

STEEPLAND HARVESTING PROGRAMME

POST-PROGRAMME REPORT 2019



31 July 2019



Ministry for Primary Industries
Manatū Ahu Matua



Steep Land Harvesting Programme

Annual Programme Report

to 30 June 2019

Acknowledgements: Steepland Harvesting was a Primary Growth Partnership between the Ministry for Primary Industries (MPI) and the forest industry led by Forest Growers Research Ltd (FGR). This annual post-programme outcomes report details progress towards achieving short term outcomes to 2018 and medium term outcomes from 2019 to 2024. This report is a contractual obligation of the programme until 30 June 2020. FGR acknowledges the support of all stakeholders in the forest industry in providing information contained within this report.

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1. EXECUTIVE SUMMARY

1.1. Introduction

In 2010 the New Zealand forestry sector and the Government, through the Ministry for Primary Industries (MPI) identified steep country harvesting as the key bottleneck in achieving greater profitability in forestry.

Forest Growers Research Ltd (previously named Future Forests Research) formed a Primary Growth Partnership programme (PGP) with MPI to realise the vision in steep terrain harvesting of 'no worker on the slope, no hand on the chainsaw'. This vision is now being achieved through the implementation of innovative mechanised and remote controlled harvesting technologies to realise substantial safety, productivity and cost reduction gains and improve worker safety in steep terrain harvesting in New Zealand.

Steepland Harvesting commenced in July 2010 and was completed on 30 September 2017. Total programme funding was \$7.60 million (\$3.92 million from the forest industry and \$3.68 million from government).

This second annual post-programme outcomes report details progress towards achieving outcomes to June 2019 and is a contractual obligation of the programme.

1.2. Programme Objectives

The goals of the programme were to improve harvesting productivity and worker safety by developing and commercialising a range of new harvesting technologies in the tree felling and extraction phase of steep country harvesting operations.

The outcomes expected by the end of the programme included:

- A 25% reduction in steep land harvesting costs. This would create operational savings of \$8.00 per cubic metre of wood produced.
- Zero lost time injuries during felling, breaking out and extraction phases of steep country harvesting.
- A 10% reduction in fuel costs.
- Development of new machinery for the harvesting industry for both domestic and export sales.
- Expected total cumulative net economic benefits of \$500 million by 30 June 2019.

1.3. Key Achievements from 2018/19

Notable sector-wide achievements (from the PGP programme and other activities) include the development and commercialisation of machinery and equipment designed to improve both safety and productivity on steeper slopes. In total the sector has supported 20 development projects (including 10 from the PGP programme). Of these projects, 15 products have been commercialised (including 6 commercial products from the PGP programme).

KEY FACTS

- **Forest Growers Research**

Commercial partner

- **7 years**

Programme length

- **\$7.60 million**

Total funding

- **\$3.68 million**

MPI funding

- **\$3.92 million**

Industry funding

HIGHLIGHTS

updated to 30/6/2019

- **25%** increase in cable harvesting productivity since 2010
- **35%** of cable operations now using mechanised felling (up from 1% in 2010)
- **64%** reduction in the number of notifiable injury and serious harm incidents in 2018 compared to 2012
- **350** workers removed from hazardous manual roles of tree felling and breaking out
- **\$170 million** investment in new harvesting technology from 2012 to 2019
- **\$376 million** total net economic benefits from 2010 – 2019

Products include:

- **ClimbMAX Steep Slope Harvester** – Commercially available from ClimbMAX Equipment Ltd. To date 11 units have been sold (8 exported).
- **Falcon Winch Assist** – Commercially available from DC Equipment Ltd. To date 92 units had been sold (including exports). DC Equipment also have orders for a further 23 units.
- **Tractionline Winch Assist** – Commercially available from Electrical & Machinery Services Ltd. (E.M.S.) in Rotorua. To date over 100 units have been sold (including 50 exported). E.M.S. also have 7 more confirmed orders.
- **Remote Operated Bulldozer (ROB)** – Commercially available from Rosewarne & May Ltd in Whangarei. To date 32 units have been sold (22 exported).
- **Waka Winch Assist** – Commercially available from Waka Welding Ltd, Waikouaiti, Otago. To date six units have been sold (all in NZ).
- **Performance Mechanical Winch Assist** – Commercially available from Performance Mechanical & Engineering Ltd (Taupo). To date two units have been sold (both in NZ).
- **HarvestNav machine navigation system** – an on-board computer tablet-based navigation system that displays real time location and multiple operating alarms. Commercially available from Margules Groome Ltd. To date 18 have been implemented as downloaded 'app' and two full systems have been sold.
- **Full Teleoperation** – a trailer-based teleoperation control system. Commercially available from Applied Teleoperation Ltd. No sales have been made as yet.
- **Teleoperated Anchor Machine** – a teleoperation control system for a mobile tail hold machine. Commercially available from Applied Teleoperation Ltd. The first unit has been sold.
- **CutoverCam hauler vision system** – Commercially available from Applied Teleoperation Ltd. To date six systems have been sold.
- **Falcon Grapple Camera** – a robust remote controlled camera system for operation on a mechanical grapple or hydraulic grapple carriage, developed by DC Equipment Ltd (Nelson). To date about 150 units have been sold.
- **Hawkeye Grapple Camera** – integrated into the Hawkeye Grapple Carriage this digital camera system also features LED lighting. Commercially available from EMS Ltd (Rotorua). To date over 50 units have been sold (including around 20 exports).
- **Alpine Grapple Carriage** – Commercially available from Alpine Logging Equipment Ltd, start-up NZ company. To date 13 units have been sold in NZ.

- Falcon Claw Grapple Carriage – Commercially available from DC Equipment Ltd (Nelson). To date, 62 units have been sold (including exports). DC Equipment also have orders for a further 10 units.
- Hawkeye Grapple Carriage – Commercially available from EMS Ltd (Rotorua). To date over 50 units have been sold (including 20 exports). E.M.S. also have 5 more confirmed orders.
- Robotic tree-to-tree prototype – proof-of-concept prototype designed by Scion and built by University of Canterbury Mechatronics programme. No further development has occurred.
- Tension Monitoring ‘app’ – Prototype developed at University of Canterbury. Two units have been installed in hauler cabs of first adopter contractors. This is in the process of being commercialised by DC Equipment Ltd (Nelson), and integrated into the Falcon Winch Assist system.
- Skyshifter Tail Hold Carriage – Prototype twin winch tail hold carriage designed and built by Awdon Technologies Ltd (Gisborne). No sales have been made as yet. Unit is available for operational trialling and lease.
- Doherty Quick Coupler – Prototype quick coupler designed and built by Doherty Engineered Attachments Ltd (Tauranga). Second prototype has been redesigned by Doherty Engineered Attachments Ltd. Not commercially available yet.

1.4. Other Developments

- Falcon 171 Hauler – Tower hauler based on redesigned Madill 171 hauler, developed by DC Equipment Ltd (Nelson). To date 3 units have been sold.
- Alpine Shovel Yarder – Excavator-based tower hauler, designed by Alpine Shovel yarders (South Africa) and manufactured in New Zealand and commercially available from Alpine Logging Equipment Ltd. To date, one unit has been sold in New Zealand.
- Falcon Skylight – Lighting system designed and developed by DC Equipment Ltd (Nelson), for all haulers (towers and swing yarders) enabling night shift operation. To date 20 units have been sold.
- Winch Eye – a remote control camera system for yarders and winch assist machines. Commercially available from Applied Teleoperation Ltd. To date the first unit has been sold.
- Falcon Felling Carriage – Prototype skyline carriage designed and developed by DC Equipment Ltd (Nelson). Two prototypes have been built and the unit is in the process of being commercialised. Commercial production and sale is planned for later in 2019.

1.5. Outcomes

The successful commercialisation of new products and processes is aimed at improving the productivity and reducing the cost of steepland harvesting, and eliminating dangerous manual labour roles. The major outcomes have been the implementation of new processes for winch-assisted felling machinery on steep slopes and increased industry uptake of grapple yarding as an improved method of cable log extraction.

Overall the sector has supported the development of 15 commercialised models of new machinery and equipment. Total number of units of all new technology sold exceeds 670, of which over 200 units have been exported. From 2012 to 2019 over \$170 million has been invested by industry in new harvesters, winch-assist machinery, grapples, cameras and other equipment designed to enable safe work in tree felling and extraction.

As a result of these new processes, mechanised felling is now replacing manual tree fallers wherever possible. With this investment, mechanised felling is now present in 90% of ground-based harvesting

operations and in 35% of hauler operations. Overall the proportion of mechanised felling has increased from 23% of all harvesting operations in 2009 to 58% of operations in 2018.

These sector-wide developments provide innovative harvesting solutions for steep country harvesting and fulfil the objectives of the original Business Plan of February 2010 – to improve productivity and safety on steep slopes. The adoption of this new technology has seen cable harvesting productivity increase by 25% since 2010 when the programme started.

The sector-wide cumulative net economic benefits arising from the programme and other activities are estimated at \$376 million to 30 June 2019 against cumulative net economic benefits in the business case of \$500 million. These cumulative benefits comprise net operational cost savings of \$214 million, and sales of New Zealand made forest harvesting machinery and equipment (domestic and export) totalling \$170 million, less PGP programme costs of \$7.6 million.

Spillover benefits include improving the safety and quality of the workforce environment (reducing notifiable injury and serious harm incidents by 64% from 2012 to 2018). Over 350 workers have been removed from the hazardous roles of tree felling and breaking out.

Other spill overs include developing skills and training, and building technical capability in harvesting machinery manufacturing to future proof the industry. There are now five new forest machinery manufacturing companies developing and selling equipment that did not exist when the programme started in 2010.

The innovations developed by the forestry sector have the potential to further transform forest harvesting and improve economic outcomes substantially for the sector for many years to come.

This transformation will be dependent on further commercialisation and uptake of the forest engineering outputs post-programme. Continued strong support from forest management companies and contractors for increased mechanisation, plus on-going promotion of the work of FGR, will support further adoption of these technology products.

BENEFITS

The cumulative net economic benefits to 30 June 2019 are:

- Operating cost savings of \$214 million
- Machinery sales of \$170 million
- Total cumulative net economic benefits of \$376 million.
- Compared to Business Case forecast net benefits of \$500 million by 2018/19.

On an annual basis the sector-wide net economic benefits in 2018/19 were:

- Operating cost savings of \$84.2 million p.a.
- Machinery sales of \$55.6 million p.a.
- Total annual net economic benefits of \$139.8 million p.a.
- Compared to Business Case forecast annual benefits in 2018/19 of \$134.6 million p.a.

2. PGP STEEPLAND HARVESTING PROGRAMME

2.1. Programme Goals and Objectives

The primary goal was to reduce the cost of harvesting on steep country by introducing new technology that is more productive and cost effective compared with existing equipment. The secondary goal was to remove workers from the hazardous tasks of manual tree felling, breaking out and unhooking.

The total value proposition from the “Innovative Harvesting Solutions” Business Plan prepared for the Primary Growth Partnership (PGP) in February 2010 was to deliver steep country tree harvesting improvements that have a total net economic impact, from baseline 2010 figures, of \$500 million by 30 June 2019 through:

- Reducing steep country harvesting cost per tonne by 25% (\$8.00/tonne)
- Eliminating lost time injury (LTI) incidents in felling, breaking out and extraction phases of steep country harvesting operations which adopt this system
- Reducing current energy (diesel fuel) consumption in steep country harvesting by 10%
- Developing and commercially implementing three new machinery types for the forest harvesting industry (felling machine, grapple carriage and innovative yarding system) for both domestic use and export.

There would also be indirect benefits in developing technical capability in harvesting and machinery development; further reducing the environmental footprint of harvesting in New Zealand; and realising the substantial opportunity to increase establishment of forests on marginal lands, most of which are on slopes over 20 degrees.

2.2. Programme Related Activities in 2018/19

Project 1.1 Steep Slope Feller Buncher and Cable Assist Harvesting: The PGP programme in this area culminated in the commercialisation of the ClimbMAX Steep Slope Harvester (Figure 1). This machine is manufactured by Trinder Engineers and commercially available from ClimbMAX Equipment Ltd. To date 11 units have been sold, including 8 exported. No further sales in 2018/19, with only one potential sale pending. In November 2018, the Trinder Group acquired Harvestech, manufacturer of the Harvestech hydraulic delimber, and from that date all sales and service of the S3000 Harvestech Delimber is managed by Trinder Engineers.



Figure 1: Commercial model ClimbMAX Steep Slope Harvester

Other sector-wide developments include:

- Falcon Winch Assist – This machine is commercially available from DC Equipment Ltd in Nelson. As of June 2019 92 units had been sold (including exports). DC Equipment Ltd have orders for a further 23 units.
- Tractionline Winch Assist – This machine is commercially available from E.M.S. Ltd in Rotorua. To date over 100 units have been sold (including 50 exported). E.M.S. have orders for a further 7 units.
- Remote Operated Bulldozer (ROB) – Designed by logging contractor Lars Rosewarne in partnership with a local engineering firm in Whangarei, this machine is commercially available from Rosewarne & May Ltd in Whangarei. To date 32 units have been sold (22 exported).
- Waka Winch Assist – Designed by logging contractor Bill Winmill of Gillion Logging Ltd, this machine is commercially available from Waka Welding Ltd in Waikouaiti, Otago. To date 6 units have been sold (all in the South Island).
- Performance Mechanical Winch Assist – This machine is commercially available from Performance Mechanical & Engineering Ltd in Taupo. To date 2 units have been sold (both in NZ).

In total 279 winch-assist machines have been manufactured in New Zealand, and approx. 118 units have been exported, mainly to North America.

Project 1.1 HarvestNav machine navigation system: This project designed a decision support application for a computer tablet to provide operators of steep slope machinery with real-time information on machine slope and stability and reduce operator hazards. Initially released as a free download 'app', HarvestNav was later redesigned and repackaged as a commercial 'out-of-the-box' on-board machine navigation system, complete with tablet with pre-loaded software and mounting bracket. Dr Hamish Marshall of Margules Groome completed development of the new version of HarvestNav in August 2017. This was launched at Harvest Tech 2017 and demonstrated at the field demonstration in Nelson.

HarvestNav machine navigation system is now commercially available from Margules Groome Ltd. To date 18 have been implemented as the downloaded 'app' and 2 new commercial on-board machine navigation systems have been sold, complete with tablet with pre-loaded software and mounting bracket. No further programme developments occurred during the year.

On-board felling machine navigation systems are now common place in the industry, providing GPS navigation and felling production data recording on a computer tablet, such as the SATCO Logmapper system.



Figure 2: Commercial model HarvestNav

Project 1.2 (Task A) Teleoperated Felling Machine: This project employed remote control and teleoperation to a commercial model feller buncher, removing the operator from the machine on the steep slope. Two 'real world' applications used part of this research: the John Deere 909 project, and the Volvo 290 mobile tail hold project. The first application converted a John Deere model 909 feller buncher to firstly remote control, then subsequently full teleoperation. This trailer-based teleoperation control system for the John Deere 909 feller buncher is now commercially available from Applied Teleoperation Ltd, Rotorua. During the year transfer of the ownership of the teleoperation equipment to Applied Teleoperation Ltd was completed. No sales of this technology have yet been made by Applied Teleoperation Ltd.



Figure 3: Commercial model Full Teleoperation

The second commercial application of teleoperation, to a Volvo 290 mobile tail hold was initially called the ATL Cab Assist Backline. This teleoperation control system for a mobile tail hold machine, was renamed Teleoperated Anchor Machine (TAM) to better describe the system, which allows the hauler operator to move the mobile tail hold machine remotely from the cab of the hauler.

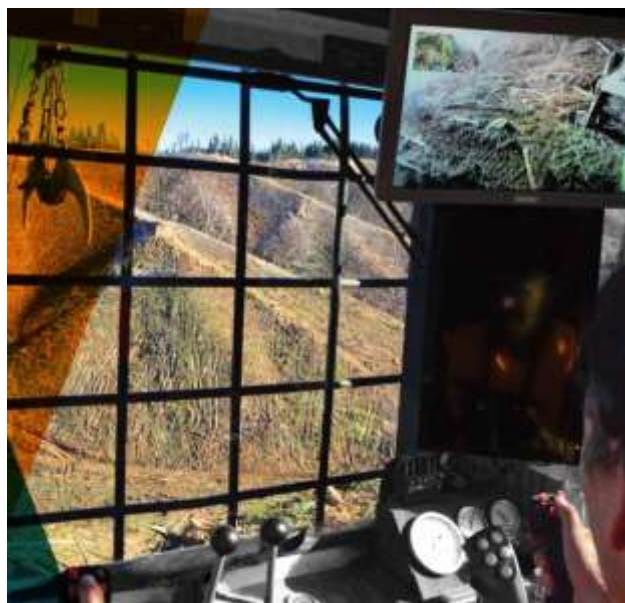


Figure 4: Commercial model Teleoperated Anchor Machine (TAM)

The technology is commercially available from Applied Teleoperation Ltd. The first unit was sold in August 2017 to the first adopter contractor (Wood Contracting Nelson Ltd). The company targets 2 sales per year from 2019.

Project 1.2 (Task B) Tree-to-tree Robotic Felling Machine: This project developed an original concept for an alternative mobility system for a felling machine, using movement from tree-to-tree to traverse across steep terrain. The concept for a robotic tree-to-tree traversing machine (the 'Stick Insect'), was initiated by Scion New Zealand, and further developed into a light weight, remote controlled prototype as part of the Mechatronics Programme at the University of Canterbury. The proof-of-concept prototype was demonstrated in the field to the forest industry in September 2016.

Further investment is required to take this development further to commercialisation. Despite discussions held with Scott Technologies Ltd, and In Fact Ltd a commercial partner for further development has not been identified. No further programme developments occurred during the year.



Figure 5: Prototype Tree-to-Tree Robotic Felling Machine

Project 2.1 Advanced Hauler Vision System: This project involved development and commercialisation of the CutoverCam hauler vision system, a camera located in the harvested cutover streaming live video of the log extraction site to the hauler operator (Figure 6).



Figure 6: Commercial model CutoverCam

Dr Paul Milliken of Applied Teleoperation Ltd completed development of the new version CutoverCam in 2017-18. Commercially available from Applied Teleoperation Ltd. To June 2019, six systems have been sold.

Other sector-wide developments in hauler vision included:

- Falcon Grapple Camera – Designed and built by DC Equipment Ltd (Nelson). It is designed for mechanical grapples on swing yarders. To date about 78 units have been sold. It is also integrated into the Falcon Claw Grapple Carriage (72 units sold).
- Hawkeye Grapple Camera – integrated into the Hawkeye Grapple Carriage this digital camera system is commercially available from EMS Ltd (Rotorua). To date over 50 units have been sold (including approximately 20 exports).
- In total, about 225 new camera systems (including CutoverCam) have been sold in New Zealand and overseas.

Project 2.2 Improved Grapple Control System: This project culminated in the commercialisation of the remote controlled light weight hydraulic Alpine Grapple Carriage, developed by Alpine Logging Equipment Ltd of South Africa. Since early 2019, all Alpine products are commercially available from Alpine Logging Equipment Ltd, a start-up NZ company. To date 13 units have been sold in NZ.

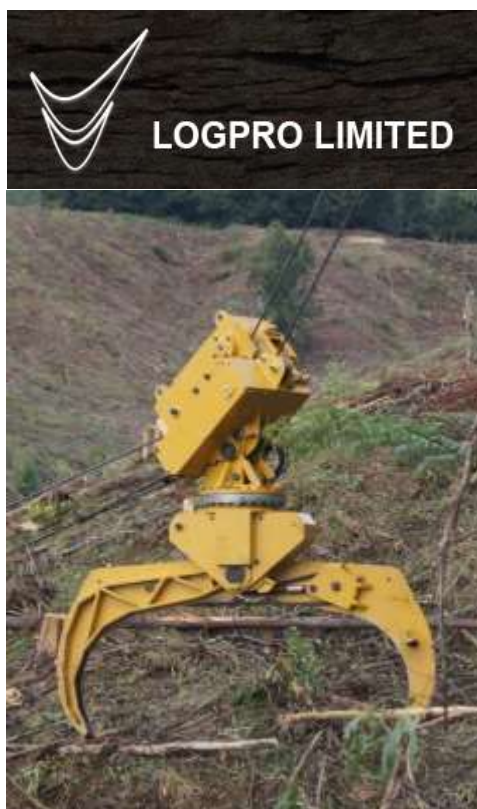


Figure 7: Commercial model Alpine Grapple Carriage

Other sector-wide developments included:

- Falcon Claw Grapple Carriage – Developed by DC Equipment Ltd (Nelson). To date 72 units have been sold (including exports).
- Hawkeye Grapple Carriage – a motorised hydraulic grapple carriage, developed by EMS Ltd (Rotorua). To date about 57 units have been sold (including 20 exports).
- In total, over 140 new Alpine, Falcon and Hawkeye hydraulic grapple carriages have been sold, with 98 sales in New Zealand.

This project also completed fundamental research by the University of Canterbury, School of Forestry in cable rigging configurations and tension monitoring of different cable yarding systems (including the Falcon Forestry Claw grapple developed by DC Equipment Ltd of Nelson) and cable-

assist harvesting systems. This led to the development of a tension monitoring 'app' to be used in conjunction with a tension monitor to extend the range of operation and reduce risks to the operator.

- The Falcon Tension Monitoring System (Figure 8). The first integrated system was installed in the Falcon 60 yarder at Marlborough Harvesting Ltd in January 2018. This unit is now commercialised by DC Equipment Ltd (Nelson), and has been integrated into the Falcon Winch Assist system.



Figure 8: Prototype Falcon Tension Monitoring System

Project 2.3 Innovative Yarding System: This project, investigating alternative new extraction systems and methods to reduce cycle time, improve cable skyline shifting and reduce operational delays, culminated in the development of an innovative twin winch tail hold carriage (the Skyshifter) designed for rapid shifting of the skyline (Figure 9).



Figure 9: Prototype model Skyshifter twin winch tail hold carriage

The developer, Awdon Technologies Ltd is now seeking a commercial partner to take the prototype to full commercial stage. The unit is commercially available from Awdon Technologies Ltd, and is also available on a “lease as required” basis, to enable contractors to use the equipment as and when required. No sales have yet been made.

Project 3.2 Doherty Quick Coupler: This project arose from the Harvesting Technology Watch investigating new technologies internationally, and supporting the development of opportunistic projects. The Doherty automatic quick coupler is a hydraulic quick coupling attachment that enables rapid changeover from grapple processor head to log loading grapple, without the operator having to leave the cab of the base machine. The prototype quick coupler was designed and built by Doherty Engineered Attachments Ltd, of Tauranga (Figure 10).



Figure 10: Prototype Doherty Quick Coupler

After testing it was decided that a second prototype will be redesigned by Doherty Engineered Attachments Ltd. This unit will be manufactured in 2019 and become commercially available in the following year.

3. OUTCOMES

There has been significant progress towards achievement of both short and medium-term outcomes. Outputs of the PGP Steep Land Harvesting programme to date have been recognised by the forest industry in New Zealand as contributing to increased productivity and reduced exposure of workers to hazards on steep terrain.

The NZIER report “Evaluation of the Steep Land Harvesting PGP Programme” to MPI in November 2018 (Nixon & Schrider, 2018), reported that the mechanisation of harvesting of forests on steep land provides a key foundation for the development of a durable steep land forestry industry and potentially has multiple benefits. These benefits include: productivity gains (of possibly over 25%, or \$31 million p.a.); safety improvements (including a dramatic reduction in injuries associated with steep land harvesting); significant domestic and export machinery sales (\$30.6 million p.a.); and a much improved research and development culture (whereby many participants commented on a reinvigoration of harvesting research and innovation activity).

3.1. Short Term Outcomes

The short term outcomes from the programme are:

- commercialisation of new products and processes that improve productivity and reduce the cost of steep land harvesting
- commercialisation of new products and processes that reduce dangerous manual labour roles in steep land harvesting
- new opportunities for New Zealand made forest harvesting machinery in domestic and export markets.

The timeframe for achievement of the short-term outcomes was 2018, only one year after programme completion. Delivery of these short term outcomes has been excellent. The programme has been extremely successful in catalysing development of technologies across the sector that have increased the rate of uptake of mechanisation, improved productivity and reduced the number of serious harm injuries in forestry in New Zealand.

Sector-wide there have been 20 projects to develop new harvesting products. These projects have delivered 15 commercialised products (six from the PGP programme), and five prototype products are in various stages of commercialisation. Many of these developments across the sector were catalysed by the success of projects within the PGP programme. This is a commercialisation strike-rate of 75%, significantly higher than most engineering development and commercialisation programmes.

Sector-wide commercialised products are:

- ClimbMAX Steep Slope Harvester – ClimbMAX Equipment Ltd (PGP)
- Tractionline Winch Assist – Electrical & Machinery Services Ltd
- Falcon Hydraulic Winch Assist – DC Equipment Ltd
- Remote Operated Bulldozer (ROB) – Rosewarne & May Ltd
- Waka Winch Assist – Waka Welding Ltd
- Performance Mechanical Winch Assist – Performance Mechanical & Engineering Ltd
- HarvestNav machine navigation system – Margules Groome Ltd (PGP)
- ATL Full Teleoperation – Applied Teleoperation Ltd (PGP)
- ATL Teleoperated Anchor Machine (TAM) – Applied Teleoperation Ltd (PGP)
- CutoverCam hauler vision system – Applied Teleoperation Ltd (PGP)
- Falcon Grapple Camera – DC Equipment Ltd
- Hawkeye Grapple Camera – Electrical & Machinery Services Ltd
- Alpine Grapple Carriage – Alpine Logging Equipment Ltd (PGP)

- Falcon Claw Grapple Carriage – DC Equipment Ltd
- Hawkeye Grapple Carriage – Electrical & Machinery Services Ltd

Prototypes in various stages of commercialisation:

- Robotic Tree-to-tree Felling Machine – Scion (PGP)
- Falcon Tension Monitoring System – DC Equipment Ltd (PGP)
- Skyshifter twin winch tail hold carriage – Awdon Technologies Ltd (PGP)
- Doherty Quick Coupler – Doherty Engineered Attachments Ltd (PGP)
- Falcon Felling Carriage – DC Equipment Ltd.

3.2. Medium Term Outcomes

The medium term outcomes expected from the programme from 2019 to 2024 are:

- Use of improved steepland harvesting products and processes by NZ forest industry
- Higher productivity and profitability in New Zealand steepland harvesting
- Safer New Zealand steepland harvesting operations
- Growth of the forest harvesting machinery manufacturing sector in New Zealand

Uptake of steepland harvesting products and processes

The programme has resulted in the successful commercialisation and uptake of new harvesting products and processes. Since commercialisation of the ClimbMAX harvester in 2012 and widespread uptake of over 160 winch-assisted machines over the last five years, the level of mechanised tree felling in hauler operations (as reported in the FGR Benchmarking database) has increased to 35% of operations, up from only 1% in 2010 (Figure 11). Increased uptake of feller bunchers in ground-based operations has increased mechanised felling on flat land to 85% of operations.

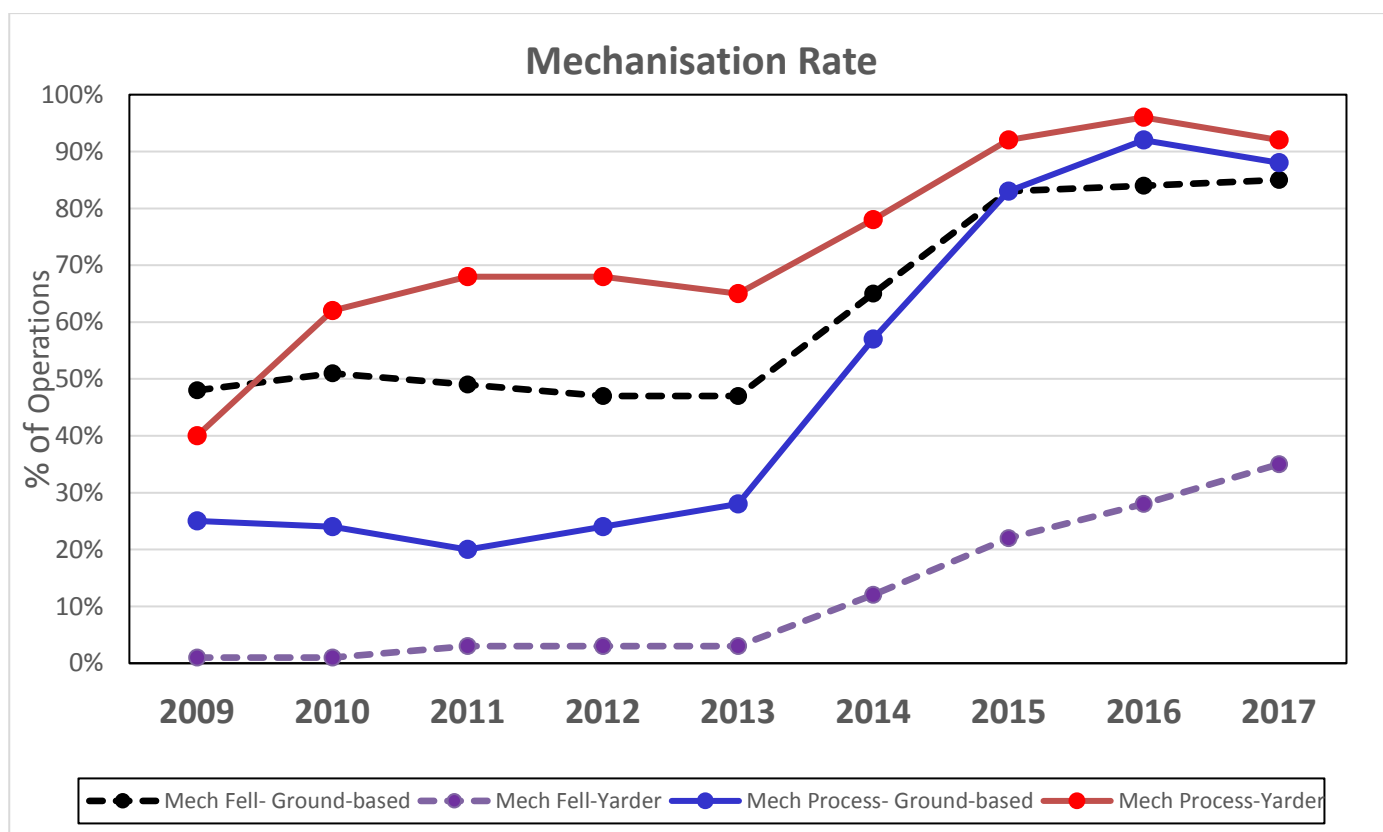


Figure 11: Increase in mechanised felling since 2009

Regarding cable hauler extraction systems, a recent update to the yarder and rigging configurations surveys last undertaken in 2011/12 shows there has been a large increase in the use of grapples (both mechanical and motorised) from 4% in 2012 to 55% in 2018 and a consequent reduction in manual rigging configurations (North Bend/scab skyline/highlead) down from 76% of operations in 2012 to 29% in 2018.

Higher productivity in New Zealand steepland harvesting

To date the industry uptake of winch-assisted felling machinery on steep slopes, and increased uptake of grapple yarding as an improved method of cable log extraction, has achieved productivity increases of 25% increase in cable harvesting productivity since 2013 (29 tonnes/hour in 2018 vs. 23.4 tonnes/hour in 2013 – FGR Benchmarking). In terms of labour productivity, the reduction in crew size together with increased mechanisation has seen continued increases since 2013 from 2.6 to 3.9 tonnes per worker-hour in 2018 (Figure 12).

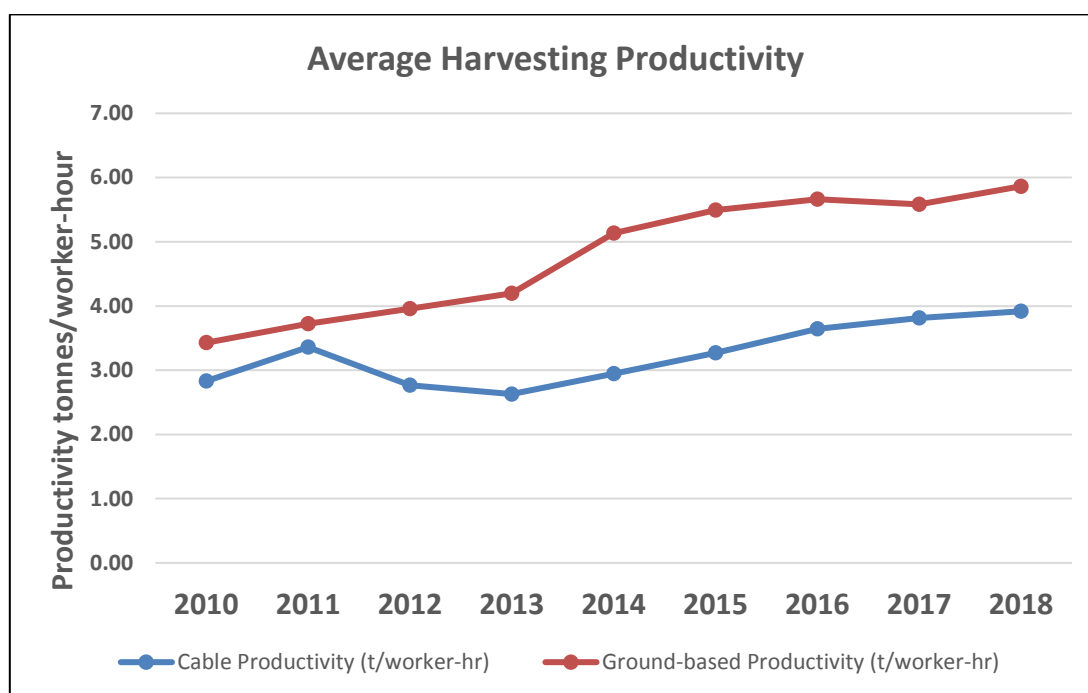


Figure 12: Increased harvesting productivity (tonnes per worker-hour) since 2013

Safer New Zealand steepland harvesting operations

As a result of forest industry safety initiatives arising from the Independent Forestry Safety Review in 2014 and developments in the Steepland Harvesting PGP programme and across the sector, forestry companies and harvesting contractors have increased uptake of winch-assist mechanised felling, and hydraulic grapple carriages. This technology provides a safe alternative to manual tree felling with chainsaws, and manual breaking out, by isolating workers from hazards.

From 2012 to 2018 there has been major investment in new harvesters, winch-assist machinery, grapples, cameras and other equipment designed to enable safe work in steep slope forests. Mechanised felling is now replacing manual tree fallers wherever possible in corporate forests and is starting to be introduced in operations in small forests and woodlots. These innovations are providing forest owners and contractors with solutions to improve productivity and reduce the exposure of workers to hazards on steep terrain.

The combined result of increased focus by WorkSafe NZ, increased injury prevention funding and a step change in harvesting mechanisation, forestry has seen a 64% reduction in the number of notifiable injury and serious harm incidents (SHI) per year from 168 incidents in 2012 to 60 incidents

in 2018. With continued mechanisation and the introduction of automation, this number is forecast to reduce to less than 10 incidents p.a. by 2025.

Even more striking – the rate of serious harm incidents and notifiable injuries per million cubic metres of wood production in 2018 has dropped to less than one-third of the rate in 2012 (Figure 13). This is measured against annual round wood removals from data collected by Ministry for Primary Industries, and the number of serious harm incidents as recorded by WorkSafe NZ. The rate of incidents per million m³ of wood production is forecast to trend towards zero by 2025.

From 2012 to 2018 it is estimated that 357 workers have been removed from hazardous manual felling and breaking out roles. Over the same period annual forest harvest volumes have lifted from 26 million to 36 million cubic metres per annum (+38%).

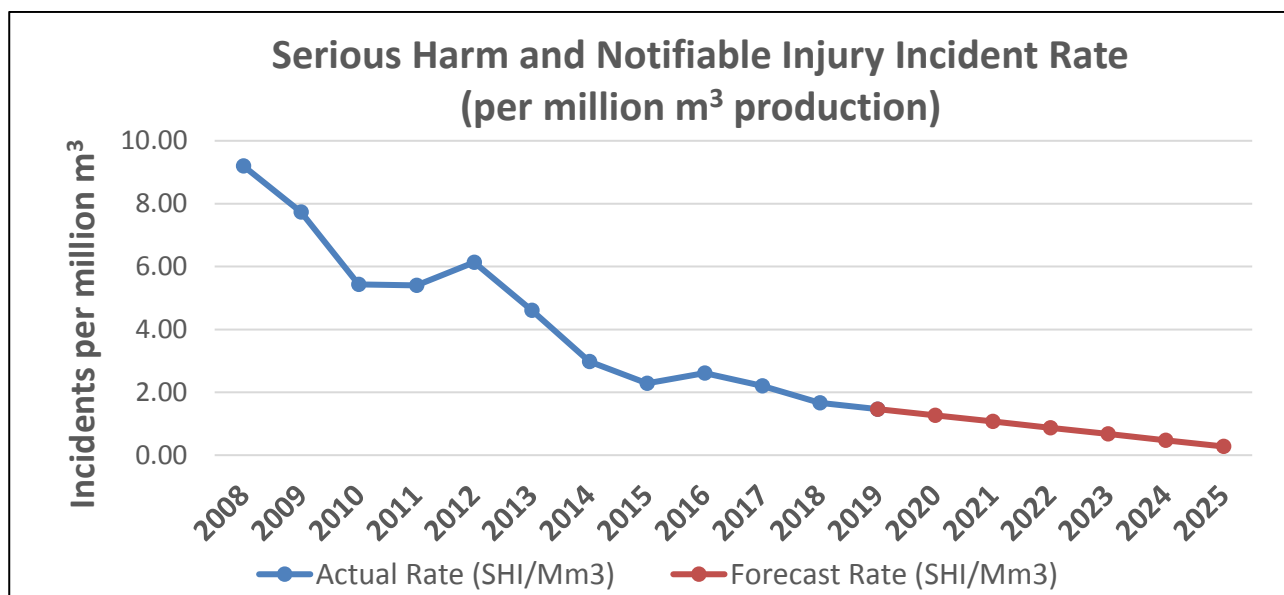


Figure 13: Improved rate of Serious Harm Incidents (SHI) per million cubic metres production

Commercial outcomes for Machinery Manufacturers

There are now five new forest machinery manufacturing companies developing and selling equipment that did not exist when the programme started in 2010 (ClimbMAX Equipment Ltd, Waka Welding Ltd, Rosewarne and May Ltd, Applied Teleoperation Ltd, and Alpine Equipment Ltd).

There are now four main New Zealand companies manufacturing over 80 winch-assist machines between them annually (ClimbMAX Equipment Ltd, DC Equipment Ltd, Electrical & Machinery Services Ltd (E.M.S.), and Rosewarne and May Ltd).

There are now three manufacturers of remote controlled hydraulic grapple carriages in New Zealand (Alpine Equipment Ltd, DC Equipment Ltd, and E.M.S.). DC Equipment Ltd of Nelson has built and sold over 70 Falcon Forestry Claw grapple carriages and over 150 grapple camera systems, plus a new lighting product called Skylight. Electrical & Machinery Services Ltd (E.M.S.) of Rotorua has launched a new hydraulic grapple called Hawkeye with an integrated grapple camera system (over 50 sales) and T-Mar Industries Ltd of British Columbia has also sold several new swing yarders and grapples with integrated camera systems in New Zealand.

4. BENEFITS

4.1. Economic Benefits

Outputs of the PGP Steep Land Harvesting programme to date have been recognised by the forest industry in New Zealand as contributing to increased productivity and operating cost savings in steepland harvesting operations. Table 1 shows the actual direct economic benefits arising from the programme against those envisaged in the original business plan plus one-year extension (2018/19 results are highlighted).

Table 1: Annual Economic Benefits – Budget vs. Actual (to 2018/19)

Benefit	Year	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Operating Cost Savings (\$M p.a.)	Budget	\$0.00	\$6.12	\$14.35	\$25.00	\$38.41	\$54.54	\$65.41	\$78.26	\$95.04
	Actual	\$0.00	\$1.70	\$3.66	\$6.76	\$12.63	\$22.07	\$33.89	\$49.28	\$84.17
Fuel Savings (\$M p.a.)	Budget	-\$0.22	-\$0.50	\$0.00	\$0.80	\$2.18	\$4.07	\$4.73	\$5.27	\$5.86
	Actual	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Injury Claim Savings (\$M p.a.)	Budget	\$0.00	\$0.10	\$0.11	\$0.25	\$0.32	\$0.39	\$0.43	\$0.44	\$0.45
	Actual	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Annual Machinery Sales (\$M p.a.)	Budget	\$0.00	\$1.58	\$3.38	\$5.33	\$7.91	\$11.55	\$16.32	\$26.86	\$33.30
	Actual	\$0.00	\$3.04	\$3.19	\$6.36	\$13.79	\$23.08	\$33.68	\$31.71	\$55.63
Annual Net Benefits (\$M p.a.)	Budget	-\$1.10	\$6.45	\$16.64	\$30.18	\$47.62	\$69.35	\$85.83	\$110.83	\$134.65
	Actual	-\$0.87	\$3.90	\$5.98	\$11.89	\$25.20	\$43.61	\$66.48	\$80.99	\$139.80
Cumulative Net Benefits (\$M)	Budget	-\$1.10	\$5.35	\$21.99	\$52.17	\$99.79	\$169.15	\$254.98	\$365.81	\$500.46
	Actual	-\$0.87	\$3.04	\$9.02	\$20.91	\$46.11	\$89.72	\$156.20	\$237.19	\$376.99

The original business plan (plus one-year extension) envisaged annual net economic benefits in 2018/19 of \$134.6 million p.a. as well as enhanced worker safety. Actual net economic benefits for 2018/19 are calculated to be \$139.80 million (104% of target benefits). Cumulative net sector wide benefits arising both directly from the programme and from related outputs total \$376.99 million to 30 June 2019 against a budget of \$500.5 million. These benefits comprise cumulative operational cost savings of \$214.1 million, plus domestic and export sales of New Zealand made forest harvesting machinery and equipment totalling \$170.4 million less programme costs of \$7.6 million. The annual programme benefits against budget are illustrated in Figure 14.

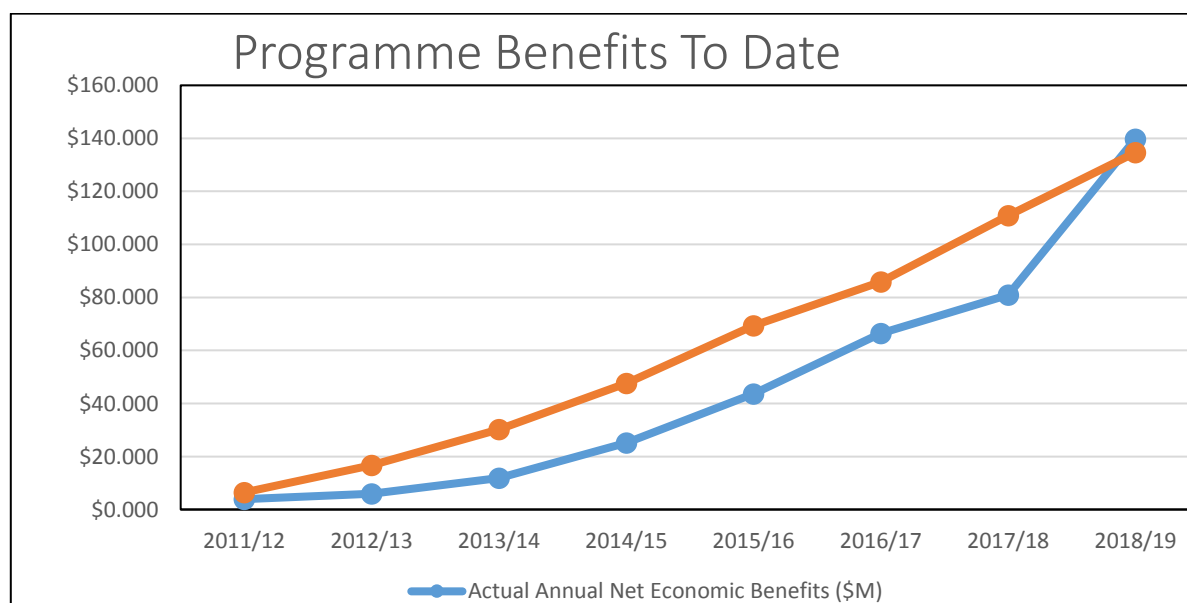


Figure 14: Annual Net Economic Benefits Actual vs. Budget

4.2. Forest Machinery Sales

Sector wide benefits include the development, commercialisation and sale of over 670 units of harvesting machinery and equipment since 2012. These sales include over 270 new winch-assist machines, over 140 new grapple carriages, and over 220 camera systems.

As of June 2019 the following NZ-manufactured machinery and equipment has been sold:

- ClimbMAX harvesters – 11 units sold
- Falcon Winch Assist – 115 units sold
- TractionLine winch-assist – 108 units sold
- Remote Operated Bulldozer (ROB) – 32 units sold
- Other NZ-made winch-assist machines – 13 units sold
- 72 Falcon Claw, 57 Hawkeye and 13 Alpine grapple carriages sold
- Over 220 hauler vision systems sold (including CutoverCam, Falcon Grapple Camera and Hawkeye grapple cams)

From 2012 to 2019 over \$170 million has been invested by industry in new winch-assist machinery, grapple carriages and camera systems and other equipment designed to increase productivity and enable safe work in tree felling and extraction.

4.3. Spillover Benefits

Spillover benefits from the programme have been a large number of training workshops, in harvesting operations on steep slopes with cable-assist harvesting, undertaken by Dr Rien Visser and Dr Hunter Harrill of the School of Forestry, University of Canterbury. The School of Forestry also ran continuing professional development courses in forest engineering, harvest planning, LiDAR analysis and cable-assisted harvesting in August 2018, which fostered uptake of the Steepland Harvesting Programme outputs.

The programme has been successful in building technical capability in harvesting machinery development. The programme has supported the business development of four technology developers (Applied Teleoperation Ltd, Awdon Technologies Ltd, Logpro Ltd and Margules Groome Consulting Ltd) in addition to three machinery manufacturing companies (ClimbMAX Equipment Ltd, Doherty Engineered Attachments Ltd and DC Equipment Ltd).

The programme has achieved a high level of recognition internationally through participation in international conferences, and strong industry collaboration with research organisations such as FPInnovations in Canada and Skogforsk, the Forestry Research Institute of Sweden. FPInnovations have now completed their Steep Slope Initiative in winch-assisted harvesting. This has driven further exports of New Zealand manufactured winch-assist machinery and contribute to the expansion of the New Zealand machinery manufacturing sector, a key objective of the PGP programme. FGR signed an extension to the Memorandum of Understanding with FP Innovations in July 2018 to continue our close working relationship.

5. CONCLUSION

5.1. On-going Activities

- The programme has continued to catalyse increased innovation in harvesting in New Zealand with new technology being developed and deployed, both from the programme and outside of the programme.
- The programme continues to deliver benefits to New Zealand through a continued investment programme by the forest industry in 2018/19.
- Programme outputs continue to be well promoted and communicated to the industry through continued Technical Steering Team meetings and industry conferences. Further extension and promotion to forest industry stakeholders of the work of FGR through industry conferences include the HarvestTECHX Conference in Vancouver in March 2019, and the HarvestTech19 Conference in Rotorua in June 2019. This ongoing communication will continue to promote uptake and adoption of outputs of the Steepland Harvesting programme.
- The programme has achieved a high level of recognition internationally, such as International Trade Shows, international conferences, and field days (such as the HarvestTECHX Conference and Field Day in Vancouver in March 2019). As a result of the programme and other sector developments, New Zealand has taken a leadership role in the development of mechanised forest harvesting operations on steep slopes.
- Continued funding by FGR of University of Canterbury projects in benchmarking harvesting cost and productivity, utilisation of winch-assist machinery, roading planning, cable yarder and rigging configurations survey.
- Continued funding of FGR through the Forest Grower Levy Trust to develop a new programme in forestry automation and robotics applied further down the forestry value chain to continue the momentum generated by this programme.
- The Steep Land Harvesting programme and the new FGR Forestry Automation programme has the potential to further transform the forest harvesting industry and improve economic outcomes in the forestry and forest products sector for many years to come. This transformation will be dependent on further commercialisation and uptake of the outputs of the forest engineering outputs of this programme, combined with strong support from forest management companies driving further adoption.

5.2. Further Post-programme Reporting

An annual programme outcomes report detailing progress towards achieving short term outcomes (to 2018) and medium term outcomes (from 2019 to 2024) will be prepared by Forest Growers Research and submitted to MPI within one month of the period ending 30 June 2020.

6. REPORTS AND CONFERENCE PRESENTATIONS

The following is a list of research reports, journal articles, and conference papers relevant to the PGP Steep Land Harvesting Programme produced in 2018/19:

1. Brown, K., and Visser, R. (2017): "Erosion sources and sediment pathways to streams associated with forest harvesting activities in New Zealand. Report H034, June 2017. Forest Growers Research Ltd, Rotorua.
2. Broadley, J. (2018): "Harvester Simulator Training in Finland". Harvesting Technology Watch HTW-019, October 2018. Forest Growers Research Ltd, Rotorua.
3. Harrill, H. and Visser, R. 2018: "Survey of Yarders and Rigging Configurations: 2018. Harvesting Technical Note HTN10-04 2018. Forest Growers Research Ltd, Rotorua.
4. Nixon, C. and Schrider, J. (2018): "Evaluation of the Steep Land Harvesting PGP Programme". NZIER report to the Ministry for Primary Industries, November 2018. New Zealand Institute of Economic Research Inc., and Forme Consulting Group, Wellington.
5. Prebble, R. and Scott, D. (2019): "Comparison of Felling Heads to Reduce Tree Breakage". Harvesting Technical Note HTN11-01 2019. Forest Growers Research Ltd, Rotorua.
6. Raymond, K. (2018): "PGP Steepland harvesting – a collaborative research and development programme". Presentation to the NZ Institute of Forestry Conference, Nelson, 10 July 2018.
7. Raymond, K. (2018): "Steep Land Harvesting Programme – Post Programme Report 2018". Report H035, 31 July 2018. Forest Growers Research Ltd, Rotorua.
8. Raymond, K. and Hill, S. (2018): "Alpine Shovel Yarder in New Zealand". Harvesting Technology Watch HTW-018, October 2018. Forest Growers Research Ltd, Rotorua.
9. Raymond, K. (2018): "PGP Steepland harvesting – a collaborative research and development programme". NZ Journal of Forestry, November 2018, Vol 63, No.3. Pp18-21.
10. Raymond, K. "Harvesting Programme Update" Issue No. 33, December 2018. Forest Growers Research Ltd, Rotorua.
11. Raymond, K. (2019): "Forestry Automation". Presentation to the HarvestTechX Conference, Vancouver, B.C., 13 March 2019.
12. Treanor, J., Hartley, A., Harvey, G., May, B. and Bell, T. (2018): "Design of a Prototype Autonomous Forestry Extraction Machine". Report H037, October 2018. Forest Growers Research Ltd, Rotorua.