SESSION 3
Paper (a)

EXPERIENCES FROM THE FOREST RESEARCH INSTITUTE

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Introduction

The harvesting of smallwood has been both extensively and intensively researched since man came out of his cave seeking firewood. History shows the development from manpower to animals to the utilisation of the internal combustion engine. Now extensive research involving vast sums of money, is focussed on various combinations of manpower and horsepower to achieve acceptable cost levels for smallwood harvests. Systems have been designed - sophisticated machinery developed at great cost, however, the results have been disappointing. Inspite of all modern technology the high cost of smallwood handling remains. (1) The purpose of this seminar then must be to exchange views in a combined effort to minimise the costs of smallwood harvesting.

There is no one solution to the handling of smallwood. Smallwood harvesting will remain expensive relative to large wood harvesting. (2 By its very nature smallwood is difficult to aggregate into load sizes which will effectively defray the cost of the capital and labour used in the process. The more costly the elements of production become, be they labour or capital so will costs of small-wood increase.

The output arising from the inputs of capital and labour are not it appears of acceptable volume or value to the industries which rely on this type of wood supply. This must be the major reason for spending so much research effort and money on smallwood operations whose total production only amounts to 6.8% in 1986 to 3% in 2001 of the total cut. (National Planning Model). The gains from this effort must be small in the overall harvesting scene.

The significant components of production

Labour: In current motor/manual smallwood harvesting operations labour is required to fell and prepare the piece for extraction. Depending on the size of the extracted material and the size and cost of the extraction machine there are irreduceable levels of manpower required to ensure efficient use of the plant employed. (3) The balance between the cost of the labour and the cost of the plant is critical if costs are to be kept to the absolute minimum.

Sub-optimal labour input will lead to under utilisation of the plant component which in turn will lead to a production fall and a

higher than necessary cost of production. Excess labour will result in a greater level of production than can be transported by the machinery employed again resulting in a higher than necessary cost.

As manpower always comes in units of one the balancing of the logging crew over a range of haul distances is technically difficult. This can and has been avoided by separating the bush and extraction phases. This approach can lead to significant productivity gains through the prevention of interference at the breaking out element. It also ensures that the optimum haul size (number of pieces) is more readily available.

Labour is relatively inexpensive in New Zealand (4) by many overseas standards and it is a general rule of the thumb that machines should not be kept waiting for wood during their cycle, i.e. the operation should be machine controlled. This situation tends towards a safer working environment.

Capital: In logging operations this is represented by extraction machines, sorter/stackers, powersaws and crew transport plus ancillary equipment. Crew transport will not be considered, nor will the loading and cartage phase at this juncture. Low capital options have been the general choice in the past for handling smallwood. (5) The primary reason being that small piece size wood results in low production rates and therefore attracts high costs. One option to reduce the high cost is to reduce the capital input.

At the other extreme the highly mechanised and fully mechanised systems are an attempt to largely replace the labour component with capital. (6) Initially these options were introduced to defray the cost of smallwood handling. This approach has not been as successful as originally expected both overseas and in New Zealand. Emphasis has since moved from cost savings to worker shortages, worker protection and the assurance of an even wood supply. These latter factors are important considerations but are considerably removed from the original objective. The main reason for not meeting the primary objective is the high cost of capital and the fact that both machine productivity and manpower productivity are very sensitive to piece size.

Piece size: The critical factor in smallwood operations in both the bush preparation and extraction phase is the size of the piece of material to be processed. See Table 1. To add to the complexity, in thinning operation the pieces are unevenly distributed over the area to be harvested. The residual crop stems which should be protected from damage further complicate the aggregation of an optimum haul size.

Load aggregation: Breaking out is the element in the extraction cycle that is primarily concerned with load aggregation. It is this segment of time where unevenly distributed pieces of wood are drawn together to form a unit load and where individual pieces of wood merge into a haul volume.

In conventional long length thinning operations the individual pieces are secured by a strop which is then attached to the main cable on the winch. In many current operations the strops are permanently attached to the main rope - introducing some inflexibility into the number of pieces to be secured and extracted. This can lead to the transport of pieces to be secured and extracted.

The cost of capital in harvesting operations is recovered by charging a daily dollar rate for the equipment and this can be further subdivided to a cost/minute. Therefore every additional minute at the breaking out site inflates the cost of the operation if pieces are not being accumulated efficiently.

Method changes have been introduced to overcome the problems associated with load aggregation in smallwood. (7) The motor manual shortwood system is a good example of this. In this approach the bushman piles the billets of wood into heaps of near optimum haul size for the extraction machine (modified skidder). The breaking out element time is kept to the minimum by pre-stropping the load. This approach embodies the two principles of optimum haul size and minimum breaking out time. In some cases the modified skidder has been replaced by a self loading forwarder.

Pre-stropping and the employment of a specialist breaker-out were essential components of many logging crews in the 1960s. Both components are now difficult to find in today's smallwood harvesting operations. Pre-stropping has been largely replaced by ring mounted strops with the machine operator doing double duty as the breaker-out. The most common explanation given for this change is the cost of the additional strops required for pre-stropping and the cost of employing labour for breaking out. Both these arguments are debatable. Strops are costly but so is the waiting time for machinery. The greater the capital the greater the cost. Labour is expensive but so is the cost of sub-optimal load sizes. If further research was envisaged by FRI personnel it would be in this segment of the operation.

The use of grapples in smallwood operation was another attempt to overcome the time and cost of terminal times in the bush and on the landing. Early experience with grapples fitted to low capital cost machines (modified agricultural tractors) highlighted the difficulty of aggregating good payloads in long length thinning operations particularly where 2-3 pieces/cycle were required. Furthermore the low capital machinery resulted in low availability and utilisation

percentages due in part to the hostile forest environment and unsympathetic operator attitudes.

PREVIOUS FRI RESEARCH

Wood Preparation

Early work by the Harvesting Group at FRI was concerned with increasing productivity. Felling levers were imported to reduce the time consumption and heavy physical effort associated with hang-ups in felling in thinning operations. (8) The tool met with limited success.

To improve felling and trimming performance four light weight power saws in 48-55 cc range were purchased and tested in the field. These tests coincided with intensive research activity overseas, and growing concern for worker protection from Raynard's Phenomenon and hearing losses. Overseas industry demand for better power saws led to rapid improvements to the power saw, particularly in the European countries with a consequent spill-over of these benefits to the New Zealand industry.

Spring loaded tapes were also introduced into smallwood operations in the early 1970s and have gained some acceptance in the industry. (9) The tapes were relatively expensive and prone to breaking and these characteristics together with the time involved in their use retarded rapid and extensive acceptance.

Safety helmets featuring ear defenders (muffs) and eye protection were also introduced and tested extensively in the field by FRI personnel. The design and the modification (hole drilling) to secure the ear muffs were at variance with the then standards pertaining to safety helmet specifications and therefore met, understandably, at the time with little acceptance.

These approaches were promulgated to improve the productivity and increase the protection afforded to the bush worker. It should be noted that much of the foregoing equipment and approaches were more concerned with long term productivity gains through protection of the labour force from injury. However, in the short term they tended to they tended to inflate work cycles and therefore reduce production rates and increase costs. It is this syndrome that led to the slow acceptance of some of the approaches.

The use of spring loaded tapes could have led to more accurate measuring and cutting to length on the landing with a consequent increase in the value of the end product; but while as an industry we are preoccupied with production rather than value we are unlikely to see the rapid acceptance of approaches that reduce production rates. One of the most significant results from these various trials

and the background research was the lead time enjoyed by many overseas countries in machinery development and the manner of its introduction into the forest environment. (10) The benefits arising from this situation should be fully utilised; some modifications of overseas experience will be necessary to suit our conditions but certainly we should not dissipate our resources by unnecessary duplication of expensive research.

Machinery - Method development: Extensive trials were carried out in smallwood operations with a variety of low capital cost extraction machines. These include the Holder AG 35 Tractor; (11) the Drabant and the Matthews Mini Skidder. The objective of these trials was to develop harvesting methods in smallwood operations that minimised the cost of production through low investment and balanced gang strength. Results were mixed and though some cost reductions could be shown in the short term, important factors such as repairs and maintenance costs, availability and utilisation percentages were not established. Time however has shown that the low capital approach met with little acceptance in the Bay of Plenty region and the machines have virtually disappeared from the arena.

One of the most significant trials undertaken by FRI was the extensive testing of the Mercedes Benz (MB Trac) 4-wheel drive tractor. This machine featured twin winches which could be controlled from outside the cab through a remote control box. To complement the existing Mercedes Benz, quick attachment chokers were imported and teamed with polypropylene strops. A quick release system based on the British Forestry Commission development for their Hydrostatic Tractor was incorporated into the trials. (13) These developments together with the twin winch configuration allowed a high number (10-12) of pieces to be broken out each haul and the quick release pin reduced landing terminal times dramatically. The system required a large number of strops (20-24) and a skid worker to ensure a rapid turn round of the machine. The additional skid worker added to the cost of the operation, and unlike his British counterpart, manufacture to increase value was not possible, as virtually all our smallwood operations produce only low value pulpwood. An attempt was made to identify and cut post material from the tree lengths produced. This option proved to be feasible and would have helped defray the cost of the skid worker. The features of the Mercedes Benz and the work methods developed around it did not capture the interest of the forest industry and the system disbanded.

Highly mechanised systems: In the 1970s highly mechanised systems were introduced into New Zealand to clearfell unthrifty small piece size stands of Pinus ponderosa in Kaingaroa State Forest (14). The system intensively measured by the FRI Harvesting Group was composed of a feller/buncher, a chain flail delimber, and grapple skidders for the transport to the landing phase. As this system represented the first New Zealand attempt to

replace labour with capital the system generated considerable interest Work measurement over a 3-year period showed that although the highly mechanised approach had considerable potential to produce high volumes this was not achieved for several reasons. Firstly the availability and utilisation percentages of the system were below expectations. This led to reduced daily production and consequently inflated costs. Furthermore studies showed that the highly capitalised logging approach is very sensitive to piece size.

TABLE 1: PIECE SIZE/MACHINE PRODUCTIVITY RELATIONSHIP *

	Operation	Piece size (m^3)	Productivity (minutes/m^3)
A.	Selection thinning C 4 Skidder	0.22	9.83
		0.29	8.04
B.	Row thinning C 4 Skidder	0.22	9.32
		0.29	7.25
		0.36	6.31
C.	Downhill strip thinning Lotus Hauler	0.27	11.51
		0.40	9.86
D.	Clearfelling Pinus ponderosa Drott Feller/Buncher **	0.16	4.27
		0.23	3.01

* Based on selected FRI case studies, for a 480 minute working day

** Based on 67% utilisation

It would seem certain that the problems associated with highly capitalised systems in clearfelling will be present in smallwood thinning operations which tend to concentrate on the smaller trees within the stand. Added to this will be the restraints of machinery movement within the stand because of the residual final crop pruned stems and the need to protect these stems from damage. It is therefore extremely difficult to see high capital cost systems competing cost-wise with the "conventional motor manual system" without a radical departure from the selection thinning concept, and certainly not on more difficult terrain.

Observations in Australia suggest that some silvicultural principles are being modified to ensure that high cost harvesters can operate in first thinnings competitively. Comparable cost figures with alternative harvesting approaches are not readily available but it is evident that motor manual operators are not given the same degree of

latitude when undertaking the first thinning silvicultural operation. It was evident that in some cases the Australians are not having to protect and enhance a pruning investment as is the case in many New Zealand operations.

Cable logging: Cable logging operations producing smallwood will have a cost 65-85% higher than an equivalent operation on tractorable country. (15) What has been previously said about tractor operations applies equally to extraction thinning on cable country. The problems associated with small piece size such as load aggregation, low value product are further aggravated by a reduced productive day because of rope shifting times.

Organisations that are intending to production thin their steep country should be aware of the effects of increasing the capital invested without commensurate increase in productivity. Failure to elicit increased production must lead to direct cost increases.

Salvage operations: Little research has been carried out by FRI on the salvage of smallwood from cutover *Pinus radiata* stands, and what has been done has been restricted to tractorable country. (16) However the problems in this operation are those of other smallwood operations - small piece size, low value and the produce scattered unevenly over the cutover. The observed operation is similar to the shortwood system in thinnings. The pieces are prepared and stacked on the cutover for extraction to the landing by a modified rubber tyred skidder. The operation has now been stopped because of the cost and an alternative supply of cheaper wood. In some cases where the terrain is suitable and the lead distance to the processing plant short - the salvage of wood from the cutover may be a viable alternative to thinning operations on difficult country.

Re-organisation of the stand: The problem of load aggregation in smallwood harvesting led the FRI to establish extensive logging trials at Turangi, Rotoehu, Esk and Woodhill Forests. The objective is to concentrate the thinnings into pairs of rows, physically separated from pairs of final crop rows. The thinnings are to be removed before they affect the growth of the pruned final crop stems.

The first trial area logged is situated in Rotoehu Forest. (17) A contractor from NZ Forest Products Limited was hired to harvest the area using a "Wilhaul" cable machine. The results from work measurement indicate a productivity gain in the order of 15-30% when compared to similar operations harvested on an outrow/selection basis. This was achieved through raising the average number of pieces stropped/haul. The concentration of stems underneath the skyline was successful in enabling the breaker-out to increase the average haul volume.

Subsequent row thinning trials on tractorable country at Turangi showed less dramatic productivity gains (6-12% in comparison to the selection thinning option. Although improved load aggregation (30%) was recorded in the row layout the overall production gain was diluted as a percentage of the extended cycle time. In retrospect method changes should have been instituted to take better advantage of the concentrated layout of stems in the row thinning option. These method changes should have included some pre-stropping, a larger tractor than 60 kw used in the trial, which was considered with the ring mounted strops the most suitable available machine for the selection thinning option. Time and money did not allow these and other options to be tested such as a highly mechanised system or a clambunk skidder. None the less it is clear that this line of research is worth pursuing.

A productivity gain for this approach has been demonstrated. The effect of the row arrangement of the final crop trees and thinning element, is not fully understood. The effect of the strip arrangement on the final crop tree growth has not been fully measured. Some reduction in growth is possible but the degree to which it occurs and how much the increase in productivity in thinning and possibly clear-felling offsets any possible loss, is at this stage still being evaluated. A further important result from the Turangi trial was the achieved piece size (see Table 1) was greater than the critical size of 0.20 m^3 as Graph I shows. This is an important factor in the harvesting of smallwood, if a reasonable cost/m^3 is to be achieved. Further trials of this nature will be initiated in the late 1980s in areas specifically established to test the row felling option.

FUTURE FRI RESEARCH

Conclusions

1. Smallwood harvesting costs will remain high relative to the cost of largewood harvesting because the small piece size cause problems in aggregating on optimum haul size.

2. A large research effort to solve some of the problems associated with smallwood harvesting problems is taking place overseas. These developments should be monitored with a view to adopting/adapting pertinent developments into the New Zealand harvesting scene.

3. Increased inputs of plant and/or labour without corresponding increases in production will inevitably lead to increase in the cost of production.

4. Many aids to production have been introduced into the New Zealand logging scene to minimise the costs of production. Many have failed for a variety of reasons, but not because

they were unpromising. A detailed review of these is warranted with a view of reviving some of the more promising, e.g. the double winch option.

5. Were a production thinning operation considered essential some consideration should be given to reorganising the stand to make the cost of production more acceptable while protecting final crop values.

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