SESSION 7
PAPER (b)

ACCUMULATING SMALL PIECES IN LOGGING

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INTRODUCTION

The problem of an almost exponential rise in the unit cost of handling products, as the piece size of product being handled decreases, is common to materials handling in any industry.

In the simplest case, for a machine or system which handles a constant number of pieces per unit time, the output is directly proportional to the piece size handled, and the cost follows a hyperbolic function.

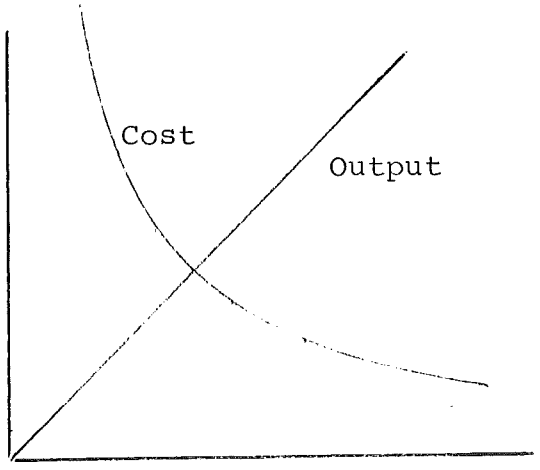
i.e.

$$\text{Output} = \{\#\text{ pieces per unit time (a constant)}\} \times \{\text{piece size}\}$$

$$\text{and Cost} = \frac{\text{Machine cost per unit time}}{\text{Output per unit time}}$$

This relationship is illustrated in fig. 1.

Fig. 1



The three main approaches to reducing the effect of decreasing piece size are:

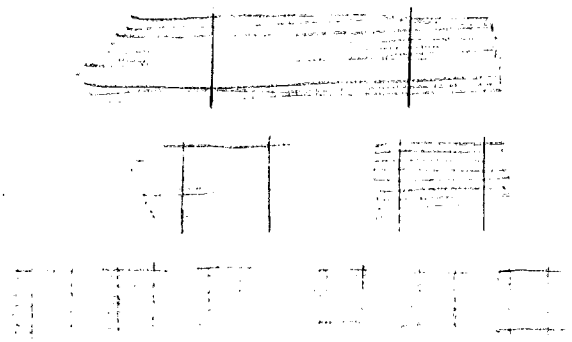
1. Reduce the system operating cost as much as possible by sizing the system to suit the piece size handled.

2. Reduce cycle times by improved system engineering and training and motivating operators

3. Accumulate a number of small pieces to form a larger unit load for further handling.

This paper examines the problems and methods of accumulating small stems in logging operations.

The beginning and end points of materials handling in the harvesting and loading phase are: the single stem on the stump measuring 0.1 to 0.2 tonne, and the truck payload of approx. 24 tonne consisting of 120 to 240 accumulated stems.



A large variety of methods of accumulating small pieces in logging are practised and some of these are outlined in table 1.

Table 1 Examples of Smallwood Accumulation in Logging

1.	Manual	- Shortwood, 1.2 to 2.4 m, hand carrying and stacking	
2.	Motor - Manual	- Bunching winches	- Nord for 'flying saucer' - O.S.U. pre-bunching winch - Rosin pre-buncher
		- Extraction winches	- Single drum plus chokers - Double drum plus chokers
3.	Mechanical	- Grapple bunchers	- Small grapple skidders - Bell Logger - Clam-bunk skidder - Forwarders
		- Feller-bunchers	- hydraulic boom type - front end loader type
		- Multifunction (including bunching)	- Kockums 875 processor - JD 743 - Koehring shortwood harvester - Windsor harvester

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1. Manual Accumulation

Most manual shortwood systems involve some degree of manual accumulation of the product by the cutter to improve the efficiency of the extraction phase.

The size of the stack of shortwood and its position relative to the extraction route is determined by the type of extraction machine.

A 50 to 70 KW skidder requires a stack of 1.25 to 1.75 tonne, conveniently placed so that the skidder can back right up to the stack. The stack must be placed on one or two runners to enable the winch cable to be passed around it. The manhours required to build a stack are strongly influenced by the stocking (in stems per hectare) of the trees being logged, the size of the stems and their product bolts, and the slash hindrance. Presented with such stacks, the skidder extraction phase is very efficient; with short terminal times to choke up and to unload the bundle of shortwood and a consistently-sized payload. Productivity is unaffected by stem size.

The productivity and cost of a typical shortwood system is

illustrated in fig. 2. The figure graphically illustrates the trade-off between the costs of accumulation (the cutting phase is separated into the fell, trim and top and the cut and stack operations) and the savings in subsequent handling.

Comparing the total cost curve with a true hyperbolic function indicates the effect the accumulation approach has had.

Forwarders require smaller stacks, normally sized to suit the crane and grapple capacity (0.5 t plus). Placement of the stack is less critical but must be within 4 to 5 m of the extraction route. As a result, accumulation for a forwarder is relatively less affected by stocking and conditions underfoot, and affords higher cutter productivity.

Forwarder productivity is affected somewhat by stem size since, as stem size drops, the distance between stacks increases and the forwarder spends more time moving while accumulating a load.

The productivity and cost of a manual shortwood/forwarder extraction system is shown in fig. 3. The increase in cutter productivity in building smaller stacks is mostly offset by the additional forwarder travel at smaller stem sizes as noted above.

In comparison with the manual shortwood/skidder extraction system the forwarder system shows a small relative advantage as stem size decreases.

Accumulating bundles of shortwood for a cable thinning operation was tried (LIRA, 1978) but the increase in extraction machine productivity was not sufficient to offset the cost of cutting and accumulating shortwood on steep slopes.

2. Motor-Manual Accumulation

Motor-manual accumulation includes the use of single or double drum winches, either independent bunching winches or winches attached to extraction machines.

Independent bunching winches such as the Nordfor "Flying Saucer" and the pre-bunching winch developed at Oregon State University for cable thinning are used to pre-bunch longer log products or tree lengths for more efficient extraction by a larger secondary extraction machine. These two types of pre-bunching winch pull themselves about using their own winch line. Radio control is an important feature in their productivity.

Pre-bunching winches mounted on a carrier, such as the Rosin buncher and the small extraction machines operating at Tumut, Australia, are also used.

The general principles of pre-bunching are that the pre-bunching unit must be low cost and work over short extraction distances, and that the main extraction machine is a high production unit, generally working over long extraction distances.

Fig. 2 PRODUCTIVITY AND COST -
Short Pulp Cutting and Skidder Extraction

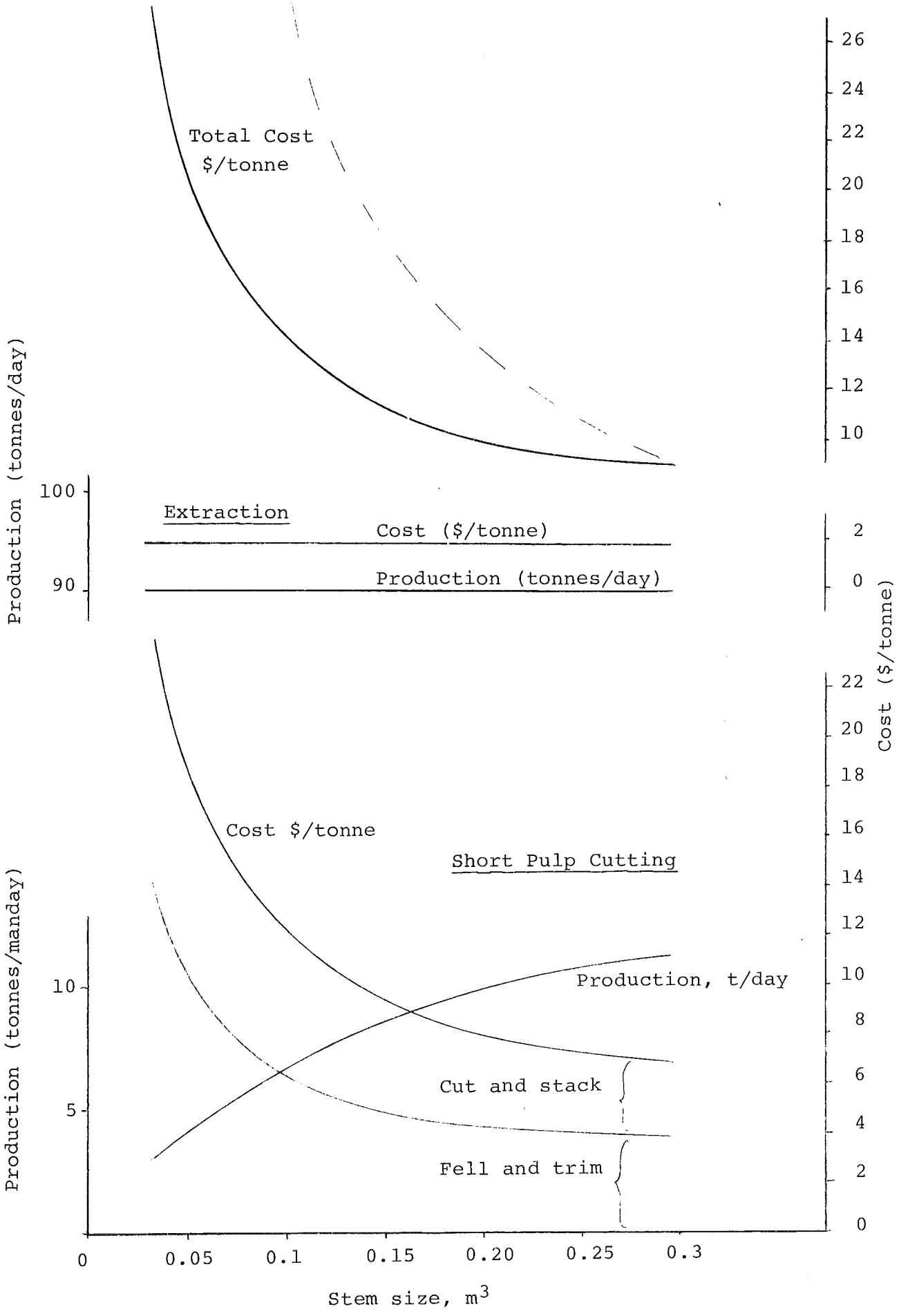
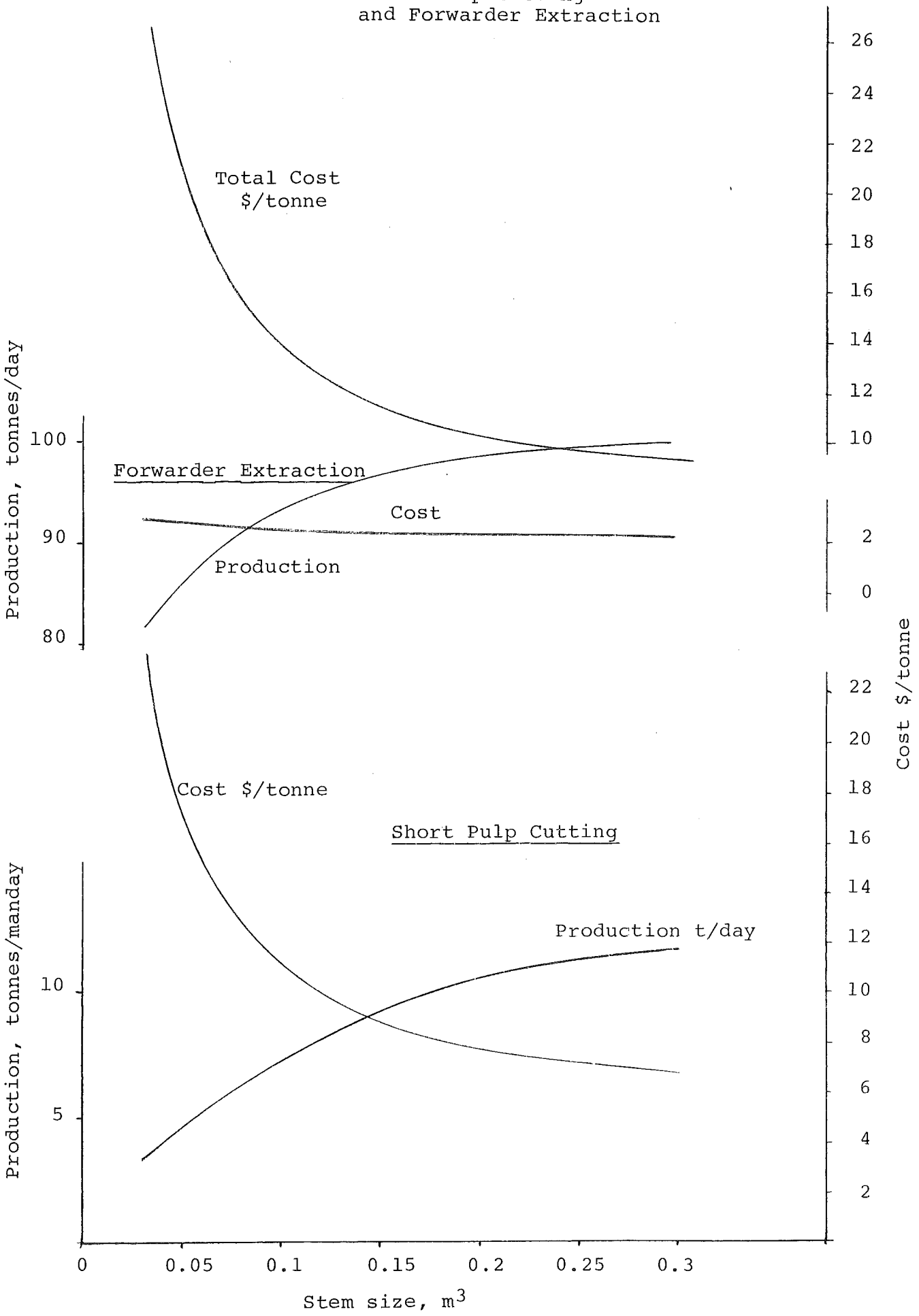


Fig. 3 PRODUCTIVITY AND COST
Short Pulp Cutting
and Forwarder Extraction



Single-drum winches mounted on the extraction skidder or crawler are of course the most common method of accumulating small stems in New Zealand. Six to eight chain or wire chokers can be used - more than 8 tends to cause tangling. Normally the extraction machine waits while the winch line is pulled out and the chokers set. This operation, although simple and straightforward, consumes ca 40% of the machine cycle time. Pre-setting chokers will reduce this time and generally improve the productivity of the bunching operation.

The productivity and cost of a manual felling/agricultural tractor extraction system is shown in fig. 4. The system is more sensitive to piece size than the shortwood systems examined. (This relative disadvantage will increase if the long length wood needs to be slashed before joining the shortwood in a drum debarker - since the productivity of slash-decks, fixed or mobile, is also very sensitive to piece size.) Closer analysis shows that the problem is in the limiting number of stems that can be hooked up. Above a piece size of approx. 0.15 m^3 the maximum average drag size that can be skidded by the tractor is the limiting factor. Below 0.15 m piece size the number of stems that can be hooked on is limiting and production becomes proportional to piece size.

Double-drum winches allow more stems to be accumulated behind the extraction machine and show a clear advantage when extracting very small stems.

3. Mechanical Accumulation

In mechanised harvesting operations accumulation of small stems is of utomost importance. Capital investment and hence fixed costs are much higher than in the manual and motor-manual systems, and handling of small stems one-by-one has unacceptable cost results.

In feller-bunchers for example, the first approach to accumulation in the felling phase was to add small arms to the single stem felling head to allow one or two additional trees to be collected in the head before swinging or manoeuvring the head to the bunch. This is generally as far as the hydraulic knuckle-boom type of feller-buncher has progressed due to weight restrictions on the felling head. With the front-end loader type of feller-buncher, however, there has been a recent trend to heads which can accumulate up to 12 small stems. The Rome accumulating shear recently demonstrated at FIME is a good example of this.

The evolution of small stem feller-bunchers and the resulting effect on productivity is outlined in Table 2 (Davidson).

Fig. 4 PRODUCTIVITY AND COST -
Felling and Long Length Extraction
with Agricultural Tractor

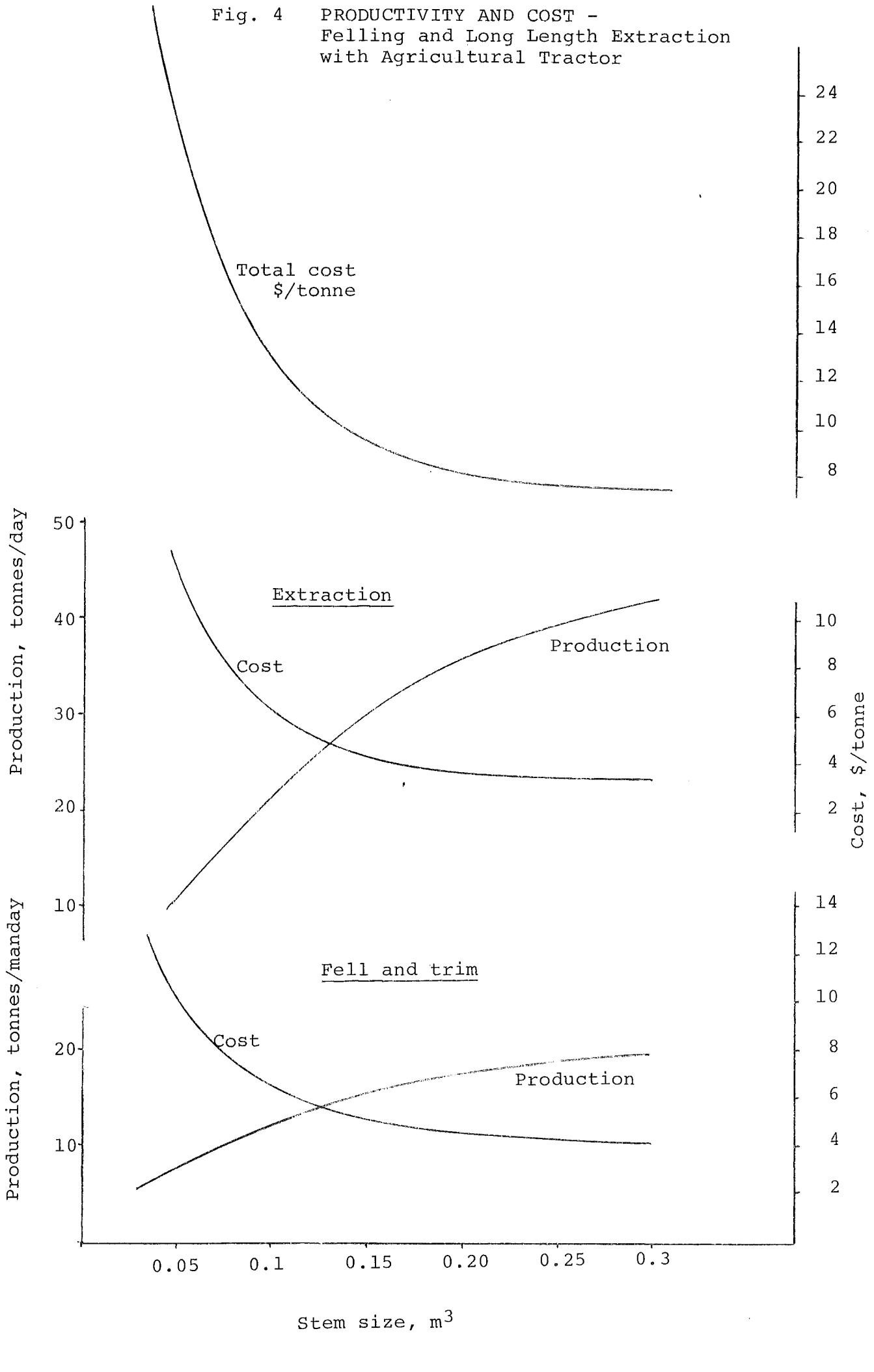


Table 2 Evolution of Feller-Bunchers for Small Stems

Feller-Buncher	Accumulating Capacity (stems)	Productivity (stems/sch.hr.)
Bobcat with Morbark Shear	2	55- 80
Bobcat with Allen BB Shear	4	70-100
JD 544 with Rome Shear	10	115-175
Hydro-Ax Swathcutter	12	150-280

The productivity of the JD544 with Rome accumulating shear is illustrated in fig. 5 against stem size (from Tufts, 1976). Comparison with the theoretical single stem handling production and cost curves shows how much progress has been made.

Grapple skidders and forwarders are further common examples of machines which mechanically accumulate stems or shortwood.

An interesting development in accumulating smallwood is the Bell Logger from South Africa. Originally used for handling sugarcane, this very simple machine is now used extensively in the forest industry for bunching, skidding, sorting and loading. The machine is well suited to accumulating small pieces either for extraction by itself or by a secondary machine (Taylor, 1978).

The development of very large feller-forwarders in Canada probably marks the ultimate in small stem accumulation to date. The Koehring Feller-Forwarder, for example, fells and accumulates a payload of up to 25 tonnes of full trees on its back before forwarding them out to roadside. Such machines are designed for clearfelling of small stems and forwarding long distances off-road and have no obvious application in New Zealand.

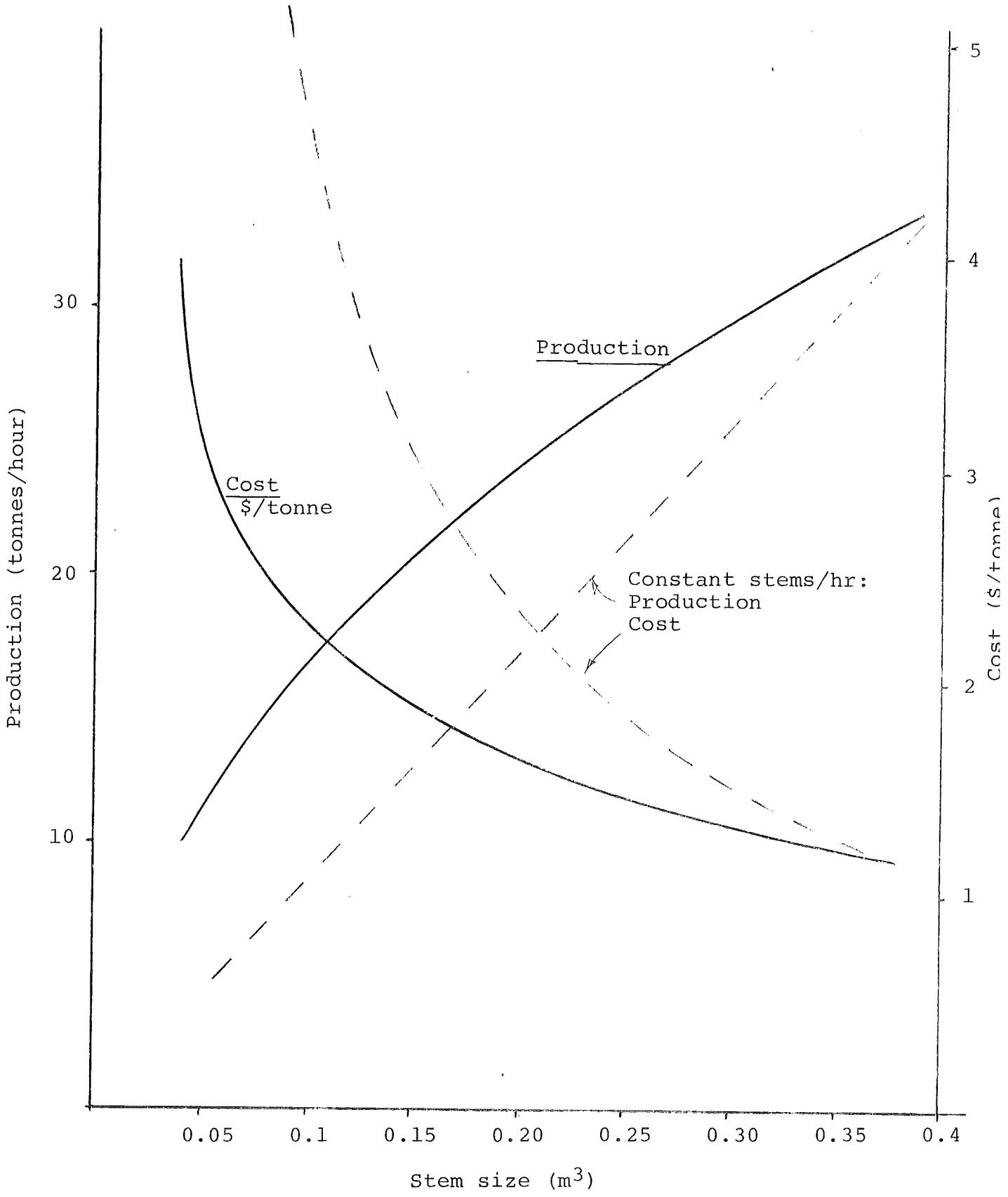
Probably the only machine concept with the potential to achieve a constant productivity regardless of stem size is the continuous shearing type of feller-buncher investigated by Newnham (1972) and others. In this concept the machine moves forward continuously and trees are sheared off and moved across the front of the machine to be deposited in windrows or bunches. Coupled with grapple skidders and flail delimbers, such a system offers perhaps the only hope of a harvesting system with productivity and cost independent of stem size.

Conclusions

Accumulating a number of small stems together in the stump area to make a larger unit load for subsequent handling has been an effective method of reducing the costs of harvesting small stems. In choosing a system, the costs of accumulating stems must be weighed against the efficiencies of subsequent handling.

On a stump to chip basis, shortwood systems, with manual accumulation at the stump, appear more likely to contain the costs of logging very

Fig. 5 Productivity and Cost: JD 544 plus ROME ACCUMULATOR SHEAR



small pieces (less than 0.1 m^3) than long length extraction.

The development of accumulator heads for feller bunchers has made considerable progress in recent years. However, much of the benefit of bunching whole trees will be lost if stems need to be singly handled in subsequent delimbing and/or processing operations.

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