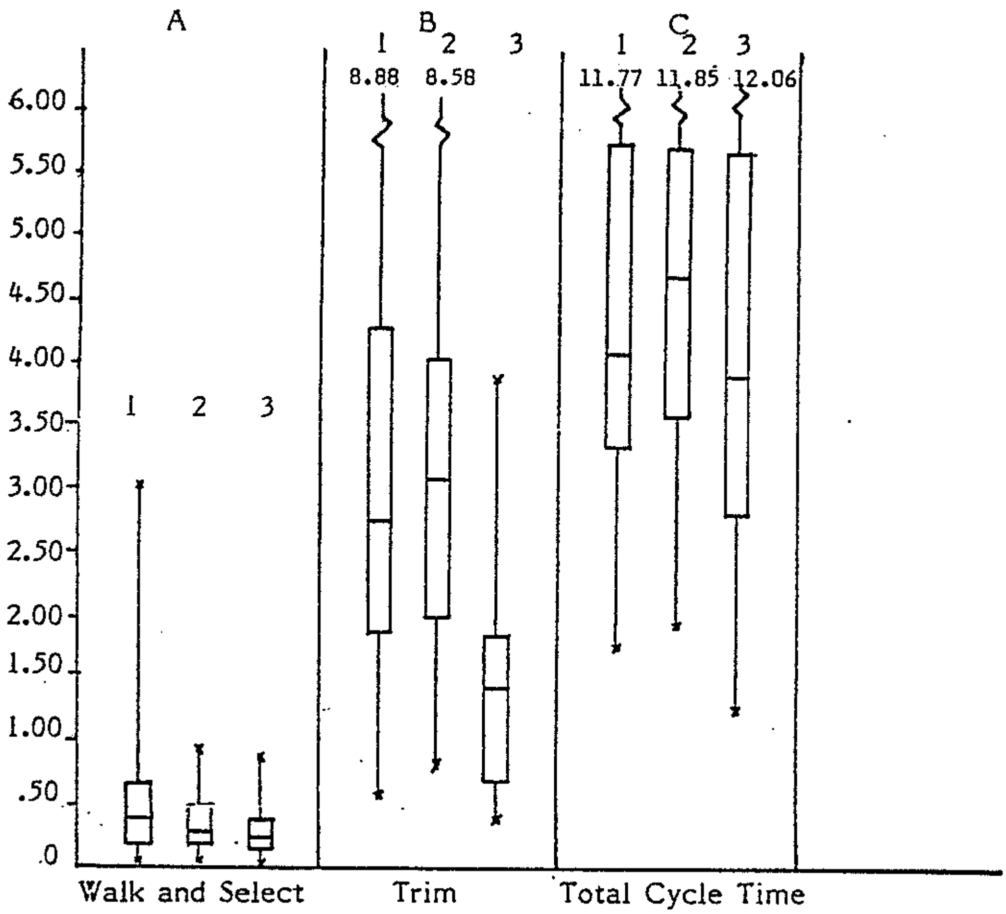


TABLE 5 - FIGURE 21 - DESCRIPTION

	Median	Upper Quartile	Lower Quartile	Low	High
A. Walk and Select					
Cutter 1	0.42	0.20	0.67	0.07	3.05
Cutter 2	0.31	0.20	0.52	0.07	0.96
Organised 3	0.27	0.17	0.40	0.05	0.90
B. Trim					
Cutter 1	2.77	1.87	4.29	0.59	8.88
Cutter 2	3.11	2.00	4.05	0.84	8.54
Organised 3	1.44	0.70	1.87	0.39	3.91
C. Total Cycle					
Cutter 1	4.08	3.35	5.77	1.77	11.77
Cutter 2	4.73	3.61	5.73	1.91	11.85
Organised 3	3.92	2.82	5.71	1.28	12.06

Graph Description - Column A of this graph represents data from walk and select for all three fallers - conventional 1 and 2 and organised 3. Little difference can be noted here. Given the improved environment in which the organised faller was working, a decrease in walk and select time could be expted. However, a certain amount of this decrease may well have been taken up in the extra select and assessment required for organised felling.

Column B is the trim part of the cycle. A substantial difference in trim time is highlighted. This is attributed to the substantially improved working environment created through slash removal.

The final Column C illustrates total cycle. Again, even though two new elements have been introduced there has not been an increase in cycle time, in fact a slight decrease is evident, (although this is not a significant difference, given the spread of results).

Historically the conventional fallers had been managing only about 8 m^3 per day each, thus restricting the machine to 16 m^3 per day. Within two months of having organised felling demonstrated both fallers had started felling in this manner. Their productivity six months later had reached approximately 12 m^3 per day. An extra man was employed in a flexible role, assisting where required, i.e. he would break out if the contractor was away, or assist falling if the fallers got behind. Long term weighbridge data indicated production levels rose to an average of 27 m^3 per day.

The key features highlighted by this study were :

1. Organised felling could be successfully carried out on steep slopes, in excess of 40°, in a production thinning hauler extraction system.

2. Cycle time per tree excluding rest, smokos, production delays, and saw maintenance etc was not increased. In fact it was reduced.

3. Slash could be adequately cleared from the corridor without unnecessary delay.

4. Log manoeuvring, especially in this situation where stems were being cut to 5.5 m lengths, was achieved relatively easily.

5. Offered the right incentive, even the most obstinate faller could see the advantages of organised felling over conventional felling, and after only a short period of familiarisation could change to organised felling and carry it out competently.

6. Working in a slash free environment was ergonomically better, although the effect has not yet been quantified.

4.2 Skidder Thinning

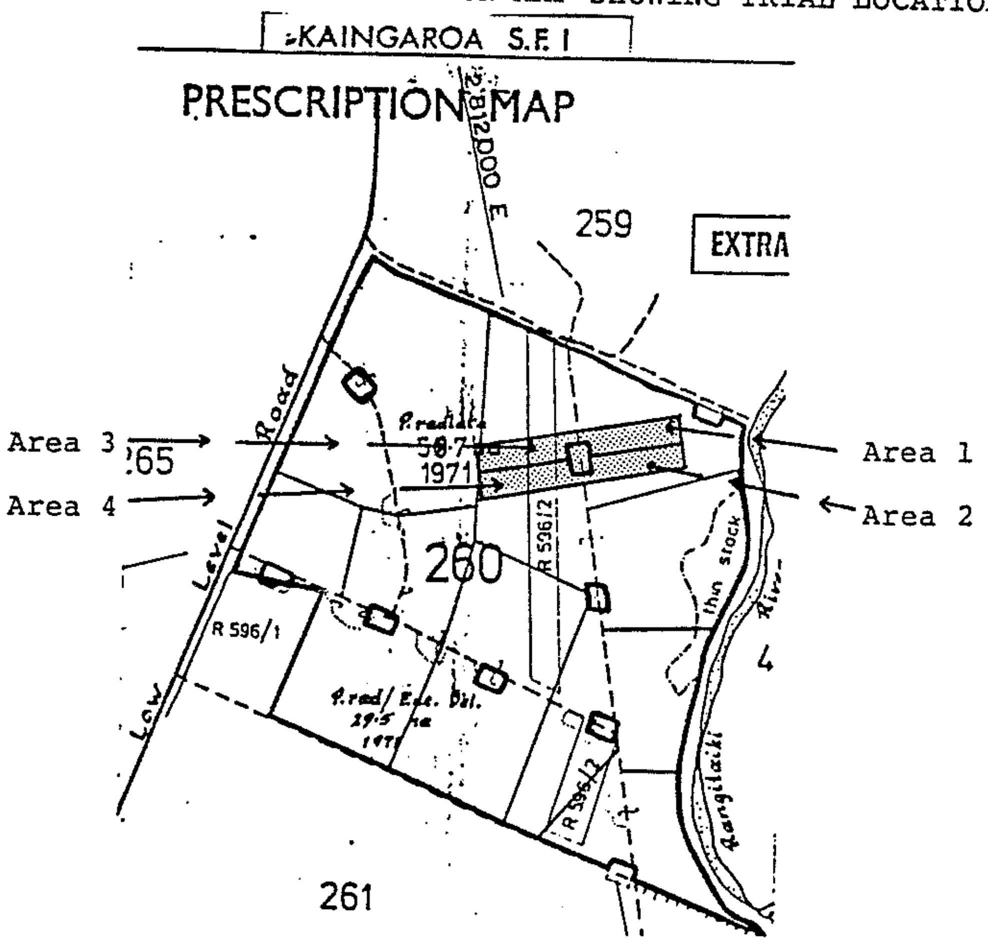
In early 1985 a trial was set up specifically to compare faller and skidder productivity in conventional and organised felling (Gaskin 1985). The compartment stand prescription is shown in Table 6 and the prescription map is included as Figure 22.

TABLE 6 - STAND PRESCRIPTION

	Before Thinning	Thinning	Residual
Stocking (sph)	539	302	236
Basal Area (m^3/ha)	31.6	16.0	15.5
Mean dbh (cm)	27.3	26.0	29.0
Mean top height (m)	18.8		
Total stand volume (m^3/ha)	196.0	98.0	97.0
Mean merch. volume (m^3/tree)		0.276	
Avg merch. length (m)		10.9	
Merch. volume (m^3/ha)		83.5	

The points of note in this table are the given mean dhb, mean merchantable volume and average merchantable length. In the subsequent analysis significant variation to this data will be illustrated, especially with regard to average merchantable length.

FIGURE 22 - PRESCRIPTION MAP SHOWING TRIAL LOCATION



Area 1 and 2 were felled for butt extraction (Area 1 organised, 2 conventional).

Area 3 and 4 were felled for head extraction (Area 3 organised, 4 conventional).

Areas 2 and 4 were felled conventionally by two fallers from the contract gang of D. King. One faller was considered above average in experience and speed while the other had only recently started with King. Both fallers had good levels of motivation and appeared to work very hard for the entire time of the study. In this situation conventional felling consisted of felling trees roughly in line for extraction. Area 2 was better felled (butt pull) than Area 4 where trees were regularly felled at right angles to the line of extraction. No effort was made to clear any of the butts or heads to facilitate hooking on. Trimming consisted of removing the branches off the tops and sides of the stem. Of the branches beneath the stem only those easily located were trimmed. For both fallers cycle times per tree, and length of stem trimmed, were recorded.

The photographs in Figure 23 and Figure 24 illustrate the conventionally felled butt and head pull wood prior to extraction.

Fig 23 - Conventional Felling
Head Pull

Fig 24 - Conventional Felling
Butt Pull

Areas 1 and 3 were felled using the organised felling approach by three LIRA researchers. The three fallers were fully conversant with the technique, having been involved in its development. Obviously it could be reasoned that their level of motivation was higher than that of the average faller. It could equally be assumed that their level of work fitness was below that of an average faller, having been office-bound for at least two months prior to this exercise. Figure 25 and Figure 26 illustrate the result in wood presentation for butt and head pull prior to extraction.

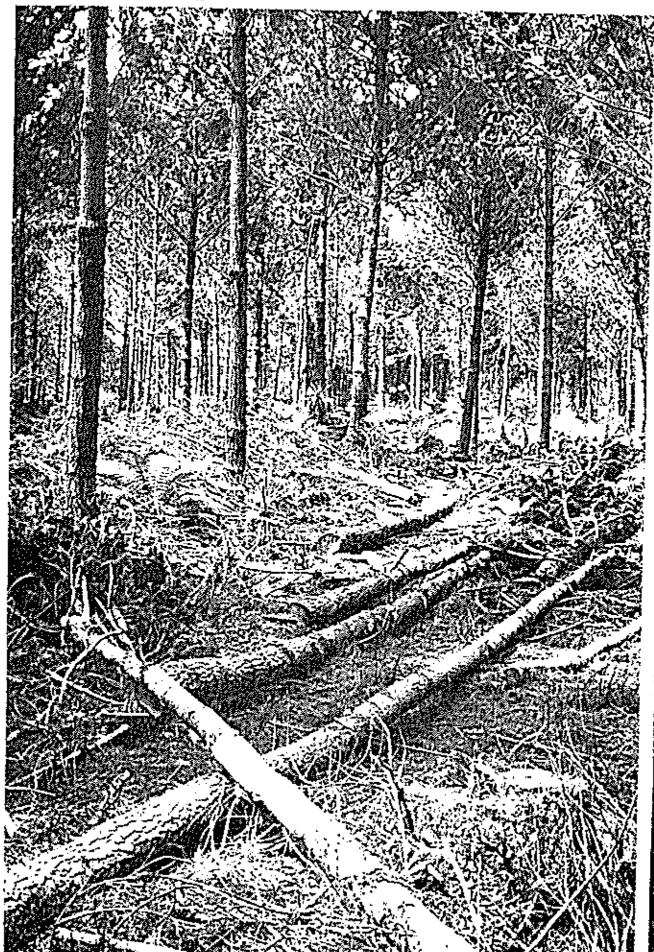


Fig 25 - Organised Felling Extraction by Butt Pull

Fig 26 - Organised Felling Extraction by Head Pull

Cycle times and wood dimensions were also recorded for these fallers. All the falling was based on random extraction track as opposed to an outrow system. Extraction was by an Iwafuji T30, (as described by Liley, 1985), this being the machine most readily available.

The cycle elements recorded were essentially the same for both groups of fallers, although the organised felling included the 'clear slash' element. Roughly 80 cycles were recorded for both types of falling.

The stand characteristics were considered to be similar enough to allow meaningful comparison. Similar size samples were taken from both head pull and butt pull areas.

The table below illustrates the results of that study, summarised by individual cutters.

Table 7 - Conventional Falling Cycle

Element	Faller 1 Mean Time Per Cycle	Faller 2 Mean Time Per Cycle
Walk and Select	0.19	0.34
Clear Butt (1)	0.05	0.12
Scarf	0.13	0.30
Back cut	0.20	0.33
Sloven (1)	0.02	0.09
Trim	1.57	1.50
Total Cycle	2.16	2.68
Length (m) (2)	10.35	8.94

Note : (1) In elements such as clear butt, sloven etc, which didn't occur in every cycle, the sum of observed times has nevertheless been divided by the total number of cycles, giving a mean time per cycle.

(2) The length of the delimbed stem was measured to the part where it was headed off. If a double header was trimmed the length of each leader was added together.

Table 8 - Organised Faller Cycle

Element	Faller 1 Mean	Faller 2 Mean	Faller 3 Mean
Walk and Select	0.33	0.36	0.32
Clear Butt (1)	0.01	0.07	0.15
Scarf	0.20	0.28	0.37
Back Cut	0.31	0.37	0.45
Sloven (1)	0.09	0.12	0.12
Trim	2.10	2.58	2.85
Clear Slash	0.77	1.20	1.57
Total Cycle	3.81	4.98	5.83
Length(m)(2)	13.62	12.60	13.37

Note : (1) and (2) - as per previous table.

Figure 27 - Box Plot of Total Cycle Times for Conventional Felling (A), and Organised Felling (B)

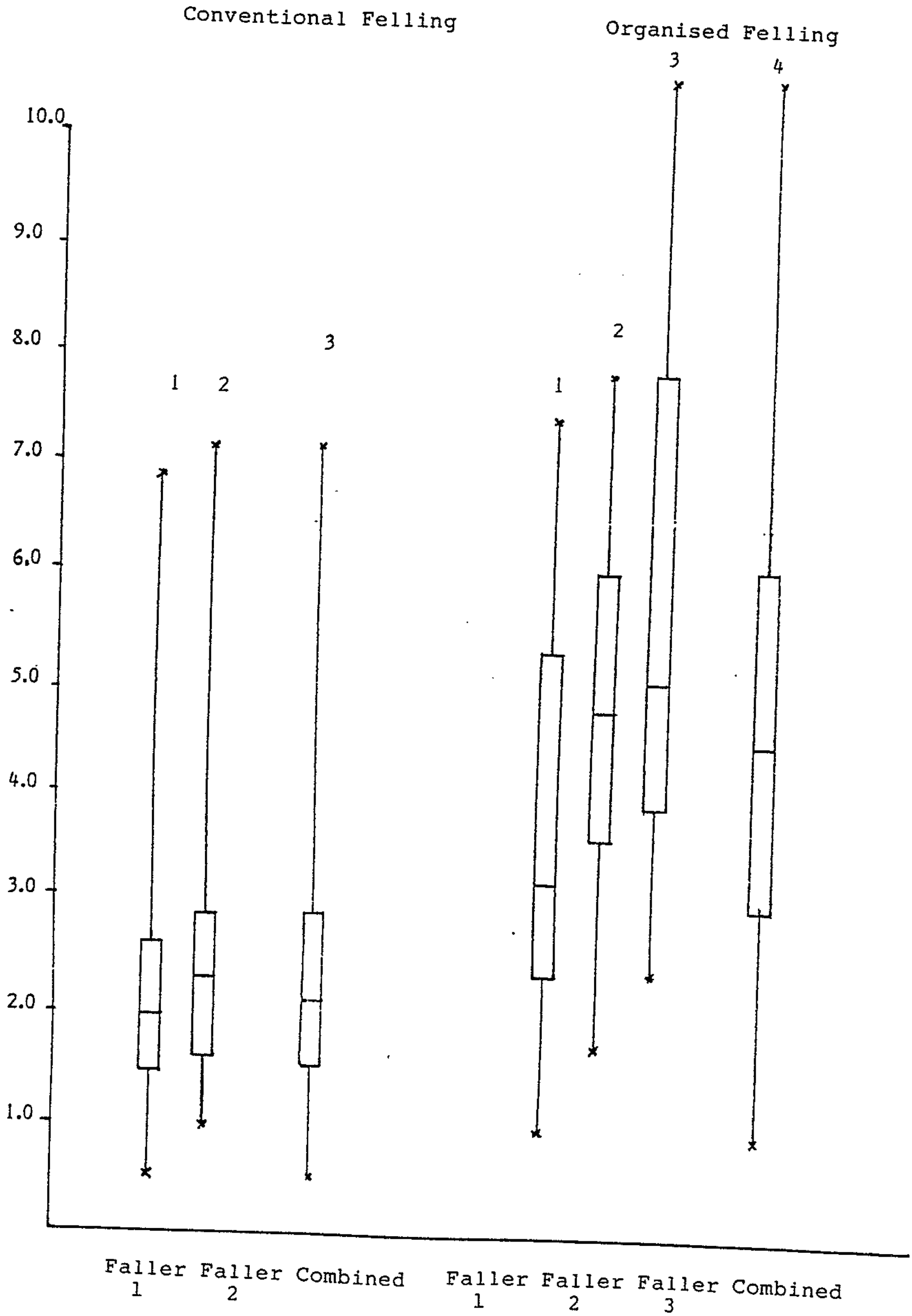


Table 9 - Description of Figure 27

Column A - Total Cycle Time Conventional

	Median	Lower Quartile	Upper Quartile	Low	High
Faller 1	1.96	1.42	2.61	.50	6.87
Faller 2	2.29	1.58	2.88	.95	7.12
Combined	2.10	1.50	2.90	.50	7.12

Column B - Total Cycle Time Organised

	Median	Lower Quartile	Upper Quartile	Low	High
Faller 1	3.32	2.44	5.40	1.74	7.48
Faller 2	4.88	3.70	6.12	1.82	7.92
Faller 3	5.14	3.99	8.94	2.53	10.63
All Combined	4.60	3.10	6.20	1.74	10.63

Analysis of the information using T Test for unpaired data indicated a significant difference between the combined organised and combined conventional results at the 95% level - conventional being considerably quicker. Using the same test within the group of organised felling data showed no significant difference between fallers 2 and 3, but a significant difference at the 95% level was evident between those two and faller 1. In analysing only faller 1 organised and faller 2 conventional, conventional was still quicker (significant at 95% level).

The organised felling cycle was 4.60 minutes - 100% slower than conventional felling cycle at 2.28 minutes. The result is somewhat different to that expected after earlier work, especially that done with the Igland hauler. The conventional fallers were of a much higher standard and the organised felling data had been collected from three fallers of varying levels of experience.

The scaling carried out at the landing showed an interesting trend. From 200 samples of stems measured, extracted from the conventional areas, and 116 samples from the organised, the following pattern emerged:

Table 10 - Trimmed Piece Size Difference

	Conventional Felling	Organised Felling
Average butt diameter, cm	23	23
Trimmed length, m	9.73	13.10
Small end diameter, cm	11.94	9.67
Extracted volume per piece	0.23	0.28
Time per cubic metre (1)	9.91	16.43

The difference made by increasing the length trimmed and reducing the head off (s.e.d.) point to a nominal 10 cm instead of 12 cm was dramatic. Although cycle times were 100% slower, because of the increased volume in the organised wood the time per cubic metre was only 66% slower.

The final part of the study on the fallers was undertaken at the landing during scaling. The number of branches on each drag was tallied. That tally is summarised in the table below :

Table 11 - Branch Count

	Conventional Felling		Organised Felling	
Area	2	4	1	3
Number of branches	242	350 (1)	144	188
Total	592		332	
Total pieces extracted	345		448	
Branches per piece	1.72+		0.74	

Note : (1) Two trees were extracted untrimmed and haven't been included in this sample as it was too difficult to count the branches.

The standard of trimming was much higher in the organised area than in the conventionally felled areas. Of 74 drags extracted from organised, 36 (half) had no branches at all on the logs. Of the conventionally felled areas only 12 drags out of 67 had no branches. 11 of those 12 drags were from the head pull area. Logs dragged head pull normally arrive at the skids much cleaner than from butt extracted areas.

4.3 Summary of Faller Productivity

The results presented are highly individual and take no account of levels of motivation, skill and experience. In the Igland hauler study the results were consistent with those of overseas studies where organised felling was noted as being not significantly slower than conventional. Given the extra work involved, the level of slash and on occasions the manoeuvring, this was somewhat surprising. In the trial reported from Kaingaroa, significant differences in total cycle time per tree are shown. That difference is reduced when considered on a time per cubic metre basis, but it is still significant. It would not then be unreasonable to expect an extra faller to be required. It becomes important to calculate if the additional cost of that faller can be recovered through increased extraction. That concept will be dealt with in a subsequent section after discussing machine productivity.

These results do demonstrate that the organised felling technique, can physically be carried out. The benefits are listed below :

(1) Increased faller awareness. The effect a decision will have on the amount of work they are required to carry out if a tree goes in the wrong place, i.e increasing the amount of slash removal required. That results in better directional falling.

(2) By removing the slash, creating a better working environment for themselves and subsequent operations.

(3) Adoption of better chainsaw techniques, i.e. delimbing, thereby making the job ergonomically less demanding.

(4) Improving the standard of delimbing, reducing the requirement for further delimbing at the landing or during extraction.

(5) Better recovery of available volume per hectare through more exact heading off. Often the temptation is to continue trimming a little extra to reduce the need to physically handle the heavy head section of the tree.

5. EFFECT ON EXTRACTION MACHINE PRODUCTIVITY

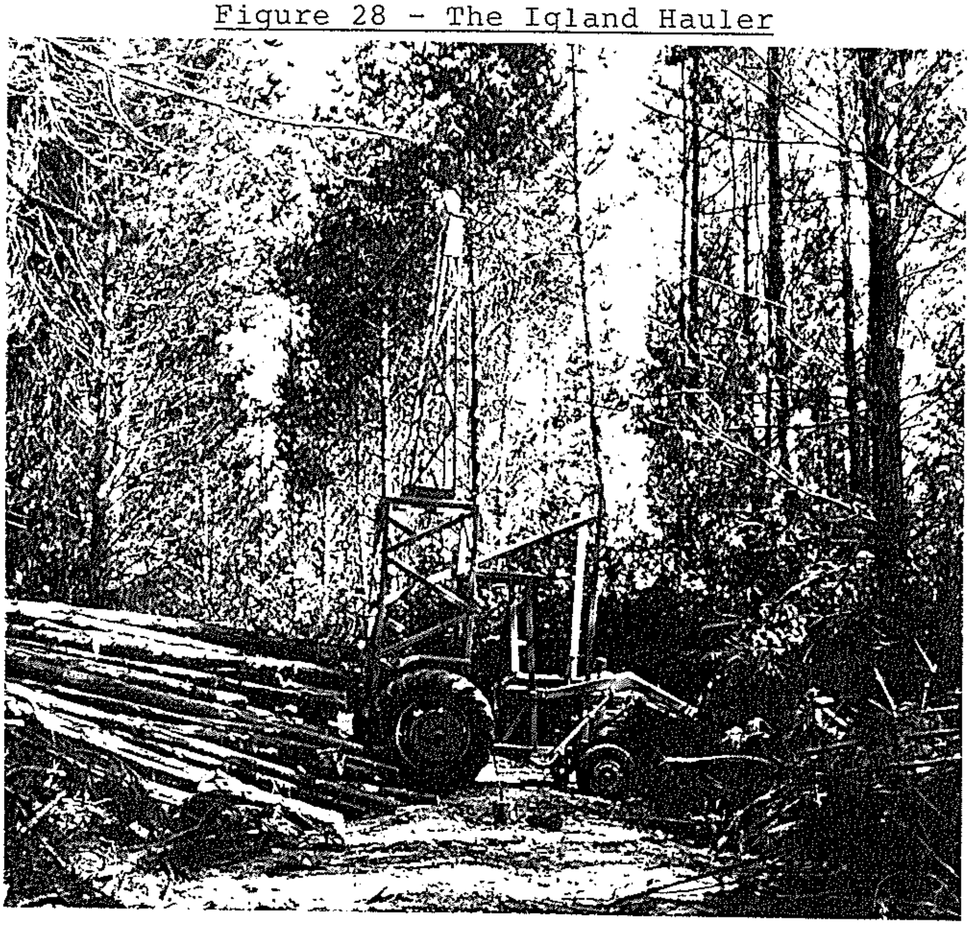
It was reasoned, due to the improvement in the breakout environment, that substantial improvements in productivity of the extraction units would be achieved. Trees to be hooked on were much more easily seen and, through improved standard of delimbing, breakout resistance would be minimal. The clearing of the part to be hooked on should also result in less slash being taken to the landing which would result in reduced unhooking time. The extraction phase of the two trials already mentioned were monitored and this section discusses the results of these studies.

5.1 Igland Hauler

The Igland Hauler is a small, relatively simple cable logging machine commonly used in Europe. It is based on an agricultural tractor of around 45 kw which has an Igland 4000/2 double drum winch attached. The winches are chain and sprocket driven off the PTO. Control of the drums, free wheel, brake, and power in, is through direct acting mechanical linkages. A 6 m lattice tower completes the unit.

During the study the machine was rigged in a running skyline configuration and extracting downhill. One drum had 300 m of 8 mm tower rope and the other had 180 m of 10 mm mainrope. In this particular study, three 10 m continuous loop polypropylene rope strops were used. These strops were made up of sections of strawline.

Figure 28 - The Igland Hauler



The data in the table below explains only the breakerout part of the cycle. Greatest improvements were achieved here resulting in corresponding improvements in productivity.

Table 12 - Breakerout Cycle for Igland Hauler

Element	Conventional Mean Element Time (minutes)	Organised Mean Element Time (minutes)
Walk and select	0.36	0.21
Wait out haul	0.60	0.62
Walk in	0.17	0.11
Pull rigging	0.26	0.21
Attach	1.34	1.12
Move clear	0.20	0.16
Wait clear	1.48	1.39
Wait in haul	1.14	1.09
Clear slash manoeuvre(1)	0.20	0.30
Pre-attach	0.19	0.10
Untangle strops	0.06	0.07
Reattach	0.05	0.02
Work at stack	0.17	0.25
Total Cycle Time	6.22	5.65
Number of drags	57	283
Number of pieces	175	1029
Pieces per drag	3.07	3.74
Time per piece	2.03	1.51

Note: (1) In the organised felling this element was predominantly manoeuvring of logs to increase the number attached to each strop.

Element descriptions and break points are described in Appendix III.

Through organised felling machine productivity was significantly increased. Cycle time was 10% faster and number of pieces per drag 22% higher - leading to an overall reduction of 25% in time per piece. Based on that information, given an average utilisation of 76% and an on-site time of 8.5 hours, the daily productivity would be expected to be 31 m^3 for organised and 23 m^3 for conventional. Historic records of volumes loaded out over a 12 month period show that these daily productivities should be reduced by 5 m^3 each. The effect of having researchers study the gang probably led to an increased pace. Also long term machine utilisation and a number of other factors affecting productivity, such as piece size, average haul etc, may be different to the conditions of this trial.

Given the levels of faller productivity described earlier, two fallers would be stretched to the extremes if they were expected to maintain the machine's potential production. It is likely, and in fact has happened, that an extra faller was required. The effect of this extra faller on daily cost is discussed in a subsequent section.

5.2 Skidder Thinning

The machine used for this study was an Iwafuji T30. This is a Japanese manufactured, four wheel drive, rubber tyred skidder. The power rating is 30 KW. A double-drum winch is a standard fitting. During the study the machine was fitted with four strops per winch rope. The same four areas described in the felling productivity section (pp 22 to 38) were extracted randomly (determined by tossing a coin). The operator had never operated this machine previously and a clear learning curve was notable.

During the extraction of head pull areas it became obvious that load size was machine limited. The load which would make best advantage of the felling would be 8-10 pieces, and yet this was too heavy for the machine to extract without frequent dropping and winching.

A Bell Infield Logger was used to fleet on the landing This avoided non-productive skidder time on the landing.

Table 13 below illustrates the results of the study. Details of element break points are included in Appendix IV.

Table 13 - Skidder Extraction Cycle Time

	Average Cycle Times (minutes)			
	Butt Pull		Head Pull	
Element	Conventional	Organised	Conventional	Organised
Travel empty and position	1.76	1.72	2.04	2.00
Hook on (1)	3.96	3.40	3.17	2.60
Breakout	2.03	1.62	1.33	1.34
Travel Loaded (2,3)	1.61	2.30	2.52	2.52
Drop and winch	0.26	0.35	0.65	0.56
Unhook	1.83	1.52	0.92	1.07
Blade	0.99	0.41	0.36	0.34
Delays*	0.61	0.50	0.30	0.32
Total	13.05	11.82	11.29	10.75

* Minor production delays, e.g. personal time, talk to supervisor/researchers etc.

Notes :

1. Pieces hooked on	6.2	6.8	4.8	6.0
2. Mean haul distance	71	91	122	98
3. Drag Volume, m^3	1.52	2.20	1.47	1.44
4. Number of cycles	31	36	36	38

It should be noted that piece size extracted to the landing and piece size quoted earlier in cutter productivity do not necessarily correspond. That is a function of the particular area where the fallers were working during the study and the fact that only a small number of samples were collected. Piece size extracted, on the other hand, was collected for each drag extracted so therefore is a more accurate data base. There was also substantial piece size variation within the stand.

Substantial load size increases are evident from the butt pull area - 2.20 m3 from organised versus 1.52 m^3 from conventional. In the butt pull areas the results confirm the expected benefits of organised felling. The better presented wood allowed more pieces to be hooked on in a shorter time and to be more easily 'broken out'. Less blading was also required to clear the haul path and assemble drags. The increased travel loaded time from organised felling was a result of the longer haul distance and heavier drag volume.

In the head pull area the benefit from organised felling was again shown in hooking on more pieces in a shorter time, but breakout and blading times were not significantly different.

The similarity between the drag volume and cycle times shown for the head extracted areas indicated that under head pull conditions extraction was machine limited. Substantial increases in the drop and winch element were observed. Organised felling for head pull extraction can result in the heads of the logs being too easy to hook on. The machine operator is then tempted to put on more than the machine can easily extract. The concept needs to be further tested under different conditions, ideally using a larger capacity machine.

There was a disappointingly high use of the machine blade during the extraction of the organised felled areas. It was felt that often the use of the blade was unnecessary and it was only used because it was there.

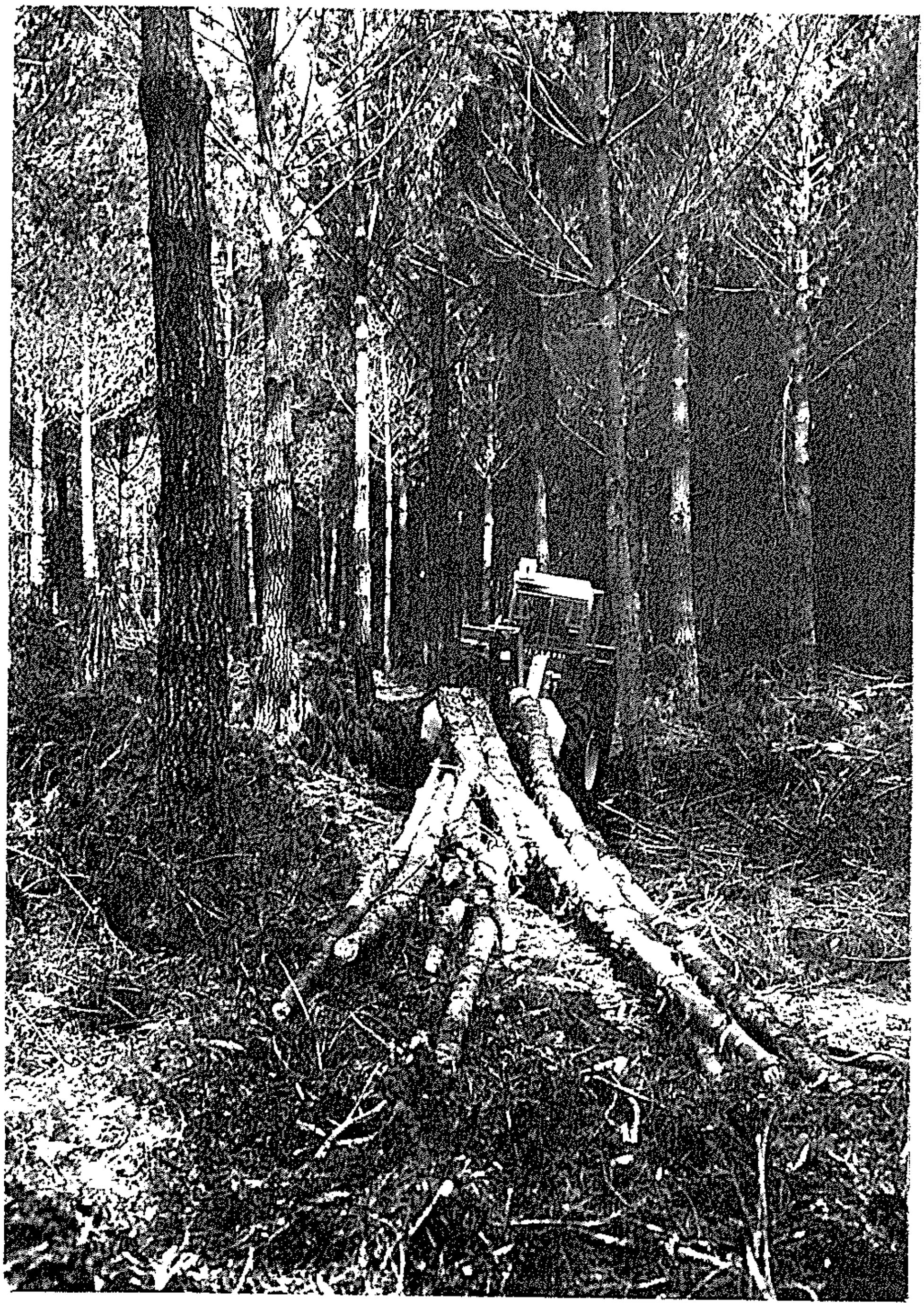


Fig 29 - Iwafuji SKidder with Full Drag from Organised Felling Butt Pull Area

6. ORGANISED FELLING EFFECT ON COST PER CUBIC METRE

Two key points have come to light in the last two sections

- faller productivity in one trial was substantially reduced, with an increase of 66% in the time to prepare each cubic metre. This indicates the need for an extra faller.

- Machine productivity, by contrast, is substantially increased.

In this section the cost effectiveness of organised felling is examined. Costs are derived using a computer program (Gaskin, 1983) based on the LIRA Costing Handbook (Wells, 1981). The computer printouts of the machine costs and labour costs are included in Appendix V. Current prices (early 1985) for the various machines have been supplied by the distributors.

6.1 Igland Hauler

The conventional gang size and structure was :

- 2 fallers
- 1 machine operator
- 1 breakerout

Equipment consisted of the Igland hauler, gang transport vehicle and three or four chainsaws. The production was 18 m^3/day, allowing for shifts and smokos. The change suggested was to employ an extra faller after which it was anticipated productivity would increase to 26 m^3/day, again allowing for shifts and smokos.

Table 14 summarises costs and productivity of the two systems.

Table 14 - Production and Cost Estimates for Igland Hauler

	Conventional Felling		Organised Felling	
Haul distance, m	150		150	
Haul volume, m^3	.37		.45	
Cycle time, min	6.22		5.65	
Add 10% to cycle times to allow for minor operational delays, min	6.84		6.21	
Productivity, m^3/5.5PMH/day	19.63		26.28 (34% increase)	
<u>Costs $/day</u>				
Fallers and saws (1)	207	(2 men)	311	(3 men)
Machine Operator (2)	104		104	
Breakerout (3)	104		104	
Igland Hauler	104		104	
Incidentals, transport	120		120	
Total	639.00		742.00	
Unit cost, $/m^3$	32.50		28.20	

Note : (1) The faller has been costed at $88.66/day plus an allowance of $15.00 for owning a chainsaw.
(2) A chainsaw at $15.00 has been included with the machine operator.
(3) A chainsaw allowance has been added to the breakerout.

The increase in production achieved through organised felling, even though an extra faller had to be employed, resulted in a cost/m^3 saving of $4.30 or 13%.

6.2 Iwafuji Skidder

The conventional gang size and structure was :

- 2 fallers
- 1 machine operator

This situation was also unusual in as much as a Bell logger was used for approximately two hours per day to fleet the wood extracted. Thus the skidder was extracting all the time, rather than fleeting logs at the landing - a job at which it is not efficient.

It was considered that for organised felling three fallers should be used. No other changes were considered necessary.

Table 15 below summarises the production cost estimates of those two gang structures. The table indicates costs for the four different types of extraction tested.

Table 15 - Production and Cost Estimates for Iwafuji T30 Skidder (Using a 100 metre average haul distance*)

	Conventional Felling			Organised Felling		
	Butt	Head	Combined	Butt	Head	Combined
Haul distance, m	100	100	100	100	100	100
Haul volume, m^3	1.52	1.47	1.5	2.2	1.4	1.8
Cycle time, min	13.93	10.98	12.45	12.05	10.48	11.27
Add 10% to cycle times to allow for operational delay, i.e. cycle time, min	15.32	12.07	13.69	13.0	11.52	12.38
Productivity, m^3/7PMH day	42	51	46	70 (67% inc.)	51	60 (30% inc.)
<u>Costs</u> ($/day)						
Fallers and saws		207 (2 men)			311 (3 men)	
Machine Operator and Saw		104			104	
Iwafuji Skidder		211			211	
Bell (20% of 147.06 plus 88.66)		47			47	
Incidentals, transport		120			120	
Total		689			793	
Cost, $/m^3$	16.40	13.50	15.00	11.30	15.50	13.20

The resulting estimated unit cost showed that :

- In butt pull organised felling resulted in a 30% reduction in logging costs
- In head pull organised felling resulted in a 13% increase in logging costs. This was due to the machine being limited to 1.5 tonne drag while head pulling.
- The combined results of both butt and head pull showed a 12% reduction in logging costs from organised felling.

* Based on the following regression equations :

Travel unloaded = 1.29x + 0.006 (r^2 = 0.80)
Travel loaded = 0.56x + 0.018 (r^2 = 0.86)

7. IMPLEMENTATION OF ORGANISED FELLING

No development is complete until such time it has been incorporated as part of every-day practise. To date that, unfortunately, has only occurred in one instance - the Igland hauler operation at N.Z. Forest Products Limited. A comment often passed by logging managers when discussing the possibilities of organised felling is that the return is not sufficient to be "bothered with the investment in training required". That comment is, unfortunately, typical of the New Zealand scene where the preference seems to lie with investigating expensive machinery with which to replace men. It seems to be further assumed that this machinery would be operated by machine operators with little or no training.

The transition from conventional to organised felling with the Igland hauler proved a relatively painless exercise. The contractor decided he wanted wood presented as had been demonstrated during the study. Both his fallers were told that if they felled conventionally they would have to break out their own wood the first time they reverted, and if they did it a second time the wood would not be extracted. The contractor also changed his payment method to a piece rate system (so many dollars per tonne extracted). In this situation each cutter's wood could be kept separate.

Both fallers spent a day watching a LIRA researcher carry out the organised felling technique, and Jim Thomasen, of N.Z.F.P.'s training group spent two days with them. It was remarkable how quickly the technique was picked up by the fallers.

A more recent example was where a logging manager was assisting a post thinning operation during weekend work. The first line cut was conventional, i.e. everything buried by slash. Two other fallers using the organised felling were working alongside him. On completion of a line he was told it was not up to standard and had it clearly pointed out where he had gone wrong. The second line he cut was as good as any done by the two proficient organised felling cutters.

Both these examples suggest that providing the faller has the basic skills required to operate a chainsaw efficiently, there is no problem in learning organised felling. Basically it only introduces two major departures - that of slash removal and careful directional falling. It does, however, require a commitment from the fallers, the contractor or employer, and the forest manager. Forest managers have to convince contractors that it is in their best interests to change and encourage experimentation or provide the contractor with access to a person skilled in organised felling to demonstrate the technique. The contractor must be able to see the advantages of such a change and be able to pass his enthusiasm on to his fallers. If his attitude if one of feigned interest to keep his logging manager happy, he iswasting everyones time. The faller must have the a willingness to try something different.

Interestingly enough, of those three groups of people, it has been my experience that the last, the faller, is the one most receptive to change. The other two groups are much more difficult because they are often too far removed from the physical problems of swinging on a chainsaw all day.

It is also essential that the gang's immediate supervisor should at least know the basics of the system so he can give assistance to the fallers if the fallers start having problems with any aspects.

Organised felling has been shown to be within the learning capabilities of those fallers working radiata thinning. Unfortunately findings remain based on a limited sample. There has been little interest from training groups with the exception of N.Z.F.P. Although not yet quantified, it is a technique that is ergonomically better which will mean that the expected working life of a faller could be extended.

8. CONCLUSIONS

Organised felling has been well tested over the past three years and in all instances has at least met expectations, often well surpassing them. In the author's opinion, (based on five years as a faller in radiata thinning), the technique is well within the learning ability of the average faller.

The key points of organised felling are listed below.

(i) The organised felling technique has been based on the recommendations of overseas consultants. Little change has been made to those techniques as they are considered to be the best currently developed.

(ii) Organised felling imposes on the faller a disciplined approach to preplanning and assessment. The technique involves :

- good directional felling to facilitate the easiest extraction;
- 100% delimbing;
- removal of slash from the section of the log to be hooked on, and placement of slash around crop trees to protect them during extraction.

(iii) With the introduction of organised felling, faller productivity showed considerable increases on steep country, due, it is suggested, to the improved environment. By contrast on flat or easy country productivity declined. An improvement of up to 21% in recovery of available volume was realised.

(iv) Organised felling led to significant increases in machine productivity. Hauler thinning productivity increased by 34% while skidder productivity showed increases of up to 67%. This machine productivity increase is attributed to the improved hook on, break out and unhook times which result from better presented material.

(v) Even with the addition of an extra faller to counter the possible reduction in faller productivity, the cost of a cubic metre stacked at the landing was still considerably less than for conventional felling. 15% and up to 45% for hauler and skidder cost respectively.

Organised felling has the potential to substantially reduce the onride cost of wood from production thinning in radiata. The technique will not be introduced overnight but the basic skills required to carry it out are already there. It now requires a firm commitment from loggging managers, supervisors, contractors and bushmen alike if the advantages are to be exploited.

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Appendix I

DESCRIPTIONS OF THE FELLING SYSTEMS

SCOOT FELLING

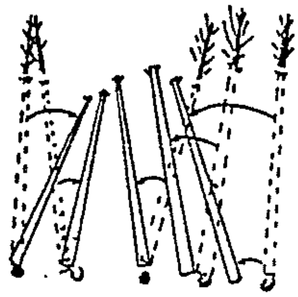


Diagram 1. In a strip 5 trees in width each of the trees are felled with their tips away from the centre of the strip. After snedding the tip is dragged to the centre and thus kept free from brush.

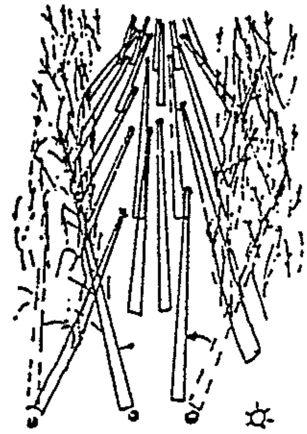
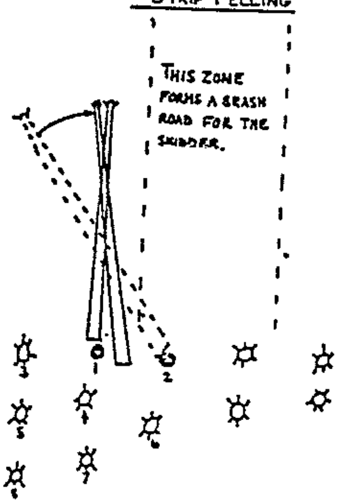


Diagram 2. As work proceeds some bench effect is gained using the butts of previously felled trees.

STRIP FELLING



)iagram 1. Tree No. 1 is felled down the axis of the ;trip and the top and brush cleared. Tree No. 2 is 'elled across No. 1 which now serves as a bench. ıfter snedding is completed No. 2 is pivotted and/or 'olled so that its tip is close to but still resting ın No. 1

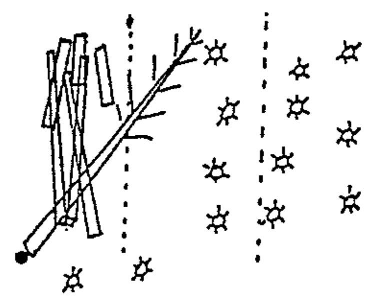
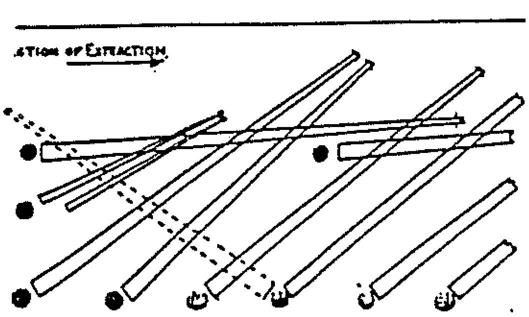


Diagram 2. When the top of this tree is close to the standing trees it is time to move into the other half of the strip.

FACE FELLING



iagram 1. Face felling with bench trees. Some rees may be moved to bring tips together to aid ıokering. The felling angle for butt first xtraction is shown in broken lines.

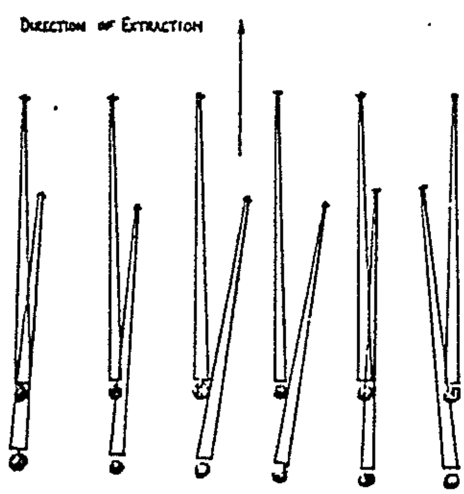


Diagram 2. The type of face felling generally practised in large dimension trees if done well can lead to high skidder outputs.

Appendix II

ELEMENT DESCRIPTION - Fallers

Walk and Select

This started after the faller had returned to the butt of the tree just trimmed, or after heading off a tree, started to move to his next tree. It ended when the faller started clearing the butt of his next tree. The element includes a certain amount of clearing undergrowth to enable him to move from tree to tree.

Clear Butt

Started when the faller moved into the tree to clear around it and the lower branches off the tree. Ended when scarfing commenced.

Scarf

Started when the faller commenced his top cut and finished when the scarf biscuit was removed.

Backcut

Started on the removal of the scarf biscuit and ended when the tree was on the ground, and included any delays incurred if a tree had to be pushed and cutting off the sloven. When a tree hung up it was noted and the backcut element ended at the point when the faller moved away to deal with the hangup.

Trim

Started when the faller commenced moving down the log after the backcut and finished when he moved off to his next tree. Includes walk back from heading off.

Clear Slash

This occurred only in the organised felling as part of the trim cycle. When the faller stopped trimmng and removed slash to when he started trimming again. It often occurred several times within each trim cycle.

Cross cut

Again occurring within the trim cycle and was simply the act of cross cutting logs to length. Heading off was not considered part of cross cutting but included in trim.

Manoeuvre

Only in organised felling - was where the faller physically manoeuvred cut logs from the edge onto the line or bunched two or three heads together. It started when he put down the saw and continued until he had finished manoeuvring or started some other task. Manoeuvre normally occurred on his return from trimming and heading off.

Diameter

This was taken off each tree trimmed and was measured at the stump.

Appendix III

ELEMENT DESCRIPTION - IGLAND HAULER BREAKEROUT ACTIVITY

Walk and select - move to the area where the next drag will come from and identify the likely pieces to make up the drag.

Wait out haul - stand clear of the moving ropes as the rigging is returned to the bush. Radio machine operator to stop lines. In most cases the breakerout was waiting for the whole of the time that the lines were moving, but occasionally he would be in the walk and select element while the moving rigging was still near the hauler.

Walk in - from when the line stopped moving to when the breakerout handled the rigging.

Pull rigging - after the breakerout first handled the rigging he would pull it to the vicinity of the logs to be attached before starting to attach individual strops.

Attach - attaching strops to the individual pieces which make up the drag. Some further pulling of the rigging was included within this element.

Move clear - after the strops were attached the breakerout moves clear before the lines start moving.

Wait clear - a fairly general element that could occur at any stage within the cycle. It applied where the breakerout was unoccupied and the hauler was not moving the rigging. The most frequent occurrence of this element was when the breakerout was waiting for the hauler operator to unhook the drag at the stack.

Wait in haul - when the breakerout waited clear of the moving ropes while the drag was hauled to the landing.

Clear slash and manoeuvre - this element most frequently occurred while the hauler operator was occupied unhooking at the stack. The breakerout would clear slash away from the pieces likely to make up the next drag and manually move some into a better position for attachment.

Pre Attach - time spent attaching strops before the rigging returned to the bush.

Untangle strops - from when the breakerout first held the strops to when they were untangled and ready for attaching.

Reattach - time spent attaching strops after logs had come loose.

Work at Stack - the breakerout would occasionally assist the machine operator with tidying up the log stack. This work was most likely to take place immediately before or after smoko breaks.

Appendix IV

ELEMENT DESCRIPTION - IWAFUJI EXTRACTION

Travel empty - started when the machine moved off after unhooking and continued until the machine positioned to the next drag to be attached. This element stopped when the machine operator actually dismounted.

Hook on - started when the operator dismounted and continued until he was again sitting on the machine, having attached the strops. Number of pieces attached was also counted at this stage.

Break Out - started when the operator was on the machine after hook on and continued until the drag was clearly broken out and pulled in behind the machine. The stop point for this was when the operator disengaged the winch control.

Travel loaded - commenced when winch was engaged and continued until the drag was dropped at the landing and the operator made to dismount and unhook.

Drop and winch - if during travel loaded the drag was released it was timed out from when the drag was released until when the drag was again up behind the machine and the winch disengaged.

Unhook - started when the operator made to dismount from the machine at the landing after travel loaded and continued until strops were pulled up into the fairlead. If the operator had to winch a log clear to get at a strop that was still considered part of unhook.

Blade - as soon as the blade was lowered it was timed out. That normally occurred in the bush either blading the haul path or pushing slash off logs, or pushing logs into bunches to ease hook on. It continued until the blade was lifted up.

Appendix V

VARIABLES USED FOR COSTING - MACHINE COSTING

MACHINE DAILY COST

VARIABLES USED :

IGLAND 4000/2 03-MAY-1985

COST OF MACHINE	= $30,000	RESALE VALUE	= $5,000
LIFE OF MACHINE IN YEARS	= 4		
PROD. HRS/YR	= 1200	PROD. HRS/DAY	= 4.5
RATE OF INVEST.	= 15%	INSURANCE	= 2%
FUEL CONSUMP.	= 4.5	FUEL COST	= $.773
OIL CONSUMP.	= .15	OIL COST	= $2.65
R. & M. FACTOR	= 75%		
STROP COST	= $147.24	STROP LIFE	+ 250

DRUM	SIZE/MM	LENGTH/M	COST/$	LIFE/HR	AV/HR
STRAWLINE	10	350	136.5	1200	.11375
TAILROPE	9	300	600	1200	.5
MAINROPE	11	150	417	1200	.3475

IGLAND 4000/2 03-MAY-1985

OWN COST/HR		OPERATING COST/HR	
DEPRECIATION	4.375	FUEL	3.475
RETURN INV.	2.57813	OIL	.3975
INSURANCE	.34375	TYRES	0
		MAINROPE	.96125
		STROPS	.58896
		R. & M.	3.28125
TOT OWN $/HR	7.29688	TOT OP $/HR	8.70744

TOTAL COST PER DAY = $104.028

VARIABLES USED FOR COSTING - MACHINE COSTING

MACHINE DAILY COST

VARIABLES USED :

BELL IN FIELD LOGGER 03-MAY-1985

COST OF MACHINE	= $55,000	RESALE VALUE	= $12,000
LIFE OF MACHINE IN YEARS	= 5		
PROD. HRS/YR	= 1500	PROD. HRS/DAY	= 7
RATE OF INVEST.	= 15%	INSURANCE	= 2%
FUEL CONSUMP.	= 5.9	FUEL COST	= $.773
OIL CONSUMP.	= .15	OIL COST	= $2.65
R. & M. FACTOR	= 100%		
STROP COST	= $0	STROP LIFE	= 0
MAINROPE COST	= $0	MAINROPE LIFE	= 0

BELL IN FIELD LOGGER 03-MAY-1985

OWN COST/HR		OPERATING COST/HR	
DEPRECIATION	5.13333	FUEL	4.5607
RETURN INV.	3.78	OIL	.3975
INSURANCE	.504	TYRES	1.5
		MAINROPE	0
		STROPS	0
		R. & M.	5.13333
TOT OWN $/HR	9.41733	TOT OP $/HR	11.5915

TOTAL COST PER DAY = $147.062