# Mechanisation Developments Within the New Zealand Forest Industry: The Human Factors.

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## ABSTRACT

The ergonomic benefits of mechanisation for the forest worker focus around the removal of the worker from the majority of the hazards and severe physical workloads inherent in the forest workplace. However, the characteristics of the current New Zealand forest industry workforce, the lack of trained operators, lack of appropriate training and selection programmes, and the high level of turnover in the New Zealand forest industry, are current obstacles to the full achievement of mechanisation's ergonomic benefits. In order for the New Zealand forest industry to maximise the economic and ergonomic benefits of mechanisation, some formal preparation of machine operators is essential.

**Keywords:** *human factors, ergonomics, mechanised harvesting, logging.*

## INTRODUCTION

The concept of mechanisation is not a new phenomenon within the New Zealand forest industry. As early as 1976 the Logging Industry Research Association (LIRA) reported on a variety of feller buncher options for New Zealand plantation forests [39, 3, 27]. This process continued on through the late 1970s and 1980s, evaluating a variety of overseas machines [15, 16, 33] and methods [17, 23] to see if they could be successfully applied to the New Zealand forestry environment. However, by 1988, locally developed forms of mechanical harvesters and processors began to appear on the scene [8, 36].

By far the majority of the mechanisation developments up to and including the late 1980s were aimed at the production thinnings phase of the forest harvesting process [34, 35, 8]. This area of the operation required relatively simple processing procedures, in that the end products were primarily destined for the pulp market. Therefore there was no requirement for complex length measuring or log making capabilities and delimbing quality requirements were not as stringent as those required in sawlog production. Consequently, it was within the thinning domain that mechanisation initially developed, with clearfell operations being left relatively isolated from such developments until the early 1990s.

One major factor preventing the rapid integration of mechanisation into clearfell operations has been the tree characteristics of New Zealand's plantation forests. Approximately 90% of New Zealand's 1,239,000 hectares of plantation forestry is planted in *Pinus radiata*. Final stockings of between 250 to 350 stems per hectare are achieved as quickly as possible, usually by age 14 years, in order to maximise individual tree volumes harvested at clearfell. The consequences of this early low stocking, and fast growth rates, have traditionally been heavily branched (>10 centimetre diameter) final crop trees with large stem volumes averaging 2 to 5 cubic metres by 30 years of age. Additional factors retarding the progress of mechanisation have included a ready supply of relatively cheap labour, lightweight safety legislation, low worker accident compensation levies and a large amount of small independent logging contractors.

Not surprisingly, a machinery survey undertaken in 1993 [21] found that motor-manual harvesting systems accounted for 95% of the total volume of timber harvested in New Zealand at that time. A further 3% was harvested by manual/mechanical combinations, and fully mechanised systems accounted for the remaining 2%.

## RECENT DEVELOPMENTS

This traditional direction has recently seen some changes that have the potential to significantly change the degree of mechanisation occurring within the relatively untouched clearfell operations. Two of these changes have consisted of smaller clearfell tree sizes, due to altered silvicultural processes and a shortening of the rotation age, and the introduction in 1992 of powerful health and safety legislation entitled the *Health and Safety in Employment Act 1992* (HSE Act).

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A gradual reduction in the clearfell tree piece size down to approximately 1.8 to 2 cubic meters, within some forest regions, has resulted in the development of machines [11, 12, 13] and systems [11, 18] that are able to be effectively implemented into the clearfell phase of the harvesting operation. Development of accurate and effective length and logmaking capabilities within the machines [12, 13] has further aided this process.

Due to the traditional predominance of motor-manual systems, New Zealand's forest industry experiences a relatively high lost time accident rate of 68/1000 forestry employees. The total time lost through forest industry accidents for the 1994 year in New Zealand was 2615 days, or the equivalent of 11.1 man years [28]. There have been several reviews of work related injuries within New Zealand industries undertaken within the last decade, all of which paint a dim view of safety in the forest industry.

One study found the forest industry fatality rate between 1975 and 1984 was 11.5 times higher than the overall workforce rate [7]. Another found that for the period 1975 to 1987 the fatality rate amongst loggers was 28 times higher than the national average, whilst that of silviculturists was twice that of the national average [19]. There is substantial evidence to show that the same trends appear in non-fatal injuries for both sectors of the forest industry [37, 20, 22, 28].

The HSE Act has created an environment whereby the forest company, contractor, and worker are all equally responsible for their own safety and that of their co-workers. All parties concerned must do their upmost to identify, minimize, and/or eliminate all actual and potential work related hazards. Mechanisation of the high risk areas of harvesting, traditionally the felling and delimbing stages [28], is seen as a major step towards the attainment of this goal. Additionally, a subsequent significant increase in worker accident compensation levies has resulted in contractors considering the financial benefits of operating a harvesting system that not only requires fewer workers but also places the remaining workers within the protective confines of a machine cab. The end result of this is reduced worker accident compensation levies.

## ERGONOMIC BENEFITS

In areas suitable for full or partial mechanisation, the workers are seen as being taken away from the dangers associated with felling and trimming, and being placed in the relative comfort of a protective, climate controlled machine cab. The results in terms of improved safety can be dramatic. Machine operators have less than 15% of the accidents suffered by chainsaw operators in harvesting the same amount of timber [37]. The impact on physical workload can also be as dramatic as shown in a review of physiological workloads associated with differing types of forest work [30].

Unfortunately, mechanisation is not the panacea it was first thought to be. More recently neck and shoulder strain injuries among machine operators are starting to emerge [2]. Such injuries are the result of long, repetitive and monotonous hours of manipulating the machine's controls. While difficult to diagnose objectively, occupational health specialists agree that such injuries may be as incapacitating as serious accidents and may force many operators to give up their jobs [37].

These new forms of occupational injuries are now being addressed and solutions being offered. Primarily these revolve around the use of ergonomic guidelines when setting up the machine cab, use of short frequent rest breaks, micro-pauses, job rotation, and more recently bio-feedback devices. The advantage of bio-feedback is that it is a realtime device that directly relays the level of tension within specific muscle groups back to the operator, who can then make immediate changes. The consequence is that the operator is able to maintain adequate blood flow through the working muscle groups, thereby preventing painful and damaging muscle fatigue.

## TRAINING

### Forest Workers

Until its demise in 1986, the New Zealand Forest Service provided several comprehensive training programmes for forestry workers. Subsequently there has been somewhat of a training vacuum within the industry, with forest workers having to rely on company and contract trainers, contractors, and fellow workers for any training. A

LIRA report [14] found that only 30% of loggers had any formal logging training. Half of the loggers surveyed had learnt from a more experienced logger on the job, the remainder were either self-taught or taught by their boss or supervisor. This finding was re-iterated by Houghton (1995) [19] who also found that when interviewed in 1990, 67% of the loggers and 74% of the silviculturists stated that they had learnt their skills on the job. The New Zealand Forest Owners Association (NZFOA) estimated in 1993 that 30% of the total forest industry workforce were trained. In 1994 the NZFOA undertook a forest industry workforce census and found that 76% of loggers and 58% of silvicultural workers had at least one training module [5].

### Machine Operators

Currently in New Zealand there are limited training facilities for operators of mechanised logging equipment. Operators of these machines have traditionally commenced operating them after receiving little if any training in the correct operation of the machine. Any training that is received usually consists of on-the-job-type training. Such training is usually supplied by either the machinery supplier, in the form of a trainer, or by a fellow contractor who operates a similar machine. Both types of training are usually of a relatively short duration (one to two weeks), and fairly intensive in nature. Operators of such machinery face the additional problem of having few fellow workers from which to learn their newly required skills, as a skilled machine operator labour pool has yet to be established within the forest industry workforce.

The high capital costs traditionally associated with mechanised operations are offset by the high daily production rates associated with such operations. For example, a standard New Zealand manual groundbased crew produces on average 190 $m^3$/day, whereas a mechanised tree harvester can produce 610 $m^3$ per day [21]. Due to the high capital investment (NZ$500,000 to NZ$2,000,000) required by mechanised logging systems, a skilled operator is essential if the investment in the machinery is to be maximised by the contractor. Since the unit cost ($/tonne) is heavily influenced by the production rate, the ability of the machine operator to quickly and efficiently learn a new task or tasks is crucial to the continued success and ultimately the economic viability of the whole operation.

However, traditionally there appears to have been little importance placed upon either the requirements for effective operator training, or the role of the operator. A current study, investigating mechanisation literature published in New Zealand [24] has found that of the 156 papers reviewed to date, only one publication specifically targeted the human factor aspects of mechanisation.

## LEARNING CURVES

One key aspect where training can have a major impact is the operators learning curve. The longer this curve, the greater the cost to the employer, as optimal production levels are not being attained. There are several benefits for the operator, contractor and forest company in being able to identify learning curves in mechanised logging operations. The operator can use learning curve information in order to assess their performance. The contractor is able to identify how long production, and in turn the operation's cashflow, are likely to be affected by new operators. The contractor is also able to calculate any additional costs incurred by the new operators if they have an idea of what stage of the learning curve their operators have reached. Typically, increased repairs and maintenance costs are associated with new machinery operators as they appear to be more severe on machinery [38]. For the forest company, the learning curve enables them to better calculate woodflows from newly mechanised logging systems and take this into account when planning.

Current research being undertaken by the New Zealand Logging Industry Research Organisation (LIRO) on machine operator learning curves [30], reveals just how disruptive operators find interruptions to their ambient work environment during the first few weeks of operation. The impact of system changes, stand characteristics, operational instructions and work method were noted to be far greater during the earlier phase of the learning curve than later on in the process.

The opportunity for operators to undergo some structured training programme prior to commencing work in the industry would significantly reduce the operators learning curve. Comments made by contractors taking part in the LIRO projects stress how valuable any training is to them, as they feel it reduces their learning curve considerably by refining their technique and helping them to utilise the machine to its fullest [25, 26]. They felt that this enabled them to obtain a higher return on their investment, as the machine began working closer to its full productive potential at an earlier stage.

Another area requiring attention is that of machine operator selection. As with training, there are currently no established operator selection programmes available to contractors in New Zealand. The potential financial losses faced by contractors as a result of choosing an inappropriate operator, in terms of increased repairs and maintenance and lost production, are extensive.

With formal operator selection and training available, contractors could reduce their unproductive down-time and the high repairs and maintenance costs incurred by trainee operators. Formal selection and training would improve the chances that only suitable candidates are employed. Forest companies would benefit as they would achieve a more consistent woodflow from their mechanised contract harvesting operations.

## TURNOVER

It is generally considered that one of the biggest obstacles towards achieving and maintaining a well trained workforce is turnover, which is a major problem within the New Zealand forest industry [31, 1, 6]. A high level of turnover creates additional problems for the forest industry when workers move between crews or out of the industry and their skills and the costs of their training are lost to the contractor and/or the industry as a whole. This may discourage contractors from investing in training, especially if they experience high turnover within their crew.

A seven-year New Zealand Forest Products Ltd (NZFP) (Kinleith region) study of turnover amongst their logging workers found an average annual turnover of 58% (workers leaving NZFP Ltd altogether) and an additional 18% turnover within the company's crews [1]. Another study found that turnover was particularly high among new recruits, and noted a turnover in excess of 80% over 2.5 years and an average turnover of 42% in the first six months [4]. A common finding from these studies was the considerable difference between trained and untrained worker turnover rates. Of those workers with certification, 68% remained in the industry, but only 19% of those without certification remained [4]. The percentage of certified workers leaving NZFP was lower throughout the seven-year study than the percentage of non-certified workers [1].

Turnover of machine operators, especially in an industry with few formal training opportunities, means that the harvesting operation is put under considerable stress if an operator leaves. At present an operator must learn on-the-job in a production situation, which may not be conducive to quality training, high production, or in fact the retention of the operator themselves. The stresses associated with trying to learn a new complex task and at the same time generate a high level of production frequently result in the operator leaving and returning to a less stressful sector of the industry. Such drastic actions can then further complicate matters as the operation is then left with only one operator who now has to work extended hours to cover the missing operator. The consequences are typically increased stress, loss of earnings, and longer working days. All of these features are not only bad for the operator/contractor but for the forest owner as well since the attainment of consistent woodflow becomes more difficult.

The process then completes a full circle at this point, as quickly finding a suitable replacement operator is usually difficult due to the lack of trained machine operators within the industry. Consequently contractors either have to import skilled workers from off-shore, or accept the cost of yet another new untrained operator's learning curve.

## CONCLUSION

Currently there is a lack of formal machine operator selection and training programmes within New Zealand's forest industry structure. This lack of such programmes results in most, if not all, current machine operator training being undertaken in an on-the-job production situation. Such ad hoc training methods are not conducive to either quality training or high production. New operators progress through their learning curves whilst striving to achieve optimum production rates as quickly as possible. The initial stresses and pressures associated with such situations often result in high operator turnover rates that further exacerbate the situation. Only by having a readily available source of appropriately trained operators can the New Zealand forest industry reverse this current situation and fully capitalise on the true advantages of mechanisation in terms of safety and production.

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