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FELLING TECHNIQUES FOR RIPARIAN MANAGEMENT ZONES

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ABSTRACT

Two models of portable chainsaw winch and two models of hydraulic tree jack were evaluated for their ability to assist in the directional felling of heavy leaning edge trees away from a riparian management zone. Results revealed the Silvey tree jack to be the most effective type of equipment tested in terms of physiological workload.

Average cycle times showed the jack systems to be significantly faster (6 to 7 minutes), than the winch systems (15 to 16 minutes). However, improvements to the winch system were identified during the study which should reduce this time.

Operational guidelines and safety criteria were established regarding the use of each system studied which must be carefully considered before application.

Figure 1 - A typical "edge tree" felled during the study

INTRODUCTION

Forest operations over or adjacent to perennial waterways or riparian management zones are of concern to forest companies, Regional Councils and other concerned bodies. There is an increasing requirement to avoid or minimise adverse impacts in such areas. Incorrect felling techniques during harvesting can damage the value of these areas and considerable production losses can occur while the resultant debris is removed.

At present, most trees in these areas that cannot be felled by conventional motor manual methods are felled with the assistance of ground-based or cable extraction machinery. The two main limitations of this method are that machine assistance is not always possible and when used, production losses of up to 50% can be expected (Day, 1976).

The purpose of this study was to evaluate the effectiveness of two models of portable chainsaw winch and two models of hydraulic tree jack in terms of capacity, productivity and safety of the equipment and physiological workload of the operator.

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EQUIPMENT AND SITE CHARACTERISTICS

Four types of equipment were trialled; the KBF and Lewis chainsaw powered winches (Kirk & Hill, 1991), the Silvey Little Feller tree jack (Donovan and Gaskin, 1980) and the locally developed prototype Kajavala tree jack.

Table 1 - Equipment specifications

Type of Equipment (less bar,fuel and oil)	Weight (kg)	Capacity (kg)	Cost excl. GST (minus saw)
KBF winch & 100cc chainsaw	48	1000 straight line pull	$3000.00
Total with rigging	87		$3694.00
Lewis winch & 100cc chainsaw	27	900 straight line pull	$960.00
Total with rigging	66		$1654.00
Silvey jack	12	35000 lift (single jack) 70000 lift (double jack)	$3100.00
Kajavala jack	15	15000 lift	approx.$3000.00

Both chainsaw winches were powered by a 100cc chainsaw and and their lines were run through a double purchase system to increase their straight line pull over the manufacturers' specifications in Table 1.

The study was conducted in Compartment 26 of Tarawera Forest, Bay of Plenty, in a stand of transition crop radiata pine bordering the Tarawera River. The stand had been previously logged up to the edge of the riparian management zone with any trees leaning toward this protected area being left for this study.

The trees felled during the study were characterised by heavier branching on the side leaning into the riparian zone which resulted in additional forces opposing the intended direction of fall (Figure 1).

STUDY METHOD

Productivity

Before felling, each tree was measured for its lean against the intended direction of fall (backlean), and sideways lean. After felling, total stem length, final direction of fall and height of the mainline (when using winches) was measured. Stem volume was calculated using a three-dimensional log volume formula (Ellis, 1986) and converted to stem weight using a measured conversion factor of $0.76m^3$ /tonne.

The faller's felling cycle was divided into nineteen separate tasks, including delays which were recorded using activity sampling at 30 second intervals. The total cycle included the faller setting up all the equipment by himself. Average felling cycle times are based on the time taken to fall one tree from initial inspection to when the tree hit the ground. Tasks not related directly to the felling time such as trimming, delays and data collection are not included in the analysis.

Physiological Workload

Heart rate data was used to estimate the physiological workload of the faller during each phase of the felling cycle (Åstrand and Rodahl, 1977). The faller's heart rate was recorded at 30 second intervals using a Polar Electro Sport Tester PE 3000 portable heart rate monitor.

Table 2 - System productivity

SYSTEM	OBSERVATIONS (TREES FELLED)	TOTAL CYCLE TIME (minutes) (mean ± S.E)	SET UP RIGGING/JACK (mean ± S.E)	PUMP JACK (mean ± S.E)
KBF winch	17	14.9 (± 3)	9.2 (± 2.1)	N/A
Lewis winch	14	16 (± 2.45)	7.2 (± 4.9)	N/A
Sig. different (p<0.05)		no	no	
Silvey tree jack	27	6.3 (± 0.8)	1.3 (± 0.19)	2.5 (± 0.39)
Kajavala tree jack	17	7.32 (± 1.1)	2.6 (± 0.45)	1.3 (± 0.25)
Sig. different (p<0.05)		no	yes	yes

These data were matched with the information from the activity sampling and an average heart rate for each work element was calculated. Since higher temperatures increase both workload and heart rate (Rodahl, 1989), ambient temperature data was collected as close as practicable to the faller and the wet bulb globe temperatures (WBGT) calculated for each tree felled so that accurate workload comparisons could be made.

RESULTS

Productivity

Table 2 shows that the Silvey tree jack had the shortest average cycle time of all the equipment trialled but was not significantly faster than the Kajavala jack ($p<0.05$). Cycle times for the Lewis winch were also higher than the KBF but again not significantly so.

Figure 2 - The Kajavala tree jack and the two vertical and horizontal backcuts

The Kajavala jack took significantly longer to set up than the Silvey jack mainly due to the difficulty in placing the Kajavala jack in the vertical and horizontal backcuts (Figure 2). Greater experience in using the the Kajavala jack could reduce this time. Both hydraulic jacks had significantly shorter cycle times than the portable winches.

A disadvantage of the Silvey tree jack is that it leaves high stumps (approximately 30cm). This is a cost consideration when operating in high value pruned stands. The Kajavala jack leaves a stump as low as conventional felling techniques.

Capacity

The stem weight and lean of each individual tree was used to calculate the moment (torque) at the stump. This gave an indication of the force each system was overcoming when a tree was felled successfully against its lean. Comparisons of the maximum moments for each system, showed the Silvey jack and the two winches to be similar in capacity (maximum moments = 59 - 88 kNm). This is equivalent to using the Silvey jack to fell a tree of a base diameter of 91cm and backlean of 7°. The Kajavala jack had limited success in felling the heavily branched edge trees in the trial area. Because of this, most of the Kajavala jacks data was collected inside the stand, felling trees with smaller, more uniform branching. Calculations showed it still did not match the capacity of the other systems (maximum moments = 29 kNm). This

Table 3 - Physiological workload of the operator of each system

SYSTEM	OBSERVATIONS	WBGT (mean ± S.E)	MEAN HEART RATE PER MINUTE (± S.E)		
			TOTAL	SET UP RIGGING/JACK	MAKE BACK CUTS TO PLACE JACK
KBF winch	457	12.38 (± 0.84)	98 (± 0.69)	103 (± 1.07)	N/A
Lewis winch	285	11.35 (± 2.27)	101 (± 0.93)	96 (± 1.53)	N/A
Sig. different (p<0.05)		no	no	yes	
Silvey tree jack	363	9.017 (± 2.23)	88 (± 0.69)	91 (± 2.27)	88 (± 1.69)
Kajavala tree jack	227	13.96 (± 0.82)	101 (± 1.12)	109 (± 3.04)	105 (± 4.15)
Sig. different (p<0.05)		no	yes	yes	yes

result was expected due to its lower capacity. The Kajavala jack appears more robust than the Silvey jack.

Physiological Workload

Analysis of heart rate data revealed that operating the Kajavala jack was physically harder than operating the Silvey jack (Table 3). This is attributed to the hammering required to set the Kajavala jack in the horizontal and vertical backcuts.

Although the KBF winch was significantly more demanding physically, than the Lewis ($p<0.05$), this was due solely to rigging and operational alterations made to the Lewis winch system during the study in an effort to decrease workload. These alterations enabled the Lewis winch to pull up to 10 trees from one position with only the ropes needing to be reset for each tree. During the KBF trials, the winch unit itself as well as all the rigging components needed to be moved for every tree.

OPERATIONAL RECOMMENDATIONS

The following recommendations on the operation of winches and hydraulic jacks were formulated as a result of this study.

Portable Winches

Attempts should be made to make the scarf as large as possible but not more than one-third the diameter of the tree. This lowers the force needed to pull the tree over (McRae, 1977).

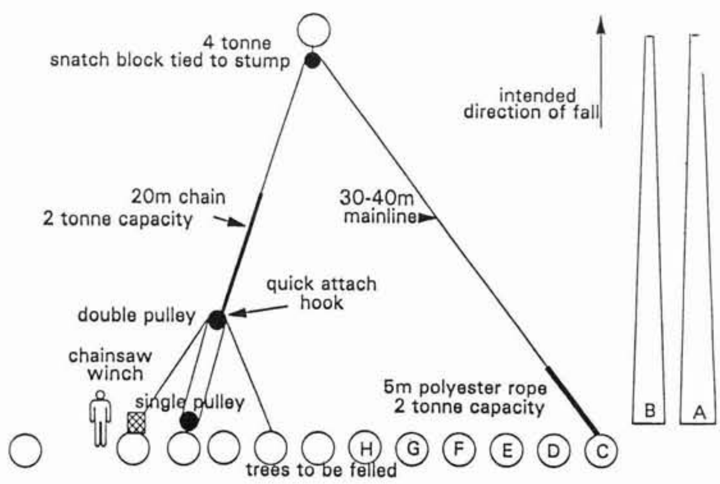

Figure 3 - Double purchase rigging system used for the Lewis winch showing the addition of a 20m chain and "quick attach" hook

The weight and limited flexibility of wire rope makes it difficult to carry up ladders and place around trees. It also has little elasticity which can cause the chainsaw winch to go from nil to maximum line pull in a matter of seconds. This sudden loading can cause severe damage to the winch and lead to a potentially hazardous situation if the tree sits back.

To eliminate this problem, a 5m length of 2 tonne capacity polyester rope and a crane hook with a safety clip were placed at the end of the mainline.

In the double purchase system, the double and single pulleys are drawn together during winching. The maximum available "winch in" capacity is determined by the distance between these two pulleys (Figure 3). This reduces the available "winch in" capacity to approximately one-quarter of the original winch rope length. This requires all of the slack to be taken out of the mainline before winching to avoid running out of winch line with the tree only partly pulled over.

Approximately 45% of the cycle time in the Lewis trials was spent setting up the rigging equipment. A large portion of that time was spent moving blocks and adding or removing short pieces of rope to the mainline to remove the slack. Although not tried, the addition of a 20m length of chain with a "quick attach" hook between the double pulley and the mainline could enable the slack to be taken out of the mainline quickly before winching commences (Figure 3)

Cycle times could be further improved by the use of a rope throwing gun (Guimier, 1980), or an extension ladder rather than the 8m fixed length ladder used in the trial. This would enable the mainrope to be placed higher up the tree which would allow the system to successfully pull larger and heavier leaning trees (McRae, 1977).

Hydraulic Tree Jacks

In general, the scarf should be cut as small as possible and no more than one-quarter the diameter of the tree as the jacking force required to fell a tree increases with scarf size (McRae, 1977).

Silvey Tree Jacks

In very heavy leaning trees, it is necessary to set the jacks in the back of the tree before the scarf is put in (Donovan and Gaskin, 1980).

Caution must be exercised when using this technique to avoid cutting too far through the hingewood when cutting the scarf. A larger than normal hinge is required to minimise the chance of the tree breaking out and going over backwards.

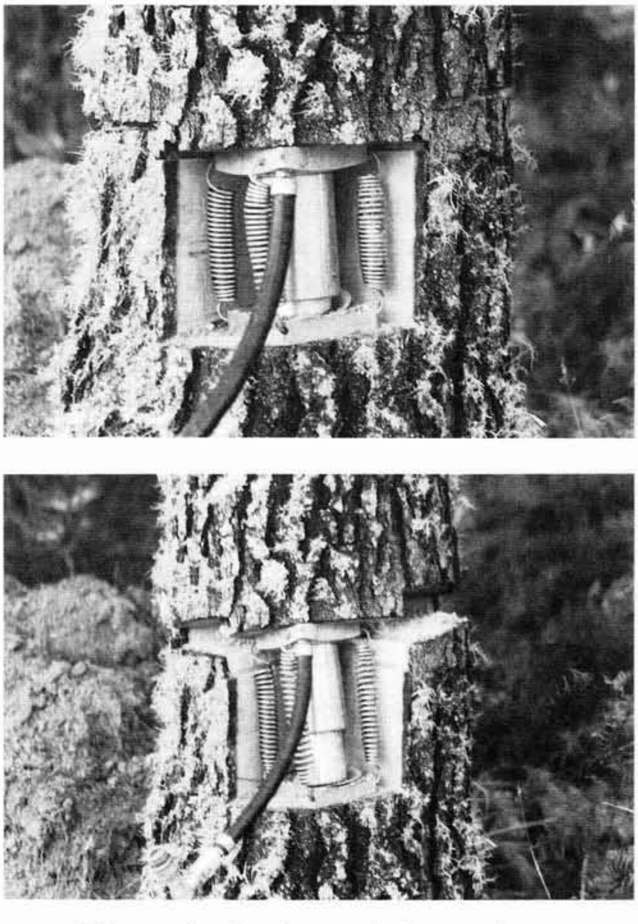

Figure 4 - Cutting technique using a single Silvey ram unit on a small tree with a heavy lean

The block for the jack is cut out first and then the jack is inserted and pumped up to around 5000 psi, before cutting the scarf. The remaining back cut should be made just above the top of the cut out block, taking care to leave sufficient hingewood and avoiding overlapping the top plate of the jack (Figure 4). The same principle can be used on larger trees and when using two ram units (Figure 5).

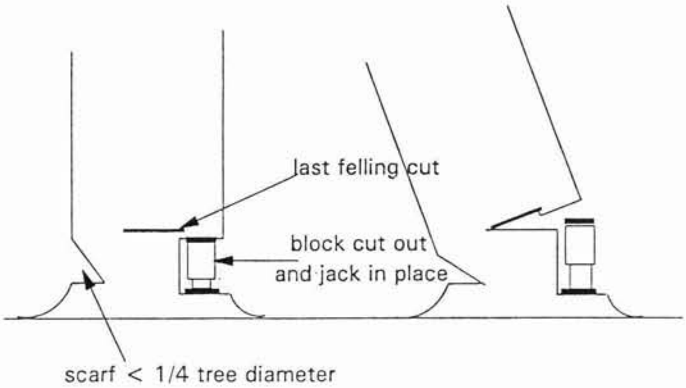

Figure 5 - Cutting technique for two Silvey ram units

It is vital that the base plates of the Silvey jack are seated on solid wood free of defects. While attempting to fall one large tree the stump gave way, destroying a ram unit. At a replacement cost of $1,200, it is important to take time to inspect the stump prior to jacking.

Kajavala Jack

Unlike the Silvey jack, the split level style of backcut used for the Kajavala jack always enables the scarf to be cut first.

SAFETY RECOMMENDATIONS

General

For all the equipment used during this study the safety and procedural provisions outlined in Sections 17 to 23 of the Safety Code for Forest Operations were followed. (OSH,1992).

The use of the alternative felling systems described in this report should only be undertaken by experienced loggers who have passed the "Machine Assisted Tree Felling" Forest Industry Recognition of Skills Module. Familiarisation time using the equipment to fell edge trees along a roadside or similar area is advised before the application of any of these systems. Additional safety procedures are recommended as a result of this study.

- A wedge should always be inserted where possible (Figure 6). This prevents the tree sitting back if equipment failure should occur. The insertion of a wedge enables a complete and precise backcut to be made and assists in felling the tree if the equipment fails to tip the tree over. As an example, a tree with a stem weight of 2.5 tonnes, backlean of 4° and a rope height of 8.5m proved to be beyond the capabilities of the KBF portable winch. However, the use of a hammer and wedge in conjunction with the KBF successfully felled the tree in the desired direction.

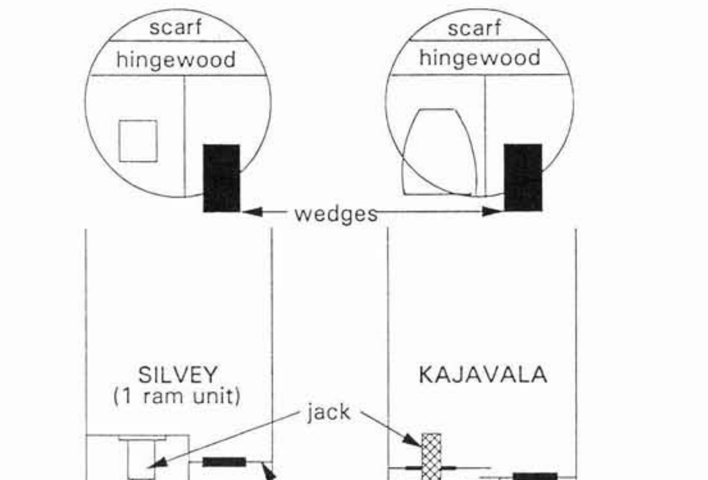

Figure 6 - Back and top view of how wedges are placed when using the Kajavala or Silvey tree jacks

- Never underestimate the tree. "Edge tree" type branching can dramatically increase the force required to fell a tree against its lean. Many of the trees felled during the study were pulled or jacked over until the stem leant substantially forward but the tree still remained upright due to the branching. It is better to use more equipment than neccessary, than to place yourself and others at risk because of a failure.

- The equipment and cutting techniques used in this report should not be used in the presence of any wind opposing the intended direction of fall. Field demonstrations with the Silvey jacks since this study was undertaken have shown that even a moderate breeze (4 on the Beaufort Scale) can increase the downward pressure on the jacks by approximately 25% and lead to failure.

Jacks

- Do not attempt to fall trees under 50cm in diameter using either the Silvey or Kajavala tree jacks. Trees of this diameter are not large enough to enable either of the jacks to be inserted properly and the felling cuts to be of a safe and acceptable standard.

- Although both jacks studied can be used by one operator, it is recommended that two operators should be used. The second operator acts as an observer and assists in jacking while the felling cuts are made. This is an added precaution when difficult trees are encountered.

- Always try to fall the tree directly against the predominant lean even though this will increase the force to be overcome. Field trials have shown that falling a heavy leaning tree sideways to the predominant lean often leads to failure. This is due to the inability of the jacks and hingewood to counter the side lean component of heavy leaning edge trees.

Portable Winches

- The winch should always be positioned so that the operator is not standing in the bight of the winch rope and remains in visual contact with the faller at all times.

- A major safety advantage of the portable winch is the option of using a single hydraulic jack or extra wedges to assist if the winch fails to pull the tree over. This is particularly important in difficult terrain where extraction machinery is unable to assist. For example, a tree with a 5° back lean, a stem weight of 5.5 tonnes and a rope height of 6.7m was attempted using the Lewis winch. This tree was beyond the winch's capabilities so a single Silvey jack was placed in a block cut out of the backcut and successfully used to assist the winch.

CONCLUSIONS

Each system looked at in this study has its own advantages and disadvantages over the others. These should be carefully considered when deciding which to use. The Silvey and Kajavala hydraulic jacks had the fastest average cycle times of 6 and 7 minutes per tree respectively . The portable winches were significantly slower than both hydraulic jacks at 15 and 16 minutes per tree.

Results showed the Silvey tree jack, Lewis winch and KBF winch to have similar capacities.

The Kajavala tree jack was the least effective in handling edge trees but has some operational and safety advantages over the Silvey tree jack. The Kajavala jack has more application as a felling aid inside the stand.

Hydraulic jacks, unlike portable winches, are lightweight, compact and able to be carried by one person in addition to their normal felling equipment.

Portable chainsaw winches are particularly suited for felling trees whose stumps do not provide enough support for the bases of hydraulic jacks or trees that have a diameter of less than 50cm. Their primary safety advantage over hydraulic jacks is that if they are not able to pull a tree over, jacks or extra wedges can be inserted to give further assistance.

Techniques described in this report should only be used by loggers who have passed the "Machine Assisted Tree Felling" Forest Industry Recognition of Skills module.

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