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HUMAN FACTORS IN LOG MAKING

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Figure 1 - Log making in Tahorakuri Forest

ABSTRACT

Log making must often be carried out under conditions of high noise, extremes of temperature and in close proximity to large mobile machines. Analysis indicated that log making has a moderate to high physiological workload and that boredom (measured by a self assessment questionnaire) influenced log making ability.

INTRODUCTION

In most logging operations in New Zealand, log making is carried out under arduous and potentially hazardous conditions which are not ideal for inspection and decision making tasks. The development of the AVIS (Assessment of Value by Individual Stems) single stem optimisation model (Geerts and Twaddle, 1984) has enabled the study of decisions made by logmakers and estimates of financial costs associated with sub-optimal log making. Losses can occur for three reasons:

- errors in detection and classification of defects
- the selection of log combinations that produce sub-maximal values for each stem
- the failure to manufacture and sort logs as intended by the log maker.

Performance of quality inspectors has been studied in many other industries. McCormick (1970) cites examples that confirm mental performance declines with greater noise, degree and length of exposure to extreme temperature conditions, and time allowed to perform a task. Detection of defects by inspection has also been shown to decline with increased complexity of the task (Harris and Chaney, 1969). Log making is considered a "complex" inspection task with many elements requiring inspection and assessment to make a grade classification. Over and above the task of classification is the need to select the combination of log grades and lengths that will maximise total stem value.

Little research has been undertaken on the human aspects of work on landings which process numerous log types under busy conditions. The influence of human variability in log making was first established by Landerud, Lier and Oy (1973). Work by Murphy (1987) also demonstrated individual variation in logmakers' abilities, although a very small sample size (three men) was used.

This report investigates psychological and physiological aspects of log making in the "hot deck" situation under normal operational pressures.

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STUDY METHOD

Six clearfell logging crews were studied for two days each. The crews were chosen because they comprised loading machines and landing organisation representative of central North Island ground based logging operations.

Value Recovery

Log making ability of the logmaker was assessed at three times during the day (first or second drag of day, last drags before meal break and last drags of day). Trees to be assessed were felled, delimbed and measured prior to extraction. The stem was assigned grades depending on branch diameter, sweep, wobble, out-of-roundness and defects. Stems were then extracted to be made into logs at the landing. The logmakers' cutting patterns were compared with optimal cutting patterns calculated by AVIS and expressed in terms of total value. Selection of combinations of logs that are sub-optimal will produce a sub-maximal total stem value. Errors in detection and classification of defects, or poor manufacture will result in "upgrading" of logs. Upgraded logs are identified by AVIS and penalised different amounts depending on the reason for upgrading (sweep, length, diameter, or quality).

Boredom

At three times during the day, (before work, start of meal break and end of day) the logmaker's self assessment of boredom was estimated by the application of a

Table 1 - Description of operations and logmakers

Crew	Type of operation	Extraction machine	Landing machine	Number of log types made	Productivity (day1 & day2)			Logmaker
					Stems	Cycles	Volume (m^3)	Age (years)
1	Hot deck	Tractor and arch	Knuckle boom	9	156 138	29 29	290 268	30
2	Hot deck	Cable Skidder	Bell super logger	5	152 164	29 33	211 208	53
3	Hot deck	Tractor and arch	Knuckle boom	5	152 160	29 22	259 286	25
4	Hot deck	Cable Skidder	Rubber tyred loader	15	122 115	41 39	344 300	28
5	Hot deck	Cable Skidder	Rubber tyred loader	14	152 158	39 42	361 409	32
6	Cold deck	Grapple Skidder	Rubber tyred loader	11	264 220	NA	483 382	28

questionnaire. The questionnaire asked the logmaker to rate his level of boredom from 1 (interested) to 7 (bored).

Physiological Workload and Time Study

Physiological workload of log making under normal working conditions was estimated by recording the logmaker's heart rate at 15 second intervals throughout the day using a Polar Electro PE3000 heart rate monitor. Shaded dry bulb air temperature on the landing was recorded at 15 minute intervals. Work activities of the logmaker were recorded at 15 second intervals on to a Husky Hunter field computer using the SIFREQ program.

OPERATION DESCRIPTIONS

A range of operating conditions was selected for study to obtain a representative sample of common extraction and landing organisation types in ground-based operations (Strang, 1992) (Table 1).

RESULTS AND DISCUSSION

Value Recovery

Average ($\pm$ standard error) value recovery over all logmakers was 93.4 $\pm$ 0.5% (221 stems) and similar to value recovery reported by Cossens and Murphy (1988) on a simulated "cold deck" operation. There was high random variation between individual logmakers, days of the study and times of the day (Figure 2). No consistent relationships were found between value recovery and work rate (stems/hour), air temperature, log maker heart rate or time of day. Perhaps with a larger sample size significant relationship may be found, particularly for work rate.

Log makers knew when they were being assessed and were able to take particular care to ensure maximum value recovery. However, logmakers had to work at normal production rates and were not able to spend additional time making logs.

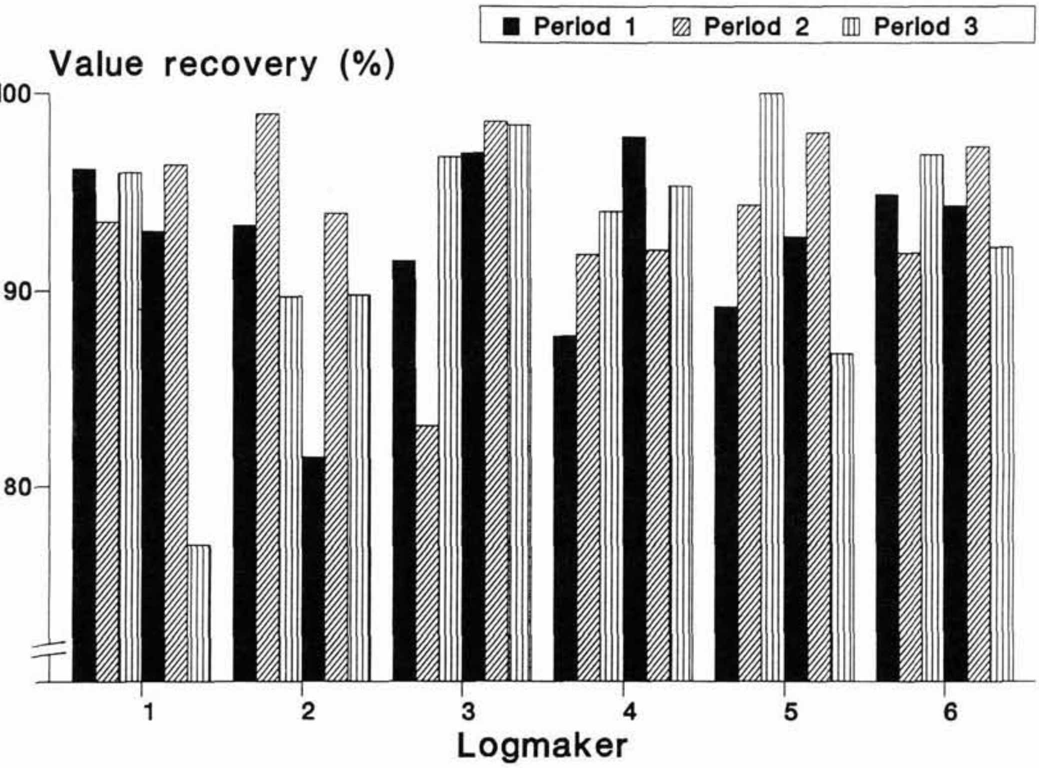

Figure 2 - Variation in value recovery of six logmakers assessed at three times each day over two days. Note the considerable variation in value recovery over the two days for some logmakers.

Value recovery exhibited a highly significant decrease of 6% for a 2 unit increase in boredom from 2 to 4, ($p<0.005$, Figure 3). Most of this decrease occurred from level 2 to 3 (1 interested, 7 bored). Therefore **a small reduction in logmaker boredom could result in a significant increase in value recovery**. Strategies to reduce logmaker boredom are presented later in this report.

The effect of the number of log types made on log making ability could not be determined in this study because production constraints made it impossible to study individual logmakers making few (4) or many (12-16) log types.

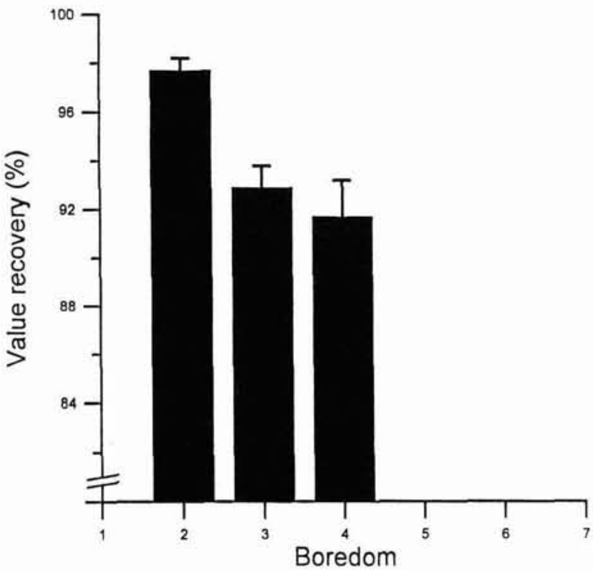

Figure 3 - Reduction in value recovery with increasing logmaker boredom. (Values separated by more than twice the height of the standard error bars are significantly different, i.e. boredom score 2 significantly different from 3 and 4).

Physiological Workload

The physiological workload of the log makers could be classified as "moderate to heavy", (average heart rate between 90 and 130 beats per minute). All logmakers used a chainsaw on the landing which would increase physiological workload. High air temperature on the landing also contributed to the physiological workload. Shaded air temperatures of 30°C were experienced on the landing and logmakers were exposed to full sunlight (so considerably hotter than 30°C). Shade (say, where the crew sharpen their saws) and cold water to drink would help to reduce workload.

Table 2 - Average heart rates and standard errors (SE) of six logmakers over two days while working (excluding meal breaks).

Log maker	Average heart rate while working (Beats/minute ± SE)
1	108.4 ± 3.4
2	116.0 ± 8.0
3	85.3 ± 4.0
4	100.3 ± 3.1
5	113.5 ± 17.1
6	93.8 ± 5.9

RECOMMENDATIONS AND FUTURE WORK TO IMPROVE VALUE RECOVERY

Random variation and other factors not measured in this study influence value recovery because boredom and individual logmaker effects only explained 35% of the variance in value recovery.

The current study has identified boredom as a significant factor influencing value recovery but to obtain a better measure of the effects of other possible value recovery limiting factors (for example, air temperature, fatigue, number of log types made and type of operation - hot or cold deck) on value recovery, more controlled studies must be undertaken.

Mentioned below are some methods that should be investigated under operational conditions to determine their effect on value recovery. These methods draw on literature from other industries and as yet are unproven in the New Zealand logging industry.

Training

Training should be the first and most obvious step to improve log making performance. In addition to knowledge of log specifications and practical log making skills, personnel should also have an understanding of what the customer wants. Companies that have organised visits to mills by logmakers have reported improved interest in work and quality performance.

It would seem very difficult to teach someone to make complex log making decisions correctly. Education experts may be able to provide the logging industry with better ways to teach logmakers the decision making skills required.

Rest Breaks

Rest breaks are an easily implemented method to reduce boredom of the logmaker and should contribute to greater value recovery. The logmaker on a "hot deck" operation has his pace of work tied to the cycle of skidder arrival. However short rest breaks in "machine-paced" jobs do not reduce output even though less time is worked (Alluisi and Morgan, 1982 cited by Krueger, 1991). The rest break serves to provide a relief from boredom, physiological stress, muscle fatigue and cardiac strain (McCormick and Tiffin, 1974). Even on the "cold deck" operations where the logmaker has more control of his pace of work (but where monotony presumably is greater) rest breaks can reduce boredom. For example, on hot days the logmaker and landing workers could rest (or do chainsaw maintenance) in the shade between drags.

Job Rotation/Enlargement

Rest breaks need not be periods of inactivity. Several authors (Fox, 1975 and Krueger, 1991) have recommended job rotation as a means to maintain worker vigilance.

In an experiment to study maintenance of inspector performance, Fox (1975) tested the concept of "job enlargement". In order to reduce the uniform repetitive nature of some tasks, a group of factory inspectors were given additional tasks to perform. The extra task involved going to get the items to be inspected from a store instead of having them delivered. Over a long period of time fault detection efficiency was shown to increase by 6%.

In logging crews this may be implemented by rotating jobs at every break. For example, make logs until first meal break, fell until second meal break and make logs again for the last run of the day.

Motivation

Theories of industrial motivation (for example, Herzberg, 1966) suggest status, recognition, self-fulfilment and perceived importance of the work are of great significance. Contractors and managers need to have skills and knowledge to ensure their working environment and relations with their employees fulfil these needs.

Differential logging rates that reward value recovery up to (or exceeding) that expected from the preharvest assessment are common with many forestry companies in New Zealand (Duggan, 1990). However, due to the relatively low differentials between log grades paid to the contractor, achieving a "trickle down" of these financial incentives to logmakers and other logging workers has proved difficult. For financial incentives to the logmaker, to work, two issues must be resolved. Firstly, the emphasis must be shifted from production to quality. At present the rewards to contractors are based primarily on production but the emphasis from the company is on quality. Secondly, greater price differentials between log grades must be paid to share rewards for greater value recovery. Pivotal to this system working is the confidence, by all parties, in the preharvest assessment.

CONCLUSIONS

In this limited study, the level of self perceived logmaker boredom had the greatest measurable influence on value recovery. If logging companies and contractors want to improve value maximisation and quality, practices such as job enlargement or rotation and better timed rest breaks could be utilised. With the current high value of logs, improvements in value recovery by logging crews may be easier to achieve and give a far greater improvement in profitability than reducing logging costs. More work is needed to quantify the benefits of these recommendations and investigate the influence of the number of log types made, on value recovery.

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