REPORT

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AN EVALUATION OF FOUR STREAMSIDE FELLING TECHNIQUES USED IN GROUND-BASED OPERATIONS

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Figure 1 - Excavator - assisted streamside felling

Summary

In this study, the production, cost, safety and environmental performance of an excavator was compared with three other felling methods: skidder-assisted felling, tree jacks and motor-manual felling using wedges.

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Table 1 - Performance comparison of the four streamside felling methods

	Method			
	Excavator	Skidder	Motor - manual	Tree jack
No of trees (n)	27	23	17	15
Cycle time (mins/tree)*f*	4.5±0.7*	5.2±0.8	5.4±1.0	8.5±1.0
Trees/hr	13.3	11.5	11.1	7.1
Cost/hr ($)**	145.90	133.16	27.95	55.15
Cost/tree ($)	10.97	11.58	2.52	7.77
Cost/m^3 ($)	4.46	4.71	1.02	3.16
Av butt damage (cm)	35	39	20	57
Hazard/100 stems	3.8	4.3	17.6	53
Trees left or in steam (%)	0	0	27	30

f adjusted for tree volume by covariate analysis

* range based on 95% confidence interval

** excludes overheads and travel time

- For streams that require a high level of protection (no trees in the stream, no channel bank disturbance) the excavator was the most productive and safest method, followed by the skidder (Table 1).

- Tree jacks and motor-manual felling were cheaper (Table 1), but more hazardous than the excavator and skidder. However, tree jacks and motor-manual felling cannot completely protect the stream from damage.

- Tree jacks and motor-manual felling can assist machine-assisted felling operations by removing the smaller, lighter leaning trees. Tree jacks, motor-manual felling and winches are options along protected stream edges which are inaccessible to machinery.

- The use of motor-manual felling is limited to streams where the required level of stream protection is low (there is no requirement to keep all the logging material out of the stream).

- Industry involvement is needed to develop an industry code of practice, standards and qualifications to incorporate excavator-assisted felling into FIRS (Forest Industry Record System). If a safe method can be developed which allows the faller to work safely under the raised boom, the excavator has the potential to improve productivity and reduce butt damage without compromising safety.

Introduction

In ground-based operations, skidders and tractors are commonly used to assist motor-manual operations in felling trees away from stream edges. Although not as widely used, tree jacks are another option for felling heavy leaning edge trees (Adams, 1993; Fraser, 1995). Another machine-assisted method being used to fell edge trees in the Central North Island is excavator-assisted felling. This method has the potential to provide the industry with an effective alternative to felling along stream boundaries as most crews either have, or have access to, an excavator.

Whichever method is used, falling trees away from protected streams reduces productivity, thereby increasing harvesting costs. The results of this study can be used to assist forest managers in determining the most appropriate and cost effective streamside felling technique for a given standard of stream protection.

Information from the study will be used in the formation of an industry code of practice for excavator-assisted felling. The code of practice will be the first step towards having this method approved as a machine-assisted felling method. Further work will be needed to develop standards for excavator-assisted felling and to include it as a qualification in FIRS.

Trial Design

Trees were left along a stream edge to allow a time trial of two productive hours for each method. Prior to the study commencing, tree heights and diameters were measured to calculate tree volume and trees were assessed for direction and degree of lean and branching (Table 2). Branching was subjectively rated as light, medium or heavy.

Table 2 - Tree assessment categories

Predominant lean direction	1 = toward stream 2 = away from stream 3 = downstream 4 = upstream
Degree of lean (Class)	1 = 0-2° 2 = 3-6° 3=7-10° 4=>10°
Branching	1= light 2 = medium 3 = heavy

To reduce inconsistencies between the trees selected for each method, any trees which were markedly different from those in other methods were excluded (excessive lean, size or branching). For each method, the time study collected cycle time per tree and total number of trees felled.

A hazard assessment was undertaken for each felling method to determine hazard type and frequency of occurrence.

Hazard ratios per 100 stems were calculated using the formula:

$$\frac{\text{Hazards}}{\text{Stems}} = \frac{x}{100}$$

All four methods aimed for the same environmental standard. Trees were to be safely felled away from the stream edge. If it was not safe to do so, then the tree was to be felled into the stream. Any trees, debris or slash deposited in the stream were removed after the trial was completed.

For each method, a record was kept of the number of stems that could not be felled away from the stream. This number was expressed as a percentage of the total trees in each methods trial area and used as a measure of environmental performance (Table 1).

After felling, butt diameter and length of butt damage were measured for each stem.

The four methods were costed using the Liro Limited standard costing system. Costings only included operational costs and excluded overheads and travel time.

The same faller was used throughout the trial and was a forest industry registered trainer and moderator. All machine operators involved in the trial held the appropriate Logging and Forest Industry Training Board (L&FITB) qualifications. Each method was carried out in strict accordance with Occupational Safety and Health Service (OSH) and L&FITB rules and guidelines where applicable.

Felling Procedure

Excavator

This method was a two-person operation using a Thunderbird 738 excavator (35 tonne) with a grapple and live heel. The tree was scarfed, backcut and wedged by the faller who then retreated to a safe position. The excavator operator moved the machine forward, positioned the grapple behind the tree, ensuring the boom was between the cab and the tree to be felled, prior to pulling the tree over (Figure 1).

Skidder

This was a two-person operation using a John Deere 640E skidder. The faller used a ladder to attach the skidder strop as high as possible up the tree, sometimes with the assistance of the skidder operator (Figure 2). The skidder operator took up the slack on the rope. The faller put in the scarf and backcut, wedged the tree and retreated to a safe position before signalling to the skidder operator to go ahead. The skidder operator took up the strain on the rope, pulling the tree over.

Figure 2 - Skidder-assisted streamside felling

Tree Jack

This operation used Linton jacks and required two people, one to set up the felling cuts, the other as the jack operator and observer. The faller scarfed the tree, and cut a block from the back of the tree for placement of the jack (another block was cut out if a second jack was used). After setting the jack(s) in the tree, the jacks were extended until they were firmly in place. The faller made the remaining bore cuts (Figure 3), before standing clear and signalling to the jack operator to jack the tree over. The trees in this section had an average butt diameter of 51 cm and required one jack to fell, apart from one tree which required two jacks.

Motor - Manual

Trees were scarfed, back cut and wedged as in standard motor - manual felling. (Figure 4)

Results and Discussion

The stand data for each method was tested to determine whether there were any significant differences. The only significant variable was tree volume. The trees in the excavator section were smaller than the trees in the motor-manual section and this was reflected in the average piece size and average stump diameter (Table 3).

Table 3 - Stand data for the four streamside felling trial areas

	Method			
	Excavator	Skidder	Motor - Manual	Tree Jack
Av piece size (m)^3	2.1	2.6	3.0	2.3
Predominant lean direction	1	1	0&1	0&1
Predominant degree of lean	1	1	1	1
Main branch pattern	1&2	1&2	1&2	1
Av stump diameter (cm)	53	58	61	51

Excavator and skidder

The excavator had the shortest cycle time of the four methods at 4.5 minutes/tree(Table 1). It was the most expensive operation to run, but its higher productivity resulted in a similar cost per tree to the skidder (excavator - $10.97/tree; skidder - $11.58/tree).

There is potential for the excavator to improve its productivity if a work method can be developed that allows the faller to work safety under the raised boom. The faller could then set up the tree while it is supported by the excavator, reducing the need for wedging and reducing the cycle time. An option may be the use of non-return valves which cause the boom to lock up should the hoses rupture or the hydraulics fail. These valves would need to be externally piloted to ensure the machine's performance is not affected.

The excavator was the safest of the four streamside felling methods with a hazard rating of 3.8/100 stems (Table 1), ahead of the skidder at 4.3/100 stems. The excavator operator and faller commented that there is the potential for the tree to fall on to the excavator during the felling process, if the holding wood suddenly breaks. This hazard could be avoided if the excavator could support the tree as the felling cuts are made. Again, this relies on the faller being able to work beneath the raised boom, a practice which is currently illegal.

The skidder and excavator were most effective at protecting the stream. All trees were successfully felled away from the stream edge (Table 1). Both methods felled the trees in a consistent direction along the felling face, allowing better presentation of stems for extraction. The excavator had the added advantage of being capable of bunching stems for extraction.

The excavator and the skidder were not limited by the size or lean of the trees in their trial areas. The maximum tree lean in the excavator section was 10^{o}, the skidder was 35^{o}. They were not limited to the same extent as the tree jack and motor-manual operations by windy conditions.

The excavator and skidder operations had similar average lengths of butt damage; the excavator averaged 35 cm per stem across all stems in its trial area, the skidder averaged 39 cm. This was due to slabbing and drawwood, a result of the extra wide hinge wood required to hold the heavier leaning stream edge trees during the felling process.

If the excavator or skidder is an integral part of the harvesting system, time spent felling streamside trees is lost production time from the rest of the harvesting operation. Alternatives are to use the machine during rest breaks or outside normal working hours, or to utilise an additional machine specifically for the streamside harvesting.

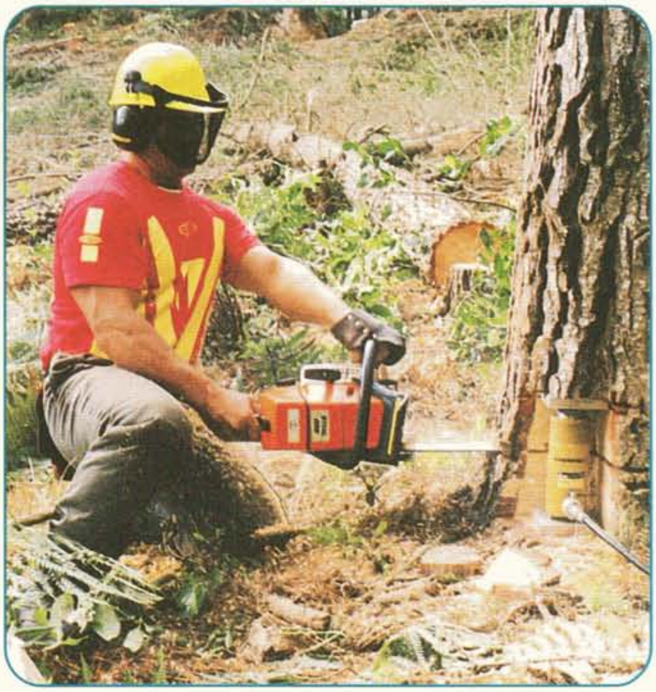

Figure 3 - A faller using tree jacks to fell stream edge trees

Motor - manual and tree jacks

The motor-manual and tree jack methods were slower compared with the excavator and skidder (Table 1). This was offset by the lower operating costs of these two methods especially the motor-manual method which used one person when all the other methods used two (motor-manual $2.52/tree, tree jacks $7.77/tree).

Kickback while placing the jack cuts made tree jacks the most hazardous of the four methods, with a hazard rating of 53/100 stems (Table 2). This was due to the frequent use of the tip of the bar during boring. It emphasises the need for a highly skilled chainsaw operator, trained in the use of tree jacks.

Kickback while placing felling cuts, gave the motor-manual method a hazard rating of 17.6/100 stems. A study investigating felling hazards undertaken in simular terrain and piece size (Kirk, et.al., 1996) recorded a felling hazard ratio of 4.9 hazards per 100 stems. The higher hazard ratio for the current study can be attributed to the heavy leaning nature of the trees being felled and the requirement for the faller to swing the trees away from the stream wherever possible.

The motor-manual and tree jack methods were unable to totally protect the stream edge. Twenty-seven percent of the trees in the motor-manual trial could not be felled away from the stream edge, the tree jacks were similar at 30%.

The main limitations of both the motor-manual and tree jack methods were the degree of tree lean and piece size. All trees in Lean Class 1 (0-2°) were safely felled away from the stream edge as well as a few trees in Lean Class 2 (3-6°). All the trees not attempted by either method were in Lean Classes 2 to 4 and the average piece size was higher than the trees that were felled (motor-manual, 4.15m^3; tree jacks, 3.17m^3). Motor-manual and tree jack operations were more sensitive to wind than machine-assisted felling and could only be attempted in relatively calm conditions or where the wind assisted the direction of fall.

The motor-manual method resulted in less butt damage than the other three methods (average length per stem, 20 cm). The tree jack method had the greatest length of butt damage, averaging 57 cm per stem. Most of the butt damage in tree jacks was from cutting out the blocks to place the jacks. There was some additional damage from slabbing. The average butt length lost from jack placement only was 39 cm.

Motor-manual felling is most cost effective along stream edges where there is no requirement to keep all logging material out of the stream, or to protect the riparian vegetation. Along protected stream edges, tree jacks, *motor-manual* felling or winches are the only options in areas inaccessible by machine. They can be used in conjunction with machine-assisted felling, removing the lighter leaning trees and leaving the remainder for the machine.

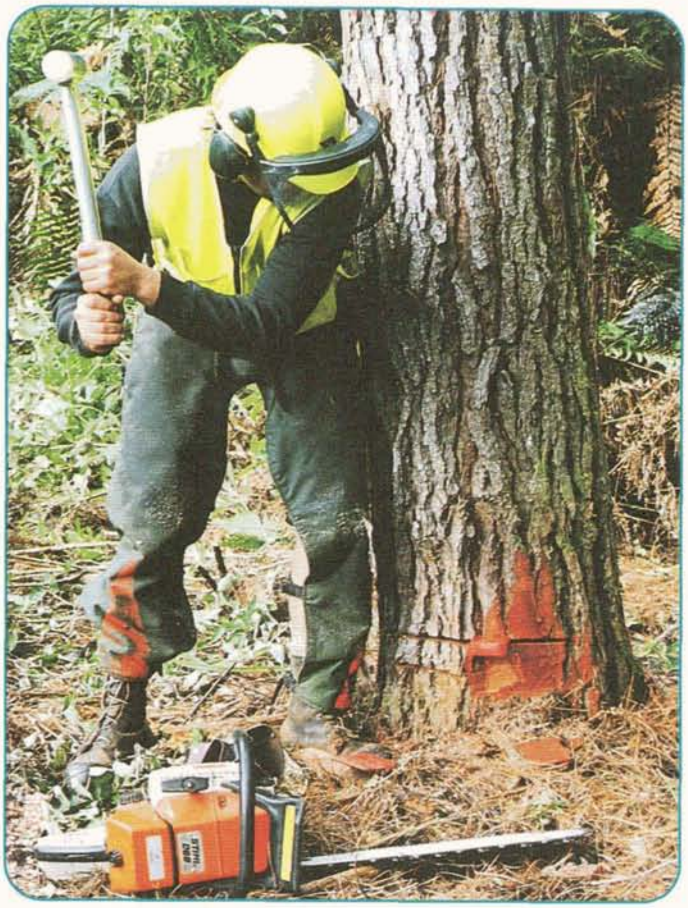

Figure 4 - Motor manual felling

Acknowledgments

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The costs stated in this report have been determined using Liro costing procedures. They are an indicative estimate and do not necessarily represent the actual costs for this operation.

References

Adams, D.(1993): "Felling Techniques for Riparian Management Zones". LIRO Report, 18 (11).

Fraser, D. (1995) : "Tree Felling Jacks". LIRO Report, 20 (14).

Kirk, P. M., Sullman, M.J.M. and Parker, R. J. (1996) : "Fatigue Levels in Motor- Manual Tree Felling and Delimbing Operations". LIRO Report, 21 (18).