FACTORS INFLUENCING MACHINE PRODUCTIVITY

Some New Zealand Experience

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Introduction

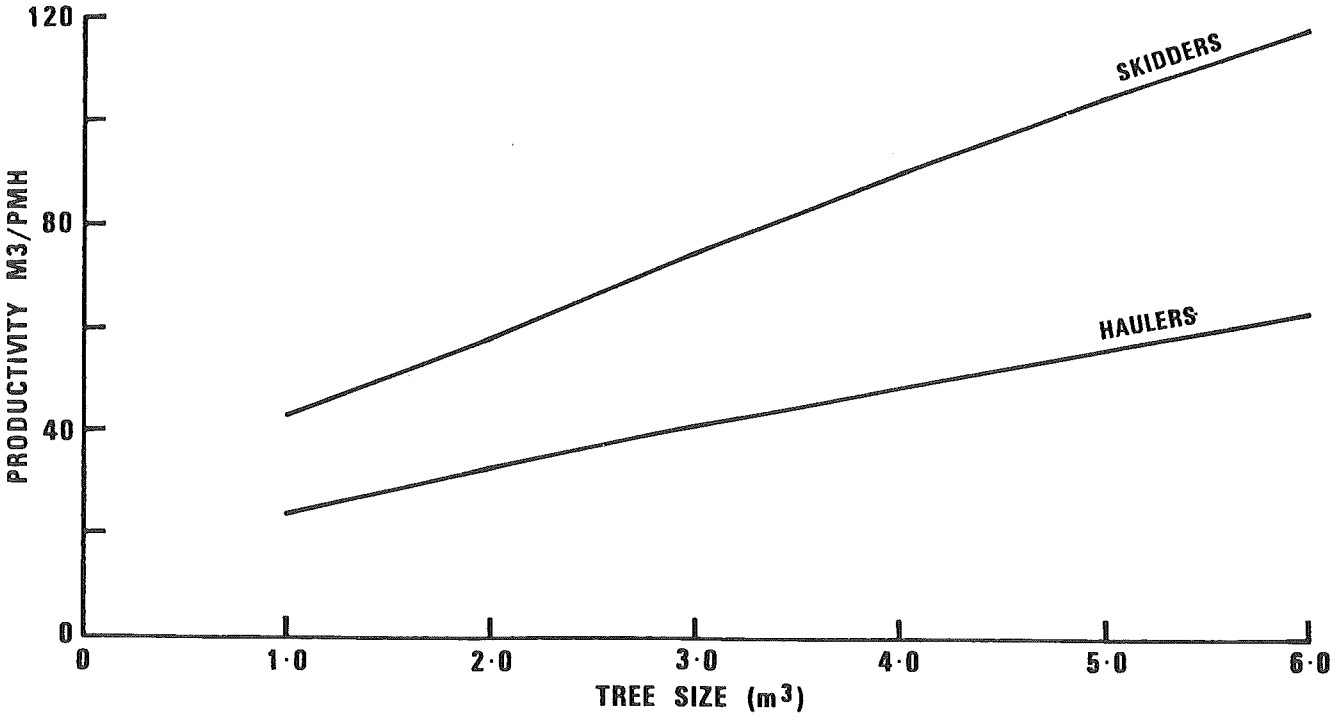
One of the main problems facing the logger is the estimation of a realistic rate of production. Knowing what level of productivity is possible from various combinations of manpower and machinery under differing circumstances is also a problem. The objective should always be to maximise the potential of these factors of production. The logger is never in complete control of the situation and there are always other factors which must be considered and will influence the course of action taken. Invariably several major factors have already been decided over which the logger has little apparent control; e.g. tree size; the road route.

This paper comments on some of the main factors affecting machine productivity. It also attempts to encourage logging operators/managers to pursue actively greater productivity through an awareness of the magnitude of these influences. The term productivity in this paper is defined as the volume of wood handled per productive machine hour (m^3/PMH).

Tree/Piece Size

Recoverable tree volume is one of the criteria often measured by forest management when assessing the stand for logging. The effect of the tree size on productivity is severe, particularly in the smaller tree classes. Fig. 1.

FIG. 1 EFFECT OF TREE SIZE ON PRODUCTIVITY



The logger has no control over the tree size that is to be logged, therefore his expectations of production are based on his knowledge/records of his capability with similar wood. Knowledge of the productivity of various machine types in relation to tree size is vital to prevent overcapitalisation and high costs.

Although he cannot change the tree size, the logger can alter the piece size to be extracted after felling. This piece size directly affects the haul volume, which in turn dictates productivity (Table 1). Most logging literature cites haul volume as one of two main factors affecting productivity.

TABLE 1: Effect of Haul Volume on Productivity

	Hauler		Skidder	
Average Haul Volume (m^3)	3	6	3	6
Average Cycle Time (min)	6.80	7.45	5.66	6.25
Cycles per Hour	8.82	8.05	10.60	9.60
Productivity (m^3/PMH)	26.50	48.30	31.80	57.60

Ref. Data Bank HARPCE computer model

It can be seen from Table 1 that increases in haul volume more than compensate for the lower number of haul cycles per hour.

The effect of piece size is reflected by the number of pieces per haul, length of rope pulled out, breakout time, and unhooking time.

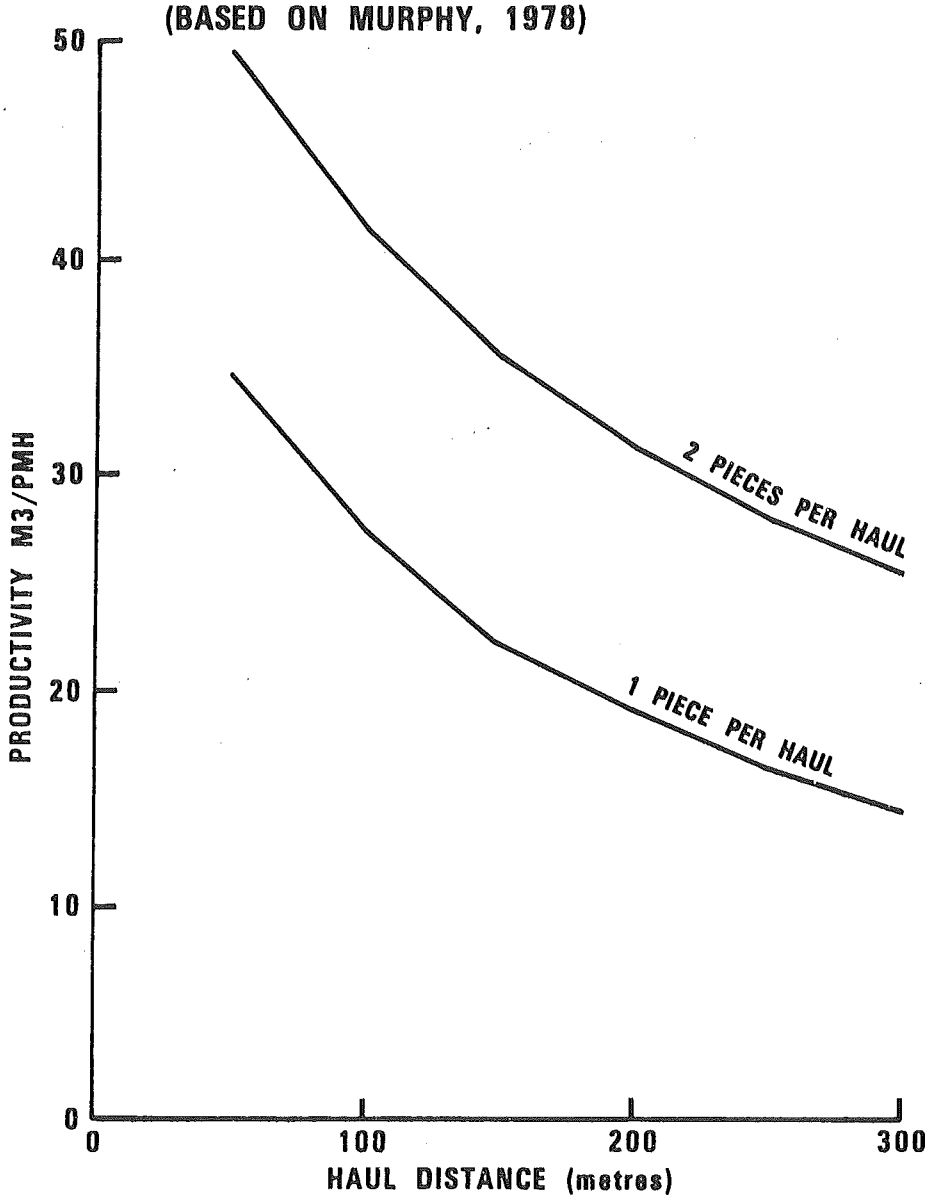
Of these the breakout element is the most time consuming, occupying approximately 20 to 40% of the extraction cycle, hence improvements to this phase of the operation are most productive. If the average piece size and/or numbers to be hooked on are increased then the haul volume increases. Some loggers attempt to reduce breakout time by reducing the number of pieces per haul, however, this tends to have the reverse effect on productivity.

Examples:

1. Productivity increased by 6 m^3/PMH for each cubic metre increase in haul volume on Westminster Skyline Hauler Operation (O'Reilly 1974).

2. An increase from 1.75 to 2.5 pieces per haul gave a productivity increase of 12% on a Timbermaster skyline thinning operation. (Twaddle, unpublished).

FIG. 2 EFFECT OF PIECES PER HAUL AND DISTANCE ON PRODUCTIVITY (BASED ON MURPHY, 1978)



All these indicate that tree size, piece size, and haul volume have significant effects on productivity. To take advantage of these gains we need to increase piece size to its maximum. Directional felling to reduce breakage, planning to ease extraction, and good supervision and training are the answer. Directional felling alone can give a 5% increase in piece size. (Murphy 1982, in press).

Haul Distance

Haul distance is the other most commonly cited factor affecting productivity.

The further the wood has to be extracted the lower the productivity.

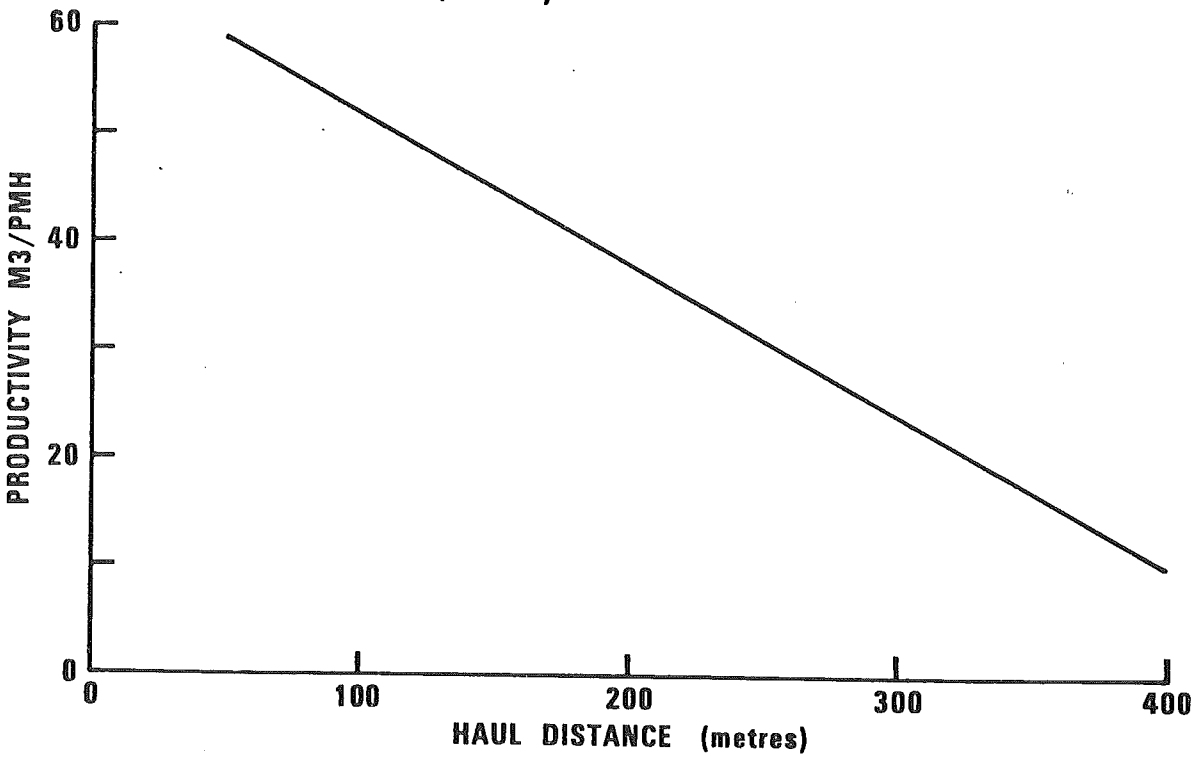
Logging planning from senior management down to the crew must be understood and used to ensure that haul distances are kept at optimum levels for the machinery being used. Too long a haul and productivity is lost through excess travel time, too short and it is lost through excess interference.

TABLE 2: Effect of Haul Distance on Productivity

	Hauler		Skidder	
Haul distance (metres)	100	200	100	200
Cycle time (min)	5.95	7.45	4.26	5.92
Cycles per hour	10.08	8.05	14.08	10.14
Productivity (m^3/PMH)	60.50	48.30	84.48	60.84
Difference %	25		39	

Ref Data Bank HARPCE computer model

FIG. 3 RELATIONSHIP BETWEEN HAUL DISTANCE AND PRODUCTIVITY FOR A WESTMINSTER SKYLINE (BASED ON O'REILLY, 1974)



Haul distance is often predetermined by forest management rather than by the operator. Management sets the roading/landing pattern, hauler sites, truck turnarounds, etc. Obviously long term planning of the overall logging area is important to achieve high productivity. Within the area, the operator can improve haul distance through planned location of felling faces, internal tracking patterns, use of profiles, landing layout, and location of tail holdings.

Human Factors

Probably the factors that most affect machine productivity, but are the most difficult to measure, are the training, experience, skill, and motivation of their operators.

Experienced operators tend to set their own pace, determined by their feel for the smoothness and control of the machine rather than its capability for quickness; i.e. the operator controls the machine not the machine the operator.

(a) Training

Training of operators is the subject of a separate paper, so the comments here will be brief.

Too often inexperienced people are ordered to do very demanding, high skill, high value operations in logging. For example, the owner who will not let his wife drive his new $15 000 car but lets the crew play around on a $100 000 logging machine. Interestingly enough, you seldom see a truck owner letting anyone near his truck. To improve machine productivity, training in machine operation, methods of using them, and methods related to the machine (e.g. breakout) are essential.

(b) Manpower

Assuming all the methods are correct, adding more manpower does not guarantee increased productivity. Only where the additional people reduce interference to the machine will its productivity be improved.

(c) Supervision

It is difficult to measure the effects of good supervision as they are usually camouflaged by other more obvious factors. The efficient supervisor not only ensures quality, safety, and general running of the operations, but is responsible for the use of correct methods and for maintaining motivation. Inefficient supervision leads to a downturn in the overall operation, low morale, and low productivity.

(d) Motivation

If the operator, or those responsible for keeping the machine busy, (e.g. skiddy) are not motivated then productivity drops. As with supervision the influence of motivation is difficult to measure. A highly motivated, well organised crew can produce 40% more than an average crew (Vari, unpublished). Some of this 40% will be from working longer hours, better team co-operation, and the organisation implied, but it gives a broad guide to the importance of motivation.

Repairs and Maintenance

A well maintained and serviced machine performs better than one made up of worn-out parts. Travel speeds, lifting capability, winching, hill climbing, and braking are all involved in determining productivity. A

reduced capability in any of these from poor maintenance or back-up services, will lead to reduced productivity.

Interference

Invariably when one visits a logging site one sees the productivity of the operation interfered with. For example, skiddies remain seated sharpening chainsaws so the tractor operator has to dismount to release the load, break outs wait for the machine to arrive before selecting logs, and loaders block off the extraction unit's access to the log dump area. The function of logging machines is to shift wood from A to B. Anything that reduces this can be called interference. It is a factor that is easily observed but with training, forethought, planning and co-operation from all persons connected with the operation much of it can be eliminated.

Two case studies with measured interference are:

1. Cable Hauler - Dispatch. 12.1% (one hour per day) of total hauler onsite time was taken up with interference. In productivity terms this represents an increase of 22% (10 m^3/PMH) if it was all eliminated. (Twaddle, unpublished).

2. Cable Hauler - Madill. This study of an experienced, motivated crew in two settings indicated possible productivity increases of 7% and 6% if all interference to the hauler was eliminated. (Murphy, unpublished).

Terrain

(a) Slope

There is little one can do to alter the general slope of the operational area, therefore it is important to select the system and equipment best suited to that slope class.

Example of choosing the wrong system for the slope:

	25° Slope	Level
Hauler	50 000 m^3	60 000 m^3
Skidder	30 000 m^3	73 000 m^3
Difference	-40 %	+22 %

Assuming that the correct system for the slope has been chosen, will changes of slope within the area affect the system's productivity? The answer is yes. With all logging systems slope affects breakout, safety, traction, and stability, therefore within any system the steeper the slope the lower the productivity. The amount of effect

varies, but for skidders a 2% reduction in productivity for a one degree increase in slope can be expected. What can we do about it? To reduce the impact of slope on productivity we can examine the methods being used and alter them where appropriate; e.g. directional felling, contour tracking.

(b) Obstacles

Rocks, guts, mounds, soil types, streams, and road surfaces are all variations of terrain obstructions and all reduce machine mobility. They have a bearing on what type of machine should be chosen and affect the capacity of those machines to maximise productivity.

Weather

Weather is an uncontrollable factor but, within reason, it is predictable. At worst it can halt all operations. The effect on productivity varies dependent on the type of weather (e.g. wind, dust, snow, ice, mud), but it can be reduced by forward planning of the work areas. Use of summer/winter blocks, different road gradients, prefelling for extraction, and prefelling landing edges for safety are some examples of methods which can be used to reduce the effect of weather.

Unexpected weather problems such as the recent windthrow in the Bay of Plenty may disrupt the flow of logging and reduce the productivity of experienced crews by 20 to 30%.

Methods

Marked increases in productivity can be obtained by incorporating flexibility into an operation. Adjusting from one method to a more suitable one will help to achieve this. For example, changing from highlead to a gravity hauling system gave a 15% increase in productivity with an Ecologger. (Peterson, unpublished).

Long term management changes can also affect productivity. Productivity gains of 30 to 40% with a hauler used to thin P. radiata were the result of changing the tree crop layout to permit a row thinning rather than selection thinning (Terlesk and Twaddle, unpublished).

Too often one system is adopted for use then maintained long after more productive systems have been proven or where slight modifications would be better. "Thats okay overseas, but N.Z. is different" often seems to be the philosophy behind this.

Safety

If the conditions for working around or with a machine are unsafe then crew performance deteriorates. This applies to safety factors that can be controlled such as truck stanchions, "spraggy" wire ropes, poor machine condition, and unsafe operator attitudes. Reduced performance leads to reduced productivity. Logging is recognised as a dangerous environment and the application of basic safety principles not only protects the workforce but gives better motivated, better thinking workers and increased productivity.

Summary

All the factors interrelate with one another rather than being easily identifiable. To maximise machine productivity requires an experienced, motivated, trained operator, supported by an equally experienced crew, operating well maintained equipment under organised, efficient, long and short term management.

It is not an impossible goal, but as an industry we have a long way to go before it is achieved.

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