

Safety benefits of a harvesting research programme

Keith Raymond

Abstract

The paper presents health and safety-related research undertaken by Future Forests Research Ltd (FFR), and provides some recommendations for further research to improve the safety outcomes of the forest industry. The forest industry has had a serious safety problem for far too long, with a long-term average annual fatality rate of five deaths per year. Steep country harvesting contributes about half of New Zealand's total annual harvest volume and 39 per cent of forestry fatalities over the last five years. Tree felling and breaking out have been identified as the most common tasks involved in serious harm accidents and fatalities in the forest industry.

The recent Independent Forestry Safety Review has consulted with forestry sector stakeholders about their views on how injuries and fatalities among workers in the industry can be dramatically reduced. It is FFR's view that accidents leading to serious injury and death in the forest industry in New Zealand are avoidable and that the major risks of these incidents in forest harvesting can be significantly reduced. We need to change direction and the Steep Land Harvesting programme – led by FFR and part of the Primary Growth Partnership (PGP) programme of the Ministry for Primary Industries – is aimed at finding out where that direction should be. It is important for the industry to be able to access expert forestry knowledge in order to implement research-based practical measures to prevent further injuries and fatalities in the sector.

The vision of the programme is 'no worker on the slope, no hand on the chainsaw'. This vision sees lower cost steep country harvesting operations carried out in improved working conditions by a highly motivated workforce using sophisticated technology. This step change away from a reaction to poor safety performance towards prevention of accidents will be achieved through isolation of forest workers from hazards, using mechanisation, remote control and semi-automation. No worker in the hazard zone means no accident. On the ground, new technology is the key to keeping workers out of harm's way. However, this programme is only the first step in researching the options and more needs to be done. Future opportunities for research to improve safety and health in forest operations are suggested.

Background

Forest industry safety

The forest industry has had a serious safety problem for far too long. During the 18-year period from 1988 to 2005 there were 94 logging fatalities, a long-term

average annual fatality rate of 5.2 fatalities per year. Analysis showed that felling (41 per cent), breaking out (14 per cent) and extraction (12 per cent) were the three most common tasks undertaken at the time of the fatal accident (McMahon, 2006).

Over the period 2007 to 2013, WorkSafe New Zealand recorded 35 fatalities in forestry – five per year on average (Worksafe, 2014). In 2012 the Office of the Chief Coroner analysed 31 logging fatalities that occurred from 2007 to mid-2013 and found that the task undertaken was tree felling in 12 cases (39 per cent) and breaking out in seven cases, or 23 per cent (Office of the Chief Coroner, 2012). In 2013 alone there were 10 fatalities in forestry – one in 700 workers – and one in every five workplace fatalities in New Zealand (Worksafe, 2014). Seven of the 10 forestry fatalities in 2013 involved tree felling.

Steep country harvesting contributed about half of New Zealand's annual harvest volume and 11 out of 28 forestry fatalities (39 per cent) over the last five years (Dempster, 2014). In the forest industry incident reporting scheme (IRIS) steep slope fatalities are defined as occurring in a cable hauler crew or with 'steep slope' in the incident descriptor. The tasks undertaken at the time of the 11 fatalities were: breaking out (five fatalities or 45 per cent); tree felling (four fatalities or 36 per cent); machine operation (two fatalities or 18 per cent).

Serious harm injuries are also too frequent. Of New Zealand's approximately 7,000 forestry and logging workers, 188 were seriously harmed at work in 2012 – one in 35 (ACC, 2014). Over the five-and-a-half year period from 2008 to mid-2013 there were 967 serious harm notifications in forestry and logging.

McMahon (2006) found that the number of fatalities per 1,000 logging workers generally decreased with increasing productivity (in thousand cubic metres per employed worker). This implied that technological and operational improvements have positively impacted on the fatal injury rate. It was, however, recognised that more needed to be done to reduce the fatality and serious harm injury rate while further improving productivity and that recognition led to the formation in early 2008 of the FFR Harvesting Theme.

Human factors research before 2010

For 10 years after the close of the Logging Industry Research Organisation (LIRO) in 1999, Scion, through its Centre for Human Factors and Ergonomics (COHFE) provided high-quality ergonomics research and consultancy services across a wide range of industries including agriculture, meat processing, wood processing, forestry, construction and manufacturing.

Much of this research is available at www.scionresearch.com/human-factors. The group formerly known as COHFE is now the Human Factors Group at Scion.

Over the period 2008-2010 the FFR Harvesting Theme focused on five research areas, including the uptake of previous human factors research. A review of previous human factors and ergonomics research initiatives from New Zealand and overseas was undertaken by Dr Sophie Hide, including an assessment of the success of implementation of this research. The purpose of the project was to determine the uptake of the research to date, and to determine the reasons for success of some initiatives and why others failed. Previously successful interventions were either of a technical or individual nature:

- Technical interventions included widespread adoption of various personal protective equipment such as high visibility clothing and helmets, or greater adoption of mechanisation, particularly in ground-based operations
- Individual interventions related to practical guidance to improve behaviour such as training or technique change, or self-care aspects such as fatigue reduction measures.

Other successes in systems development included implementation of health and safety management systems by contractors, integrating hazard identification into all production processes, and induction procedures for new workers. Findings also indicated a general lack of progress in many of the interventions relating to key work organisation and management factors. These included:

- Work scheduling – inconsistent taking of breaks and long work days for machine operators
- Production pressure – payment by volume and inconsistent productivity target calculations.

The exploration of these results is highlighted to the industry for further research and implementation (Hide et al., 2009).

Arising from the uptake of the human factors project, it was identified that work organisation initiatives (including job design, alternative communication methods and job rotation) were poorly understood across the industry. Further FFR research concerned the identification of barriers and factors influencing work organisation and scheduling within logging operations, including the effect on the physical and psychological workload of logging workers (Hide et al., 2010).

Dr Richard Parker of the Centre for Human Factors and Ergonomics at Scion carried out numerous studies on individual workers such as tree fellers using helmet-mounted and shoulder-mounted cameras and mini-digital video recorders. In one study of experienced versus novice tree fellers, differences in hazards between the two groups were measured. Critical hazards such as overcutting the back cut during tree felling, driving trees on to each other, and felling into standing trees were significantly reduced for experienced tree fellers (Parker, 2009).

The PGP harvesting programme

Despite this promising start to the FFR harvesting research programme the need was recognised in 2009 for more investment from the government. In February 2010, on behalf of the members of its harvesting research theme, FFR developed a business plan to form a partnership with the Ministry for Primary Industries through the PGP for a Steep Land Harvesting research and development programme called Innovative Harvesting Solutions. This was aimed at developing innovative harvesting technologies to improve productivity and to make steep country harvesting operations safer (FFR, 2010).

Steep country forest harvesting is lower productivity, higher cost and higher risk than harvesting on flat country, primarily due to the higher work requirements and the difficulty factor reducing the options for mechanisation. Cable logging costs are at least \$10 per tonne higher than that of ground-based logging, and tree felling and breaking out have been identified as the most common tasks involved in serious harm accidents and fatalities in the forest industry. Harvesting operations need to keep pace with work demands and new technology to reduce costs and keep workers on the ground out of harm's way.

It is FFR's view that accidents leading to serious injury and death in the forest industry in New Zealand are avoidable and that the major risks of injury and death in forest harvesting can be significantly reduced. In 2009, the New Zealand forestry sector and the government both identified steep country harvesting as a key bottleneck to achieving greater safety and profitability in forestry. They identified that:

- Harvesting costs need to be reduced significantly
- Harvesting jobs must be made safer and more desirable for workers
- The harvest machinery industry in New Zealand must grow substantially to future-proof the industry.

The business plan for the delivery of the Innovative Harvesting Solutions programme spans a six-year period from July 2010 to June 2016 at a total cost of \$6.52 million, excluding GST, and identifies total net direct economic benefits of \$169 million by 2016. These benefits are already arising from both cost savings over current practices and machine sales – domestic and export. The plan has also identified indirect benefits associated with: reduced accident injury claims through improving the safety and quality of the workplace environment; building technical capability in harvesting research and machinery development; and further reducing the environmental footprint of harvesting in New Zealand.

Programme vision

The programme vision is for lower cost steep country forest harvesting operations in New Zealand carried out in safer and better working conditions by a well-trained, highly motivated workforce using sophisticated technology. This is encapsulated in the vision statement: 'no worker on the slope, no hand on

the chainsaw'. The primary goal is 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 is to remove workers from the hazardous tasks of manual tree felling, breaking out and unhooking.

Specific programme goals are to:

- Reduce steep country harvesting costs by 25 per cent, or \$8 per tonne, through increasing productivity by mechanisation
- Eliminate lost-time injury incidents in felling, breaking out and extraction tasks of steep country harvesting operations which adopt this system, through removing operators from hazards and reducing workload
- Reduce current diesel fuel consumption in steep country harvesting operations by 10 per cent, through developing smaller lightweight remote controlled machines
- Develop and implement new prototype products that will contribute to forest harvesting equipment sales and grow the forestry machinery manufacturing industry.

A further challenge for FFR and the sector participants in achieving these goals is the relationship with harvesting contracting firms, which are contracted by forest owners and management companies to undertake harvesting operations. These operations are almost entirely contracted with arms-length business relationships between the parties. The contractors play a critical role in the uptake and use of new technology and new methods, and finding the right mechanisms to secure contractor engagement in the programme, uptake of the outputs, and achievement of outcomes by contractors is an important component of its success.

Development approach

The scope of the programme is harvesting on steep terrain and in particular on the felling, breaking out and extraction phases of harvesting. This is the area with the greatest potential to deliver benefits to this part of the value chain. The programme aims to:

- Eliminate manual chainsaw tree felling through the development of a felling machine for steeper terrain, using the traction winch-assisted machine concept
- Improve working conditions for manual breaking out and improve extraction payload, by bunching felled trees at the yarding corridor
- Eliminate manual breaking out and unhooking roles where terrain conditions allow, through the development of improved grapple control systems
- Create opportunities to increase cable extraction productivity through yarding bunched trees using grapples that reduce cycle time, and increasing the width of the yarding corridor, which reduces the frequency of line shifts

- Develop new systems or techniques that improve worker safety and reduce workload and increase hauler productivity including remote control, semi-automation, hauler vision systems, and alternative hauler and carriage designs
- Investigate safe and productive on-slope delimbing and cutting-to-length options before extraction through widespread application of felling and processing machinery on steep terrain.

The approach over the life of the programme to date has been to run a suite of complementary and mutually supporting projects targeted at a range of points along the value chain, from felling to extraction to the landing. Each project has an intermediate outcome that can be utilised in its own right, the results of which will contribute to the final achievement of an innovative yarding system.

Programme outputs to date

The commercial outputs of the PGP Steep Land Harvesting programme to 30 June 2014 have been:

- Assisting the development of the ClimbMAX Steep Slope Harvester that can safely fell and bunch in steep terrain forests up to 45 degrees slope. This has catalysed the development of many other traction winch-assisted mechanical felling and bunching options for steep terrain. The ClimbMAX is available from ClimbMAX Equipment Ltd.
- Release to the industry of the HarvestNav on-board navigation system. This system provides harvesting machine operators with real-time information about the terrain on which they are working. HarvestNav can use high-resolution LiDAR-derived digital terrain models to improve the mobility and safety of machines on steep terrain. HarvestNav is available as a free download from Interpine Group Ltd.



CutoverCam can be used to monitor breaker out retreat distances



Operator using remote control unit to fell trees with the John Deere 909 feller buncher

- Commercialisation of the first remote controlled hauler vision system, called CutoverCam, which streams live video into the hauler cab allowing the operator to monitor breaker out retreat distances, as shown in the first photo. The hauler operator can pan, tilt and zoom the camera remotely to provide improved safety to breaking out operations in steep country harvesting. It is available from Cutover Systems Ltd.
- Commercialisation of the Alpine Grapple, a lightweight hydraulic grapple carriage used for improved grapple control to facilitate the elimination of manual breaking out and reduce element times for the hauler work cycle. The Alpine Grapple is made by Alpine Logging of South Africa and is available from Logpro Ltd.

Further innovations in the FFR pipeline include:

- The installation of a teleoperation control system into a steep slope tracked feller buncher to isolate the machine operator from hazards. The recent trial of remote controlled tree felling using the John Deere 909 feller buncher on steep country, as shown in the second photo, was a world first (MPI, 2014)
- The development of a new alternative yarding system that is capable of eliminating the hazards and delays in manual line-shifting and increasing the productivity of cable yarding.

These developments are fulfilling the original 2010 aim of the six-year PGP harvesting programme, to improve productivity and safety on steep slopes and to create direct savings of over \$100 million by 2020. Altogether, the projects will produce a whole new innovative harvesting solution for felling, bunching and extraction on steep country that will be safer and more productive than current systems.

Recommendations for improved safety

Recommendations arising from the Independent Forestry Safety Review (IFSR, 2014) must be factual, non-emotive and based on research results. The excessive risk of fatal work injuries in forestry points to a need for prioritising research and intervention programmes to make this industry less hazardous.

The PGP Steep Land Harvesting programme has huge potential to make the forest industry safer while improving its productivity and cost competitiveness. However, the research programme is small compared to other development programmes in the primary sector and it is scheduled for completion in mid-2016. It is vital that the momentum gained through this programme be sustained through additional investment beyond 2016. FFR is the logical delivery mechanism to manage a more extensive harvesting research programme, especially focusing on health and safety. International

research in forestry safety (Bell, 2002) indicates the following:

- Companies using feller bunchers to harvest trees at least part of the time had a significantly lower injury claim rate than those not using them
- High injury rates persist even in companies that receive safety training; high employee turnover may affect the efficacy of training programmes
- Worker turnover was significantly related to injury claim rates, as companies with higher turnover of employees had higher claim rates
- Companies that had more safety inspections per year had lower injury claim rates.

High injury rates in the New Zealand logging industry could be addressed by finding ways to:

- Encourage, facilitate and reward companies that become more mechanised in their harvesting practices
- Address barriers to mechanisation such as short contract tenure and some contractor procurement practices
- Provide technology, such as remote control and teleoperation, that allows workers to be isolated from high hazard zones
- Expand on-job logger training programmes in safe work practices using visual and dynamic multi-media training concepts (Parker, 2010)
- Fund further research programmes to make this industry less hazardous such as:
 - developing new technologies that reduce workload and injury risks such as remote controlled tree-felling wedges to allow tree fellers to move out of the hazard zone before the tree is felled
 - improving the working conditions of loggers such as using exoskeletons to assist fellers to reduce fatigue, or retractable lines attached to breaker outs to help them walking uphill, or clothing that electronically monitors worker fatigue
 - further development and commercialisation of teleoperated harvesting machinery
 - changing supply chain processes to move log processing and sorting off the log landing to a less congested work environment
 - investigating the root causes of worker turnover and implementing initiatives to reduce it
 - identifying the barriers to long-term retention of skilled workers, particularly manual chainsaw workers
 - investigating the effect of increased performance monitoring inspections on injury claim rates
 - exploring the factors that limit the adoption of safe logging practices and the reasons for risk-taking behaviours.

While the PGP Steep Land Harvesting programme targets mechanisation and technology advancement to

remove or isolate workers from the high hazard tasks of tree felling and breaking out, not all operations can be or will be mechanised. Workers will therefore continue to be exposed to hazards and they must be the target for continued harvesting research until operationally practicable solutions can be found.

References

- Accident Compensation Corporation (ACC). 2014. *Preventing Injuries (Forestry)*. See www.acc.co.nz/preventing-injuries/at-work/industry-specific-safety/PI00087 accessed on 6 June 2014.
- Bell J.L. 2002. Changes in Logging Injury Rates Associated With Use of Feller-Bunchers in West Virginia. *Journal of Safety Research*, 33(4): 463–71.
- Dempster, W. 2014. *Statistics on Industry Fatalities from the Incident Reporting Information System (IRIS)*. Personal communication (13 June 2014).
- Future Forests Research (FFR). 2010. *Innovative Harvesting Solutions*. Business Plan prepared for the Primary Growth Partnership, February 2010. Rotorua, NZ: Future Forests Research Ltd.
- Hide, S.A., Parker, R. and Moore, D. 2009. *Human Factors and Ergonomics Research – Uptake and Evaluation*. Harvesting Technical Note, 2(3). Rotorua, NZ: Future Forests Research Ltd.
- Hide, S.A., Tappin, D.C. and Parker, R.J. 2010. *Optimising Work Organisation for Maximum Performance*. FFR Harvesting Report FFR-H003. Rotorua, NZ: Future Forests Research Ltd.
- Independent Forestry Safety Review. 2014. *Public Consultation Document: Factors Influencing Health and Safety in the Forestry Sector*. Wellington, NZ: IFSR.
- McMahon, S. 2006. *Analysis of Fatal Logging Accidents 1988 to 2005*. Report prepared for Forest Industry Contractors Association (FICA), 20 October 2006.
- Ministry for Primary Industries. 2014. *Remote Controlled Tree Felling Trial Shows Promise*. See www.mpi.govt.nz/news-resources/news/remote-controlled-tree-felling-trial-shows-promise accessed 14 August 2014.
- Office of the Chief Coroner. 2012. *Case Study – Forestry. Forestry Deaths at a Glance as at 1/8/2013*. Coroner's Report – Recommendations Recap, (4). Wellington, NZ.
- Parker, R. 2009. *Unobtrusive Work Measurement of Tree Felling*. Harvesting Technical Note, 2(2). Rotorua, NZ: Future Forests Research Ltd.
- Parker, R. 2010. *Using Videos for Training – Breaking Out*. Harvesting Technical Note, 3(3). Rotorua, NZ: Future Forests Research Ltd.
- Worksafe NZ. 2014. *Summary of Fatalities 2007-2013 – Last Updated 27 February 2014*. See www.business.govt.nz/worksafe/research/health-and-safety-data/summary-of-fatalities-2007-2013 accessed on 6 June 2014.

Keith Raymond is Harvesting Programme Leader at Future Forests Research Ltd based in Rotorua. Email: keith.raymond@ffr.co.nz.