

## AN ERGONOMIC COMPARISON OF MANUAL AND CHAINSAW LADDER PRUNING

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*Figure 1 - Ladder pruning operation*

### SUMMARY

Two methods of ladder pruning radiata pine from a height of 4.5 to 6.0 metres were compared in terms of an ergonomic comparison. Hazard frequency, physiological workload, musculoskeletal injury, productivity and pruning quality were compared for the two techniques.

Results obtained from this study showed no major difference, in terms of an ergonomic comparison, between the manual and chainsaw methods of ladder pruning.

## INTRODUCTION

Chainsaw pruning has been a contentious issue within the forest industry for some years, particularly chainsaw ladder pruning. The use of chainsaws, especially up pruning ladders, has been seen by many people as resulting in both a higher rate and greater severity of pruning related injuries. Such beliefs have been based on little or no objective data. Continuing pressure from individual forest companies and their associated silvicultural contract workforce, to have chainsaw pruning recognised by the appropriate authorities as a safe and effective means of pruning, lead to the initiation of this research project (Ford, 1995).

The objective was an ergonomic comparison of manual versus chainsaw ladder pruning. An ergonomic-based comparison was selected as such an approach assessed all the relevant and inter-related health, safety and productivity aspects of the two pruning techniques. Consequently, the specific areas of hazard frequency, physiological workload, musculoskeletal injury, body part discomfort, productivity and pruning quality were selected for investigation.

## ACKNOWLEDGMENTS

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## METHOD

### Subjects

Four manual ladder pruners and four chainsaw ladder pruners were each observed continuously for one week.

### Physiological Measures

Working heart rate and aerobic capacity were determined for each pruner in order to determine the level of physical stress

experienced by the fallers. Relative heart rate stress was expressed as percent heart rate range (%HRR). The higher the %HRR figure, the more demanding the worker found the task to be.

### Production

Production data was collected by the researcher who undertook a continuous time study while observing the subjects in the field.

### Tree Characteristics

A 5% sample of all trees pruned for each pruning method had branch size, numbers of branches, whorls and branches per whorl recorded.

### Pruning Quality

Damage events incurred as a result of pruning were recorded by the researcher. These included damage to: the branch collar, the bark on the stem around the branch, a combination of collar and bark damage and coat hangers.

### Hazards

Hazards were identified and recorded according to the Forest Industry Record of Skills (FIRS) Module 2.4 "Silvicultural Pruning" and hazardous procedures identified by experienced industry personnel. The number of hazards per tree were observed and analysed to obtain a hazard frequency.

In order to cross-check the hazard data collected during direct observation, a retrospective accident survey was also administered to the combined CHHF Hawke's Bay pruning workforce including those taking part in the comparative study. Historical pruning related accident frequency and severity data was also obtained from by CHHF (Central).

### Subjective Measures

A questionnaire was administered once to each pruner involved in the study to determine the presence of past and/or present musculoskeletal disorders. Each pruner's subjective body part discomfort (BPD) rating was also measured during each working day using a standard questionnaire at one-hour intervals throughout the working day.

## RESULTS

### Subjects

The chainsaw pruners in the sample were on average older (average 28 years versus 22 years) and more experienced (79 months versus 43 months) than the manual pruners. The subjects from both groups had similar aerobic capacities as well as heights, weights, measures of fatness, and habitual nicotine and caffeine intake patterns.

### Physiological Workload

As can be seen in Table 1, there were no statistical differences between the average %HRR of the chainsaw and manual pruners in the study.

### Production

Total cycle time was significantly longer for the manual pruners. Total cycle time included prune time, all delays and walk time. Walk time was affected by the terrain, distance and hindrance. Even when adjustments were made for the effect of these variables, chainsaw pruning was still significantly faster than manual pruning.

### Tree Characteristics

There were no significant differences in any of the tree characteristics measured between the trees pruned by the manual and the chainsaw pruners except for tree diameter at breast height (DBH) and the total cross-sectional area of branching per tree. The total cross-sectional area of branching per tree was significantly greater for the trees pruned by the chainsaw pruners (156 cm<sup>2</sup> versus 120 cm<sup>2</sup>).

### Pruning Quality

Chainsaw pruning caused significantly higher bark damage events, combined collar and bark damage events and coat hangers per tree than manual pruning.

*Table 1 - Working heart rate and percent heart rate range (%HRR)*

Subject	Working Heart Rate	%HRR
Chainsaw	122	39
Manual	128	39
Significant Difference	No	No

*Table 2 - Mean cycle elements for manual and chainsaw pruners*

Element	Manual	Chainsaw	Significant Difference
Trees/Hour	20	25	Yes
Total Cycle Time	3 min 32 sec	2 min 32 sec	Yes

Table 3 -Average damage events per 100 trees

Damage Event	Manual	Chainsaw	Significant Difference
Collar Damage.	38	71	No
Bark Damage.	0	33	Yes
Coat-hanger.	32	104	Yes
Collar and Bark Damage.	3	48	Yes

### Temperature

The average wet bulb globe temperature (wbgt) was  $11^{\circ}\text{C} \pm 4^{\circ}\text{C}$ . Work undertaken by Smith et al. (1986) investigating the effect of heat on forest worker performance, efficiency and safety, identified a wbgt of  $26^{\circ}\text{C}$  as being the point at which temperatures impacted upon the worker. Therefore, the  $11^{\circ}\text{C}$  recorded in this study was considered to have had minimal impact on worker performance.

### Subjective Measures

Analysis of the musculoskeletal data obtained from the questionnaire showed that there were no significant differences in the level of musculoskeletal disorders experienced by each group. With regard to the BPD surveys (Figure 2), manual pruners experienced a greater relative increase in the body part discomfort during the working day than the chainsaw pruners.

Figure 2 - Body part discomfort.

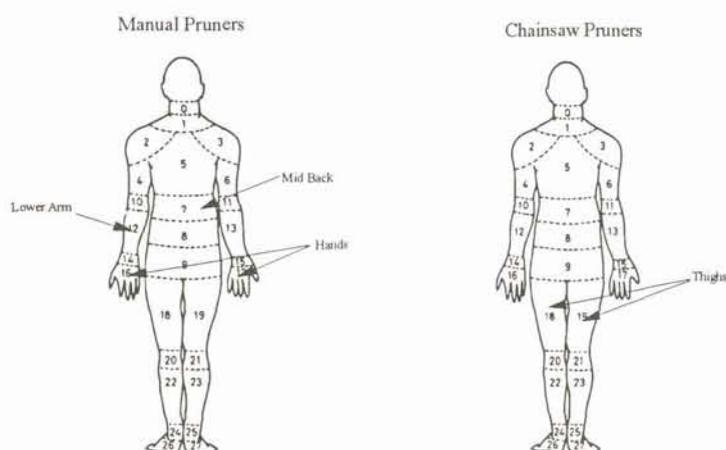


Table 4 - Average hazards per 100 trees

Hazard	Manual	Chainsaw	Significant Difference
Ladder Hazards	30.2	32.7	no
Cutting large branches above head	7.9	7.3	no
Cutting across arm / leg	1.3	5.7	yes
Cutting branch too close to stem	0.4	8.5	yes
Over reaching from ladder	2.5	6.2	yes
Holding on to branch being cut	0.9	3.7	yes

### Hazard Frequency

Table 4 shows chainsaw pruners had a significantly higher hazard frequency for four out of the six identified hazards. The only variation observed between morning and afternoon hazard frequencies was a higher occurrence of manual pruners holding on to the branch being cut in the afternoon.

## DISCUSSION

### Subjects

It is concluded that the pruners involved in the two study groups had similar aerobic capacities as well as heights, weights, measures of fatness, and habitual nicotine and caffeine intake patterns. This allowed valid comparisons to be made between the physiological costs associated with each method of pruning.

### Hazard Frequencies

Analysis of hazard frequency data revealed that, for this particular study, chainsaw pruning encountered significantly higher hazard frequencies than manual pruning. However, data obtained from the retrospective accident survey showed chainsaw pruners to have both a lower accident frequency and lower injury severity than the manual pruners. This trend was also identified in the accident data provided by CHHF (Central). Such a finding suggests that while chainsaw pruning in this case may have resulted in higher hazard frequencies, it appears that for the larger chainsaw pruning workforce, these situations are not resulting in actual injuries. However, comments made by some chainsaw pruners within the Central region, suggest that these figures may have been biased by under-reporting of chainsaw pruning accidents.

### Physiological Workload

The fact that manual and chainsaw pruners experienced the same relative heart rate response is not surprising even though both techniques are quite different. Many studies have shown that when given the chance to set their own work pace, workers will select working pace which is sustainable, usually between 30% and 40% of their heart rate range (Smith *et al.*, 1985; Vik, 1984; Vogt *et al.*, 1983). Other researchers (Vogt *et al.*, 1983), have suggested that workers have the natural ability to set a work pace in response to increased thermal stress that results in the maintenance of their average heart rates in a relatively narrow range. They termed this phenomenon *constant strain behaviour* and suggested that the increase in environmental heat load is compensated by a decrease of muscular work. Smith and Rummer (1988) also recorded this phenomenon whilst studying heat stress effects on forest workers in clearfell harvesting operations. Since both the manual and chainsaw pruners were largely able to set their own work pace, the lack of any significant difference in physiological cost is not unusual.

### Subjective Measures

While no difference could be identified between the two groups as far as musculoskeletal disorders, a significant difference in BPD was recorded. The manual pruners experienced a greater relative increase in BPD than the chainsaw pruners as the day progressed. Most importantly though, the BPD experienced by the manual pruners was not cumulative, and therefore the manual pruners were able to recover fully by the next day.

### Production

The significantly shorter cycle time achieved by the chainsaw pruners resulted in a higher hourly production rate, even when allowing for refuelling and sharpening

of the chainsaw - the reason being that chainsaw pruners have tended to be used in areas typified as having heavily branched trees. The chainsaw is largely unaffected by the larger diameter branches as the branch can still be effectively removed with one cut of the chainsaw. Manual pruners working in the same stands using loppers are frequently required to place several cuts into the branch in order for it to be removed in the appropriate manner and achieve the required quality standards. Alternatively, a jacksaw is used to remove the branch. All of these additional movements consume time which, in turn, lengthens their average cycle time per tree.

In tree species with few large branches such as Douglas Fir, chainsaw pruning has been shown to be no faster than manual pruning (Kirk and Parker, 1996). The reason is that where there are numerous small diameter branches, a manual pruner is able to keep pace with the chainsaw pruner.

### Quality

The fact that the revolving saw chain can so easily damage the bark and collar of the tree appears to work heavily against the pruning quality obtained from chainsaw pruners. Unlike the manual pruning tools, such as loppers, the revolving chain of a chainsaw has only to make slight contact with the trees for it to inflict quite heavy damage. Consequently, it appears that in order to reduce the occurrence of both bark and collar damage, the pruners have built in a collar protecting element into their pruning method. This, in turn, appears to result in an increase in the occurrence of coat hangers, as pruners try to avoid making contact with the bark or collar with the revolving saw chain.

### CONCLUSIONS

- Chainsaw pruners experienced significantly higher hazard frequencies than manual pruners.
- There was no significant difference between the physiological workload of the two pruning methods.
- Manual pruners experienced a greater relative increase in the body part discomfort during the working day than chainsaw pruners.
- Chainsaw pruning resulted in a higher rate of damage events per tree than manual pruning.
- Chainsaw pruning resulted in a higher rate of production than manual pruning.
- Results obtained from this study showed no major difference in terms of an ergonomic based comparison between the manual and chainsaw methods of ladder pruning.

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