

SOME THOUGHTS ON EFFICIENT HANDLING OF SMALLWOOD

C. J. TERLESK, A. TWADDLE, and M. McCONCHIE*

ABSTRACT

The harvesting of smallwood of approximately 0.20 m³ piece size has been well researched but, in spite of all modern technology, the cost of smallwood handling is high and will remain expensive relative to largewood harvesting since smallwood is difficult to aggregate in load sizes which will effectively defray the cost of the capital and labour used in the process.

Research effort in New Zealand and overseas has been directed at improving the productivity of the labour and capital involved in smallwood production. Various labour production aids such as felling levers, spring-loaded tapes, and safety helmets incorporating ear-defenders have been introduced into logging in New Zealand, but many did not meet with success. Extensive trials have also been carried out on a range of low-capital-cost machinery (the Holder AG 35 tractor, the Drabant and the locally developed Matthews Mini Skidder) in an attempt to reduce the cost of smallwood harvesting. However, time has shown that the low-capital-cost approach has generally met with little acceptance in the Bay of Plenty region and the machines have virtually disappeared from the scene. A technically significant trial was conducted using a Mercedes Benz twin-winch and 4 wheel-drive tractor but, although the system developed around the machine showed considerable promise with handling of small-piece-size, the approach did not capture the imagination of the industry at the time and the system disbanded.

Highly mechanised systems introduced into New Zealand about 1976 aimed at replacing labour with capital and reducing the delivered cost of smallwood. Low availability and utilisation percentages and sensitivity to piece size resulted in unacceptable cost of production and these systems, too, have been disbanded.

A fundamental problem in the handling of small piece size is load aggregation. In an attempt to ameliorate this problem, the Forest Research Institute Harvesting Group established extensive logging trials throughout the North Island in which the thinnings were concentrated into pairs of rows physically separated from

*Forest Research Institute, Rotorua.

pairs of final-crop rows. The thinnings were to be removed before they affected the growth of the pruned final crop stems. Worker measurement in three of the trial areas indicated significant productivity gains (15-30%) in the one cable system trial. Results on easy terrain, however, have not been as clear, although a productivity increase of 6-12% over conventional selection thinning was demonstrated.

The concentration of thinning stems to improve load aggregation in small-piece-size operations shows some promise where production thinning is considered essential. The effect of stand rearrangement of final-crop growth and values has not been established, however, and these critical factors must not be ignored in the effort to produce low value pulpwood at less cost. Much research effort has been directed at reducing the cost of smallwood harvesting, particularly the production thinning options, and some cost savings have been achieved, but inevitably at some sacrifice of final-crop values.

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 animalpower to the internal combustion engine. Today, extensive research, involving vast sums of money, is focused on various combinations of manpower and horsepower to achieve acceptable cost levels of smallwood harvests. Harvesting systems have been designed and costly sophisticated machinery developed. The results have been disappointing. In spite of modern technology the cost of smallwood handling is high (Morrison and Trent, 1979) and it will remain expensive relative to large-wood harvesting (Terlesk, 1980) since 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), the more the costs of smallwood increase.

The output arising from the inputs of capital and labour is not 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 will amount to only 6.8% of the total annual cut in 1986 and 3% in 2001 (N.Z. Forest Service, 1977). The gains from this research 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 irreducible levels of manpower required to ensure efficient use of the plant employed (C. Terlesk and K. Walker, unpubl. data). The balance between the cost of the labour and the cost of the plant is critical if overall 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 fall in production and a cost that is higher than necessary. 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 optimising of logging crew numbers to suit a range of haul distances is technically difficult. This problem can be and has been avoided by separating the bush preparation and extraction phases — an approach which can lead to significant productivity gains through the prevention of interference at the load aggregation point. It also ensures that the optimum haul size (number of pieces) is more readily available. Labour in New Zealand is relatively inexpensive (Terlesk, 1977) by many overseas standards and it is a general rule of 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, sorters/stackers, powersaws, and crew transport plus ancillary equipment. Crew transport will not be examined in this paper, nor will the loading and cartage phase. Low-capital options have been the general choice in the past for handling smallwood (Terlesk, 1977), the primary reason being that small-piece-size wood results in low production rates and therefore attracts high costs. Thus, one option to reduce the high cost is to reduce the capital input.

At the other extreme, the highly mechanised or fully mechanised systems are an attempt to replace the labour component with

capital (Terlesk, unpubl. data) 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 of lower costs. The main reason for not meeting this 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

TABLE 1: PIECE SIZE/MACHINE PRODUCTIVITY RELATIONSHIP*

	<i>Operation</i>	<i>Piece size (m³)</i>	<i>Productivity (min/m³)</i>
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 <i>Pinus ponderosa</i> 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.

in thinning operations 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. Unevenly distributed pieces of wood are drawn together to form a unit load and individual pieces of wood merge into a haul volume.

In conventional long-length thinning operations, the individual pieces are secured by a wire 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 sub-optimal haul sizes. The cost of capital in harvesting operations is recovered by charging a daily dollar rate for the equipment and this can be further subdivided into a cost per 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 (Terlesk, unpubl. data). A good example is the motor/manual shortwood system in which the bushman piles the billets of wood into heaps of near-optimum haul size for the extraction machine (modified rubber-tyred skidder). The breaking-out time is kept to the minimum by a major Bay of Plenty operator by pre-stropping the load. This approach embodies the two aims 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 are 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 length 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 two to three pieces per cycle were required. Furthermore, the low-capital machinery resulted in low availability and utilisation percentages owing in part to the hostile forest environment and unsympathetic operator attitudes.

EARLY FRI RESEARCH

Labour

Early work by the Harvesting Group at Forest Research Institute was concerned with increasing labour productivity. Felling levers were imported to reduce the time consumption and heavy physical effort associated with hang-ups in felling in thinning operations (Terlesk, 1974a). The tool met with limited success.

To improve felling and trimming performance, four lightweight 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 Raynaud's Phenomenon and hearing losses. The demand for better power saws by overseas industries led to rapid improvements, particularly in 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 gained some acceptance in the industry (Terlesk, 1974a). 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, 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 inflate work cycles and therefore reduce production rates and increase costs. This 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 (Terlesk, unpubl. data). 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.

Capital — Attempts to Overcome Piece-size Problems

Extensive trials were carried out in smallwood operations with a variety of low-capital-cost extraction machines. These included the Holder AG 35 Tractor (G. Muir, unpubl. data), 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 has 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) four-wheel drive tractor. This machine featured twin winches which could be controlled from outside the cab through a remote control box. To complement the characteristics of the Mercedes Benz, quick-attachment chokers were imported and teamed with polypropylene strops. A quick-release system based on a British Forestry Commission development for their Hydrostatic Tractor was incorporated into the trials (unpubl. data). 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 turnaround of the machine. The additional skid worker added to the cost of the operation and, unlike the British situation, subsequent processing 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 (unpubl. data). 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 of 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. First, 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 was very sensitive to piece size (Table 1).

It is 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 on 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 the 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. Cost figures comparable 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 too that in some areas the Australians are not having to protect and enhance a pruning investment as is the case in many New Zealand operations.

Other Harvesting Operations

Cable logging: Cable-logging operations producing smallwood will have a cost 65-85% higher than an equivalent operation on tractorable country (Terlesk, 1980). What has been said previously 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.

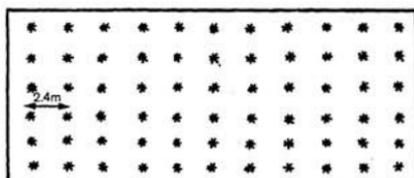
Salvage operations: Little research has been carried out by FRI on the salvage of smallwood from cutover *Pinus radiata* stands, and what has been done has been restricted to tractorable country (Terlesk, 1974b). However, the problems are those of other smallwood operations — small piece size, low value, and the produce scattered unevenly over the cutover. The observed operation is similar to the shortwood system in thinnings. The pieces are manually prepared and stacked on the cutover for extraction to the landing by a modified rubber-tyred skidder. The operation has now been stopped because the cost is high and there is a supply of cheaper wood available. However, 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 cable country.

Early Re-organisation of the Stand — A Piece-size Load-aggregation Solution?

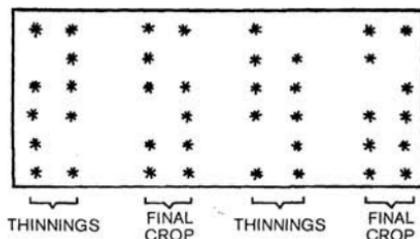
The problem of load aggregation in smallwood harvesting led the FRI to establish extensive logging trials at Turangi, Rotoehu, Esk, and Woodhill Forests. The objective was to concentrate the thinnings into pairs of rows, physically separated from pairs of final-crop rows (Fig. 1). The thinnings are to be removed before they affect the growth of the pruned final-crop stems.

The first trial area is situated in Rotoehu Forest (unpubl. data). A contractor from N.Z. Forest Products Ltd was hired to harvest the area using a "Wilhaul" cable machine. The results from work measurement indicate a productivity gain of the order of 15-30% when compared with similar operations harvested on an outrow-selection basis. This was achieved through raising the average

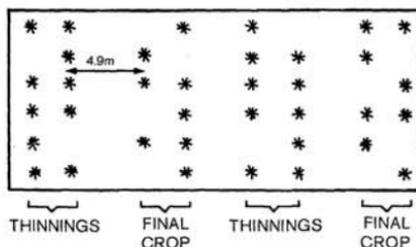
STAND AT AGE 0.
PLANTED AT 2.4m (8')
× 1.8m (6') SPACING.



STAND AT AGE 4. AFTER EVERY
3rd ROW REMOVED AND
SELECTION FOLLOWING LOW
PRUNING.



STAND AT AGE 7 AFTER
SELECTION IN FINAL CROP
ROWS FOLLOWING MEDIUM
PRUNING.



STAND AT AGE 11 AFTER
PRODUCTION THINNING. ALL
THINNING ROWS REMOVED
AND SELECTION IN FINAL
CROP ROWS.

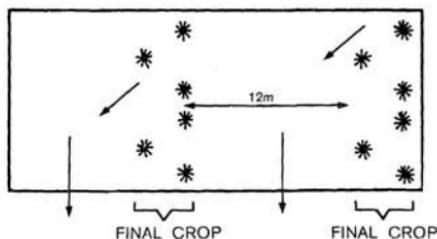


FIG. 1: Diagrammatic representation of crop layout.

number of pieces stopped per haul. The concentration of stems underneath the skyline was successful in enabling the breaker-out to increase the average haul-volume and load-aggregation efficiency.

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 and a larger tractor than the 60 kW used in the trial, which was considered with the ring-mounted stops the most suitable available machine for the selection thinning. Time and money did not allow for the testing of these and other options, such as a highly mechanised system or a clambuck skidder. Nonetheless, it was clear that this line of research is worth pursuing.

A productivity gain for this approach to the operation has been demonstrated, but the effect of the row arrangement of the final-crop trees and thinning element has not been fully examined. Some reduction in growth is possible but the degree to which it occurs and how much the increase in productivity in thinning and possibly in clearfelling offsets any possible loss, are at this stage being evaluated. A further important result from the Turangi trial was that the achieved piece size (see Table 1) was greater than the critical size of 0.20 m³ (Fig. 2). This is

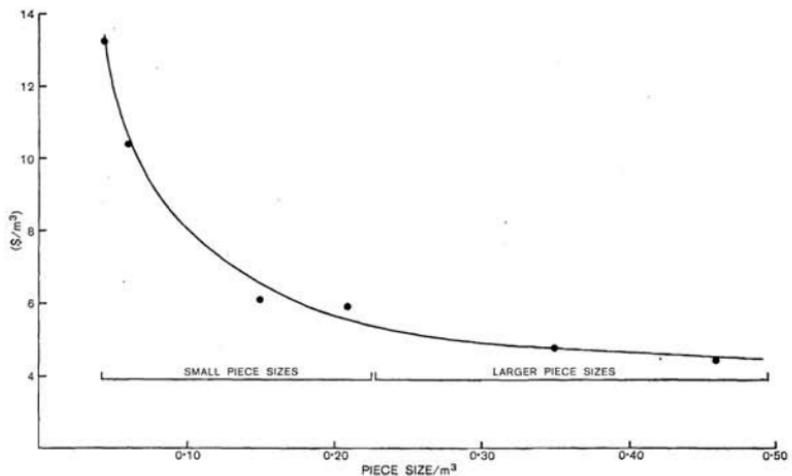


FIG. 2: Production thinning — *P. radiata*. Ground extraction — cost trend/m³ on landing 1977. Without — fleeting machine and operator.

an important factor in the harvesting of smallwood, if a reasonable cost per cubic metre is to be achieved. Further trials of this nature will be initiated in the early 1980s in areas specifically established to test the row-felling option.

CONCLUSIONS FROM EARLY FRI RESEARCH

- (1) Smallwood harvesting costs will remain high relative to the cost of largewood harvesting because the small piece size causes problems in aggregating an optimum sized haul.
- (2) A large research effort to solve some of the problems associated with smallwood harvesting is taking place overseas. These developments should be monitored with a view to adopting/adapting pertinent developments for New Zealand.
- (3) Increased inputs of plant and/or labour without corresponding increases in production will inevitably lead to increases in the cost of production.
- (4) Many aids to production have been introduced into New Zealand logging 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 to reviving some of the more likely — 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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