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The Jackson Beckham Lifting Wedge and the Koller Mechanical Tree Feller: Comparison Trials

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EXECUTIVE SUMMARY

The Steep Land Harvesting Programme developed by Future Forests Research Limited (FFR) and co-funded by the Primary Growth Partnership has the objectives of improving the safety and productivity of tree harvesting of New Zealand's steep terrain forests.

Part of this programme aims to increase the use of grapple yarding through improved payload and grapple control (Objective 2.2). One of the projects in this area is to improve directional tree felling to reduce breakage, improve grapple payload through better alignment of felled trees, and make tree felling safer.

This project was initially instigated in an attempt to minimise the common hazards faced by tree fallers in their day-to-day logging operations, such as felling trees on difficult angles or in difficult positions. With multiple trees falling in various directions, tree driving is potentially a very dangerous practice. It was proposed that an improved felling wedge would substantially lessen the risk of injury when felling trees as it has the potential to offer a faster, stronger and more controlled lift of the tree than conventional wedges. It was anticipated that, in many instances, tree driving should no longer be necessary as the wedge would enable felling large trees in the desired direction.

An earlier project investigated the use of a hydraulic tree felling wedge to determine if it was successful in improving the accuracy of directional tree felling. Following on from this initial work this project aimed at trialling and further developing a locally developed felling wedge, called the Jackson Beckham Lifting Wedge. This is an innovative tree felling wedge, developed as a response to the need for the logging industry to enable safer and more efficient tree felling.

In February 2015, FFR became aware of a commercially available mechanical tree felling wedge from Austria, called the Koller Mechanical Tree Feller. The FFR Technical Steering Team (TST) decided to trial the Koller Mechanical Tree Feller in comparison to the Jackson Beckham Lifting Wedge from New Zealand. .

This report details the comparison trials of the two wedges and proposed recommendations to the TST. The recommendation put forward to the TST is that the Koller felling wedge be used to continue development to a powered, remote-controlled prototype.

INTRODUCTION

Future Forests Research Ltd (FFR) assigned Brett Vincent of Tramroad Limited to investigate a mechanical tree felling wedge developed by Daniel Jackson and Michael Beckham, of Jackson Beckham Ltd, Whangarei (the Jackson Beckham Lifting Wedge). The aim of the project was to establish whether the felling wedge could improve the accuracy of directional tree felling, to improve safety, reduce tree breakage to improve cable extraction productivity and increase harvesting value recovery.

An earlier report (Vincent *et al*., 2014) examined the development and initial trials of the Jackson Beckham Lifting Wedge (JBL wedge). In February 2015 FFR completed trial work with Ernslaw One Ltd in Gisborne relating to a Koller K602 remote controlled cable yarder. Whilst the trial was being set up FFR was made aware that Koller Forsttechnik of Austria had a commercially available mechanical tree felling wedge, called the Koller Mechanical Tree Feller. Ernslaw One Ltd arranged the importation of a number of Koller felling wedges, with one provided to FFR for trial work.

As part of the Improved Felling Wedge project, the FFR Technical Steering Team (TST) decided to fund the comparison of the commercially available Koller wedge with the Jackson Beckham Lifting Wedge currently developed and ready for commercialisation.

This report documents the comparison trials of the JBL wedge and the Koller Mechanical Tree Feller (Koller), and summarises the issues identified with each the felling wedges. The report also provides project direction for further development of the recommended felling wedge with which FFR has decided to proceed.

BACKGROUND

This project was initially instigated in an attempt to minimise the common hazards faced by tree fallers in their day-to-day logging operations, such as felling trees on difficult angles or in difficult positions. Current manual tree felling has a poor safety record of injury and death to workers. The potential for injury is obvious when felling even individual trees, but increases exponentially when the practice of tree driving (felling one tree onto another) is undertaken. With multiple trees falling in various directions, tree driving is potentially a very dangerous practice where guidelines are often ignored. However, tree driving is a common practice in the New Zealand logging industry and is sometimes necessary in order to get particular trees to fall, or to fall in the desired direction. It was proposed that an improved felling wedge would substantially lessen the risk of injury when felling trees, as it has the potential to offer a faster, stronger and more controlled lift of the tree than conventional wedges. It was anticipated that, in many instances, tree driving should no longer be necessary as the wedge will enable felling large trees in the desired direction.

Jackson Beckham Lifting Wedge (JBL)

The JBL Wedge is designed to be carried and used by individual fellers so they always have it at the ready. It is simple, yet strong. The design essentially consists of one plate. This single plate is cut in the centre and is joined at one end by a hinge thereby forming the shape of a wedge which can be wound open by means of a jacking bolt which penetrates the cut plate at the other end.

An initial prototype of the Wedge was built and trialled. While these initial trials proved very successful, modifications were required. The modified prototype was constructed and made available for trialling by Future Forests Research Ltd.

It is foreseen that once prototyping and operational trials are completed, a local (NZ) engineering company will be instructed to manufacture a number of units to be commercially available to the New Zealand logging industry.

Figure 1: The prototype Jackson Beckham Felling Wedge

Koller Mechanical Tree Feller (Koller)

The Koller Mechanical Tree Feller is manufactured by Koller Forsttechnik Company, a forestry company in Austria founded in 1961 by Josef Koller. Coming from an agricultural background and being familiar with the problems of hauling timber in the mountainous Tyrolean region in Austria, Josef Koller developed innovative solutions for logging, such as remote control yarders, carriages and yarding equipment. The product line ranges from small equipment used for young tree thinning, to larger equipment used for the commercial harvesting of mature trees. Koller Forsttechnik is a full-range supplier, manufacturing yarders with various drive systems and mounting them on different carriers.

Koller Forsttechnik also manufactures a range of different logging accessories including the Koller Mechanical Tree Feller. The Koller wedge has been available commercially for two years and the company has sold 120 units, mainly in Europe.

As with the JBL Wedge, the Koller Wedge is also designed to be carried by individual tree fallers so that can be used as part of the tree faller's felling kit. The design is two aluminium plates that have holes punched in them, looking like a cheese grater. A composite plastic wedge is in between the plates and is driven by a screw attached to a ratchet.

Koller has expressed interest in automating the current version, either using the chainsaw as a power source or as a battery driven device.

Figure 2: The Koller Mechanical Tree Feller

METHOD

Project Objectives

Brett Vincent of Tramroad Limited was assigned by FFR to compare the JBL and Koller wedges side by side and report his findings back to the TST.

The objectives of this trial work were to compare:

- performance attributes;
- strengths and limitations relating to each wedge;
- maintenance and wedge life; and
- costs of each wedge and accessories.

While the comparison work was being completed, the original project work objectives were still to be met, which were to:

- eliminate tree driving and the hazard of driving-related accidents and deaths;
- improve the accuracy of directional tree felling;
- reduce felling breakage and thus enhance productivity and value recovery; and
- provide project direction to steer the further development of a productive, lightweight powered felling wedge (beta prototype development).

Trial Process

The trial process over a four-day period was designed to use the wedges as an assistant tool to the use of conventional felling wedges. The comparison wedge trial was to determine which wedge has the better potential to improve felling direction and reduce the impact of stem breakage during felling. A second objective was to determine which wedge would be the easiest to automate.

During the trial the tree faller (Blacky) had control of the felling site, the tree felling process and the use of the wedge. Brett Vincent acted as assistant/observer to carry the wedges and make safety

observations. If the tree faller considered that the wedge should not be used because of safety concerns or production issues, then Brett Vincent moved aside until either it was safe enough, or the tree faller had the time to continue with the trial work.

Figure 3: The JBL Wedge (left) and Koller Wedge (right) working together

Trial Description

The trial was carried out in Waiotahi Valley Forest, where a pa site was being cleared of large old crop radiata pine trees. No machine access was possible as there was farmland and fencing to one side and a water tank inside one tree length. The options for getting these trees felled had initially been discussed with the faller and it was decided to use the JBL and Koller wedges as the best options. It was felt that this would be a good test for the new Koller wedge. Each tree took some work to prepare and a couple were extremely large.

RESULTS

The first trial day allowed the faller to understand the cuts required, and the power and ability of the Koller. Both the faller (Blacky) and observer (Brett) had used the JBL wedge over the previous twelve months and understood its capabilities. Both wedges were successfully used, even together to clear the pa site of the trees.

The Koller exceeded expectations and proved it had the ability to withstand the stresses of everyday use under New Zealand conditions, and compared well to the NZ-made JBL wedge.

Figure 4: Koller wedge in action in Waiotahi Valley Forest

One issue arose from Trial Day One regarding the Koller Wedge. The Koller has a ratchet attached to the end of the screw (Figure 4). The ratchet is used to drive the screw into the wedge thereby forcing the wedge into the back cut of the tree. The ratchet handle is on a universal joint that moves to allow the handle to fold over onto itself (Figure 5). As the wedge gets deeper into the tree it gets harder to turn the handle. As the tension increased on the ratchet handle it folded over, because the operator was not positioned directly in line with the universal joint. As a result of the handle folding over the back of the operator's hand was sliced by the aluminium plates causing a minor injury (Figure 6). Holding on to the universal joint with the other hand while turning and ensuring the ratchet handle is positioned correctly were the lessons learned from this experience.

Figure 5: Universal joint on the ratchet handle of the Koller wedge

Figure 6: Minor injury created by the Koller wedge

The next three trial days were spent learning to fully understand the Koller wedge and how it compared to the JBL wedge. The first task was to understand the strengths and limitations of each of the wedges.

Strengths of each Wedge

Both wedges successfully met the project objectives. Both assisted in directional tree felling with the use of plastic wedges (Figures 7 and 8). They both eliminated the need to drive trees. The JBL wedge can be hammered into the back cut when needed, whereas the Koller can be pushed into the back cut further. The JBL is a lot more robust in its design, which can tolerate hammering. The Koller wedge has a larger lifting height when the wedge is fully inserted.

Table 1: Strengths of each felling wedge

JBL Lifting Wedge	Koller Felling Wedge
• Assists in directional felling	• Assists in directional felling
• Eliminates the need to drive trees	• Eliminates the need to drive trees
• Need to use plastic wedges	• Need to use plastic wedges
• Can be hammered into back cut	• Can be inserted deeper into back cut
• Solid and robust	• Large lifting height (8cm vs. 4cm)
	• Easier to turn

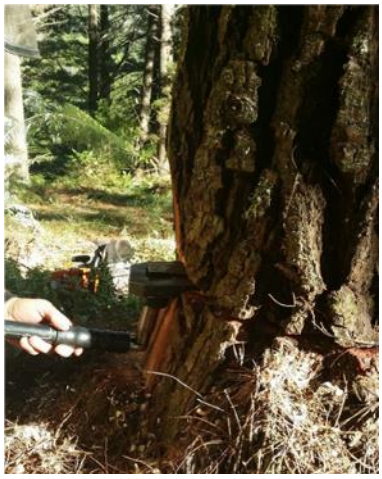
Figure 7: Felling pattern from Koller wedge

Figure 8: Felling pattern from JBL wedge

Limitations of each Wedge

Table 2: Limitations of each felling wedge

JBL Lifting Wedge	Koller Felling Wedge
• Insertion depth is limited by pin (12cm vs 15cm). Pin sticks into fluting.	• Ratchet bar moves whilst turning
• Hammer ratchet not attached to the screw pin, and can fall off the pin during use	• Can push itself out of the back cut in heavy trees
• Extra setup time to get tree over	• Cheese plates can be bent easily
• Top plate narrow and pushing into the top of the back cut	• Pin and wedge can screw apart



Figures 9 and 10: JBL wedge insertion depth

Figures 11 and 12: Koller wedge showing range of insertion depths

Faults of the Koller Wedge

The Koller Wedge is a smooth light weight mechanical tree felling wedge. It however does come with some faults which can be overcome with correct understanding of the wedge's limitations. It is essential to insert the Koller wedge into the back cut as far as practicable. A couple of times during the trials this was not done and the Koller wedge pushed itself out from the back cut (Figure 13). The Koller was inserted only about 3 cm and pulled the tree fibres, splitting the tree down and up. Once the splitting had occurred the Koller forced itself out away from the tree.

Figure 13: Result of Koller wedge forcing itself out of the back cut

The Koller Wedge has a screw pin driven by the ratchet attached at one end, and the other end screws into the composite plastic wedge inside the aluminium plates. On top of one of the aluminium plates is a painted line MAX. This MAX line refers to the full stroke of the pin inside the wedge and it must be adhered to, as overextending the pin screw causes the pin to come away from the wedge (Figure 14).

Figure 14: Koller pin screw going beyond the maximum line

Faults of the JBL Wedge

The JBL Wedge is a solid, robust mechanical lifting tree felling wedge. It however comes with some faults which can be overcome by using the correct chainsaw cuts and clear understanding of how to use it.

The JBL wedge has a small top pushing plate. On heavier trees it pushes into the tree and the tree moulds itself around the plate (Figure 15). This does affect the lifting capacity of the wedge. It requires the wedge to be pulled out, keeping the gap open with plastic wedges and reinserting it in another undamaged location.

The setup of the JBL wedge does take more time than that of the Koller wedge. This is because the screw pin is pointing down and sometimes comes into contact with the fluting of the tree (Figure 16). The back cut also needs to be slightly larger to accommodate the pin.

Figures 15: JBL top plate pushing into the tree

Figures 16: JBL wedge in tree with fluting removed to accommodate the screw pin

The JBL wedge had fail points from the continuous hammering into the back cut. The hinge pin was bent (Figure 17) and the screw pin housing was cracked (Figure 18). Through the pressure created by lifting trees the brass pin cracked at the end (Figure 19). This shortened the life of the brass pin but did not cause an issue with the pin lifting the tree. These issues have been identified in reports back to Jackson Beckham Limited, which is working on resolving the problems that may cause premature failure in the JBL Wedge.

Figure 17: JBL bent hinge pin

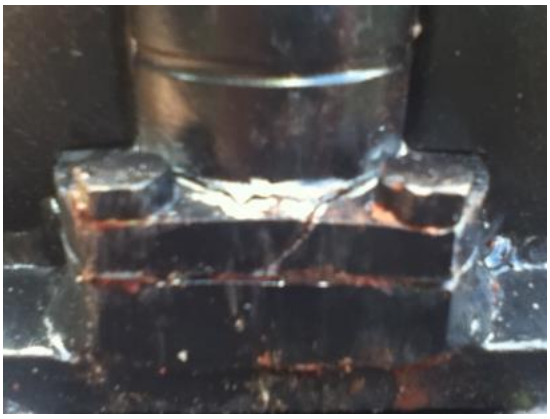


Figure 18: JBL cracked screw pin housing

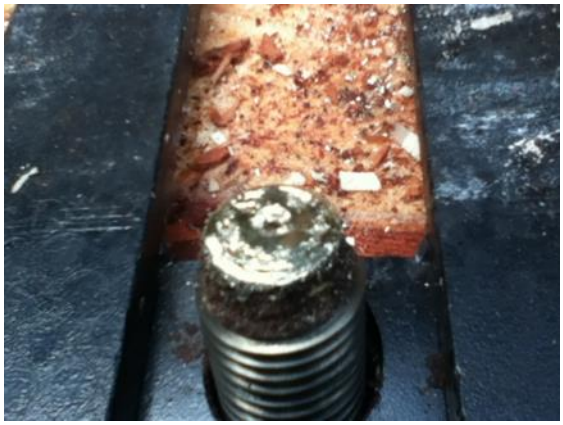


Figure 19: JBL brass pin cracking

Pouch Design

The JBL developers have designed a pouch to carry the wedge. One design uses a harness around the tree faller's combination fuel/oil container to house the wedge (Figure 20).

The first prototype will be made up of canvas with Velcro and clips/buckles on straps to go around the bottom of the container.

The design will house the Wedge threaded bolt in the gap between the petrol and oil sections of the combination container. However the pocket will be big enough so the bolt can move around to counteract weight changes when the petrol container is emptier than the oil container.

Figure 20: Pouch design attached to a tree faller's fuel container

A second design is a harness with a modified tree faller's belt at the bottom (Figure 21). The harness has been attached to allow for the extra weight of the Wedge (4.5kg) to be carried around the hips. The harness incorporates the tree faller's radio. The belt also carries the Wedge, four conventional wedges, the hammer ratchet, a first aid kit and drinking bottle.

The Koller Wedge does not come out with a pouch, but we managed to squeeze it into a faller belt (Figure 22) on the day of trials. The wedge weighs 3.2kg so it can be carried easily on the faller belt.

Figure 21: JBL pouch design on modified faller's belt

Figure 22: Koller wedge on a faller's belt

DISCUSSION

Comparing the two wedges for felling assistance required the following questions to be answered:

1. Did the use of each wedge eliminate tree driving and the hazard of driving-related accidents and fatalities?

   Use of either wedge eliminated the need to drive trees because they both had the power to wedge trees over individually. Both wedges reduced the hazards of tree felling by:

   - allowing the operator to watch the top of the tree at all times, keeping focus on the tree instead of hitting conventional wedges; and
   - allowing a quieter operation, allowing operators to listen for the sounds of felling debris from the top of the tree;

2. Did the use of each wedge improve the accuracy of directional felling and thus enhance productivity?

   These trials showed that both wedges improved the accuracy of directional felling of trees. The measured data showed that trees were laid side by side and not crossed over. Enhanced productivity resulted from the trees being felled in the correct direction for extraction, resulting in no head pulls or the need to turn trees during extraction.

3. Did the use of each wedge reduce felling breakage and thus enhance productivity and value recovery?

   The measured data showed that directional-felled wood reduced felling breakage, which led to fewer pieces to pick up (extract) and therefore improved extraction productivity.

4. Did the use of either wedge require significant changes in operating techniques?

   It must be made clear that all tree fallers will need to adjust how they work to fully utilise either wedge. If the biggest tree with the heaviest lean is attempted using either wedge, then neither will work. They are devices to be used in conjunction with the tree faller's other equipment (conventional wedges) to fell trees safely to maximise productivity and improve value recovery.

5. Did the use of each wedge provide direction for further development of a productive, lightweight powered felling wedge?

   The trials of both wedges allowed tree fallers to gain insight to provide project direction to steer the further development of a device that allows the tree faller to retreat into the safe zone before the wedge is used to lift the tree over.

COMPARISON OF OTHER FACTORS

Table 3 details other factors in the comparison of the two wedges. The cost of the JBL wedge included the pouch and hammer ratchet. The Koller is supplied as a wedge and instruction manual only. The cost of the Koller is 582 Euro which at time of writing (June 2015) converted to around $900 NZ plus shipping. Parts for the JBL wedge are made and stocked in Whangarei, whereas parts for the Koller wedge must be shipped over from Austria.

The JBL wedge at a total weight of 4.5kg was 1.3kg heavier than the Koller wedge. The heavier weight is necessary to be robust enough to allow it to be hammered into the back cut.

Table 3: Comparison of other factors

JBL Lifting Wedge	Koller Felling Wedge
• Cost: $1500, includes wedge, pouch and hammer	• $900, plus shipping
• Parts: Made by engineers in Whangarei	• Parts: Available from Koller, Austria
• Weight: 4.5kg	• Weight: 3.2kg
• Purpose-built pouch	• Can fit into some conventional belt pouches

RECOMMENDATIONS

In summary, both wedges directional fall trees, with no difference measured between tree breakage points on the data collected. Both wedges eliminated tree driving when used correctly. Both needed setup time, but the JBL required slightly longer time due to the fluting from the bottom of the tree. Setup time included the enlarging of the back cut to allow the increased width of these wedges to allow full insertion for maximum efficiency. From the data collected, the Koller wedge can be inserted into the back cut an extra 3 cm further than can be achieved with the JBL wedge. The Koller wedge also provided extra lifting height in the back cut, from being able to insert the wedge into the tree further. Conventional plastic tree falling wedges needed to be used with both wedges. The Koller cannot be hammered into the back cut like the JBL wedge can. The JBL is heavy, but more solid and robust to handle operational use.

Trialling the two wedges over the last 12 months, with recognition of the advantages and operational constraints of each wedge, together with the comparison data collected, has led to the recommendation that FFR pursue further development of the commercially available Koller wedge. Koller Forsttechnik GmbH of Austria has expressed interest in continuing this development to power the operation of the Koller mechanical tree feller (beta prototype development stage).

CONCLUSION

In their current forms the Koller Mechanical Tree Feller wedge and the Jackson Beckham Lifting Wedge can each complete the task they are required to do. The trials have proved that the final designs work. The theory that good directional felling reduces breakage has been validated with measured data. Earlier results showed that in good conditions, use of the wedges can increase average tree length by up to 6% (Vincent *et al*., 2014).

Giving a manual tree faller a tool to directionally fell trees all day long will enhance the safety of manual tree felling and increase extraction productivity. From the completed trial work it is clear that these devices can be used successfully to eliminate the need to drive trees during felling. The wedges can also be used to tip larger edge trees over in conjunction with conventional wedges.

Both the Jackson Beckham Lifting Wedge and the Koller Mechanical Tree Feller can help to improve tree faller's safety. Either unit could become part of the tree faller's standard equipment to result in safer and more professional tree felling.

REFERENCE

Vincent, B., D. Jackson and M. Beckham (2014): "Development of the Jackson Beckham Felling Wedge for Directional Tree Felling. Report No. H018, Future Forests Research Ltd, Rotorua, New Zealand.