‘Innovative Harvesting Solutions’

A Step Change

Harvesting

Research Programme

A new research programme outlines a pathway for the New Zealand forest industry to realise substantial productivity gains through improved harvesting technologies, as Future Forests Research Harvesting Theme Leader *Keith Raymond* explains.

Summary

Cheaper and more effective methods for harvesting trees on New Zealand's steep country are vital if the forest industry is to remain internationally competitive and to grow. By overcoming the limitations of current practices there is potential for the industry to improve its profitability and realise its goals to double in size over the next 30 years. Total direct and indirect benefits of developing a viable solution could exceed $1 billion per annum by 2040.

The forestry sector and the New Zealand Government have both identified steep country harvesting as the key bottleneck in achieving greater profitability in forestry today. They have identified that, after a long period of no Government investment in harvesting research, a concerted collaborative research effort between industry and government is required to improve productivity, reduce harvesting costs by at least 25%, lower the cost and social impact of accidents and make harvesting jobs safer and more desirable for workers. The harvest machinery industry in New Zealand must also grow substantially to future-proof the growth of the industry.

The vision for this plan is encapsulated in the statement - "no worker on the slope, no hand on the chainsaw". The technical outcomes of the programme are to create novel remote-controlled machines that can work safely on the harvesting slope and to develop new high speed cable extraction systems.

To achieve this vision Future Forests Research Ltd (FFR), an entity which formally embodies an alliance between the New Zealand forestry sector, Scion and the University of Canterbury, has developed a robust research and development programme. Harvest engineering and machinery companies and the Ministry of Agriculture and Forestry (MAF, through the Primary Growth Partnership or PGP) have also recently joined this alliance and have provided important input into the development of this programme.

The programme, entitled "Innovative Harvesting Solutions" promises solutions that are well beyond business as usual in harvesting today.

The programme spans a six year period at a total cost of $6.52 million and identifies direct economic benefits of well over $100 million by 2016, rising to over $400 million by 2020. These benefits arise from both cost savings over current practices and domestic and export machinery sales. The plan has also identified indirect benefits associated with: improving the safety and quality of the workplace environment; building technical capability in harvesting and machinery development to future proof the industry; and further reducing the environmental footprint of harvesting in New Zealand. The largest spill-over benefit from finding a cost effective solution to steep country harvesting is to realise the substantial opportunity of improving the profitability of the industry to the extent that the industry can expand forests on to New Zealand's marginal land, most of which is on slopes over 20°. Realising this opportunity could double the current size of commercial forestry in New Zealand by 2040.

Background

The New Zealand forest industry is on a pathway to growth. The latest MAF statistics estimate that the total round wood removals from plantation forests for the year ended 30 June 2010 was 23.49 million cubic metres. By 2016, annual harvest should expand to well over 25 million cubic metres, with a further possible increase to 30 million cubic metres by 2020.

The Challenge of Steep Slope Harvesting

The forest industry has identified harvesting on steep country as a priority. The analysis FFR has conducted indicates that the proportion of the forest harvest from steep hill country (over 20° slope) is currently 44% of the total harvest. This is forecast to rise to 53% by 2016 and to 58% by 2020. From estimates of average recoverable volume per hectare in the National Exotic Forest Description, the area of steep country forest harvested in the last year are calculated at 22,400 hectares, which is forecast to increase to 28,900 ha in 2016 and 37,800 ha in 2020. As harvesting increasingly moves to steeper land and smaller more isolated holdings, the challenges of maintaining international competitiveness with existing logging methods, that have changed little in 50 years, will mount.

Forests in some parts of the country are currently not being harvested where the direct harvesting and transport costs exceed the market value of the forests' recoverable log volume. Examples where net stumpage returns to forest owners are reduced are first rotation forests on steep terrain, distant from existing domestic processing plants and/or ports, without existing roading infrastructure, such as parts of the East Coast (Figure 1).

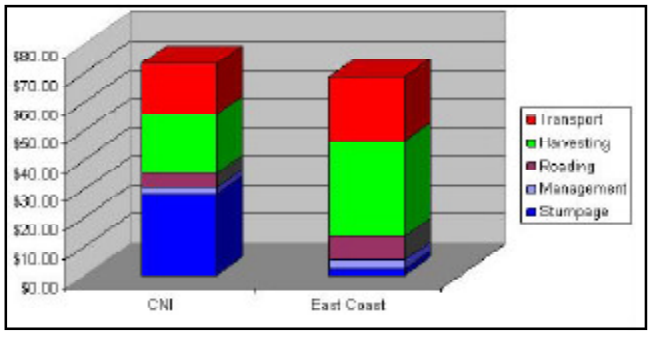

Figure 1: Components of Delivered Log Price ($/tonne)

During the most recent planting boom in the 1990's (when annual new land planting rates exceeded 50,000 hectares per year) significant areas of forests were planted by non-traditional forest owners. Some of these forests have been planted in areas that will be very costly to harvest under conventional means. According to the 2009 NEFD survey, 59 percent of the NZ plantation forest resource is first-rotation forest. Significant expenditure will be required to build roads and harvest these forests using conventional cable logging equipment. The cost of roading and harvesting these forests may well result in a negative stumpage to the forest owner. This is going to be a significant issue when the 1990's plantings are due to harvest from 2015 onwards. Unless harvesting costs are substantially reduced some of these forests may not be economic to harvest.

With harvesting representing about 46% or $32 of the $70 per m^3 cost of a log extracted on a typically hilly site such as the East Coast, the FFR harvesting research programme will create savings of an average of $8.00/$m^3$ of wood produced and result in an improvement in net stumpage returns.

Accounting for industry growth as a result of maturing of forests planted in the 1980's and 1990's to an annual harvest of 30 million m^3 by 2020, including an increase in harvest of steep terrain forests to 53% of total volume, and an increasing research uptake from 35% of total volume in 2010 to over 60% by 2020, this will equate to savings of $54 million per annum over business as usual by the end of this Programme.

This will have a major impact on wood availability as forests that are able to provide lower delivered costs to market are likely to be harvested in preference to forests which have higher roading, harvesting and transport costs.

Market Demand Drives Harvesting

Ultimately, market conditions (such as log and lumber prices and demands, harvesting and transport costs, shipping costs and foreign exchange rates) and logistical constraints (such as availability of logging crews and equipment, availability of roading planners, contractors and engineers, trucking capacity, and wood processing capacity) will determine how quickly the additional wood available from both large-scale forest owners and the large number of small-scale forest owners will be harvested.

Demand for the increased production made possible by improved profitability is underpinned by the fact that New Zealand supplies only 8.8% of the Asia Pacific region's forest products trade, and according to the International Wood Markets Group Ltd, global softwood log demand is growing at 2% per year and global timber supply growth at only 1.5% per year resulting in a tightening of supply.

Today around 70 percent of New Zealand's forest production is exported. Demand for our wood products is forecast to increase over the next two decades from a burgeoning world population and economic growth, especially in the key Asian markets of China, India and Korea which New Zealand is currently supplying. This will enable the industry to fully utilise the increasing availability of the wood resource.

Economic development in the key emerging markets of China and India is likely to remain strong. From 2010 to 2030, the average annual GDP growth rate for China is expected to be around 5.5 percent and 5.1 percent for India.

In 2007, China imported about 28 million cubic metres of logs from Russia, which made up 75 percent of its total log imports. Chinese imports from Russia dropped to less than 20 million cubic metres in 2008, and are currently around 15 million cubic metres as a result of the Russian log export tax increase to 25 percent of log value. This has left a huge supply gap that created opportunities for other exporting countries, such as New Zealand. Chinese buyers' desire to have an alternative source of supply will continue to work in New Zealand's favour. China's total log import volume for the March 2010 year was about 30 million m^3 and NZ log volumes into China have more than quadrupled from 1.221 million m^3 in the year to June 2007 to 5.384 million m^3 in the year to June 2010. New Zealand was the second largest source of log imports to China for the March 2010 year, behind only Russia.

Log marketing opportunities into India resulting from changes in India's domestic regulatory regime have seen NZ log volumes increase from 405,000 m^3 in the year to June 2007 to 1,024,000 m^3 in the year to June 2010.

But Profitability Is Still Low

In general, when net log returns increase, harvesting will increase, and when net log returns fall, the level of harvesting will generally fall. Export log prices in New Zealand dollars rose 31 percent in the December 2008 quarter, due to a depreciating New Zealand dollar and much lower shipping rates, which led to the largest quarterly increase in log export revenues since 1993. Total log export revenues more than doubled from $396M in the year to June 2005 to $1,075M in the year to March 2010.

Average export log prices peaked in February 2010, slightly below the most recent peak in the December 2008 quarter. For this quarter the average NZD/USD exchange rate however was 0.71, compared with 0.58 in the Dec 2008 quarter.

Ocean freight rates, which generally follow world oil prices but are also influenced by available capacity, have trended upwards from the lows observed in March 2009 (US$20 per JAS cubic metre) to rates in the region of US$45-50 per JAS cubic metre to China and Korea.

Looking forward, total forestry export revenue is expected to improve modestly from the year ended 31 March 2011, due mainly to the depreciation of the New Zealand dollar, with international prices and volumes expected to be weak in 2011.

The Need for Innovation

It is forecast that the outcome of cost reductions as a direct result of this programme will contribute to an improvement on forest profitability thus allowing an expansion of forestry onto marginal land. Over the last five calendar years (2005 - 2009) new planting has averaged around 4000 hectares per year.

If the profitability of forestry can be improved (as an outcome of this programme and other events) it is estimated that new forest planting could increase to 10,000 hectares in 2012 (when the benefits of this programme start to accrue); to 30,000 hectares (the average new planting rate between 1999-2003) in 2016, and then up to 70,000 hectares per year (the average new planting rate during the period 1992 to 1998) by 2020. This could see the planted forest area increase from the current area of 1.751 million hectares (March 2009) to 3.5 million hectares (i.e. double the size of NZ forestry) over the next 30 years. As a result of this New Zealand could expect to see at least another $1 billion of economic growth by 2040.

NZ's unique combination of soils, terrain, climate, forest type and infrastructure means we cannot rely on overseas research to solve our problems. Overseas research in harvesting and equipment development is focused primarily on mechanised operations on flat terrain. Much of the European harvesting equipment is not robust enough to handle New Zealand plantation grown species. This problem has been exacerbated by the closure of the North American manufacturers of harvesting equipment traditionally used in New Zealand, meaning the industry is currently reliant on ageing second hand equipment that will limit our ability to improve the productivity and safety of harvesting operations on steep terrain. The recent developments with a local engineering company signing an agreement to build Madill equipment in New Zealand will go some of the way to improving this situation, but as an industry we need to do more. In addition to meeting the industry need for equipment to significantly improve productivity and cost of operations, the programme has also identified the opportunity for more local engineering firms to produce quality forestry equipment for both local and export markets. There is an international market for New Zealand-developed forestry machinery due to its robust design.

A further reason for undertaking this programme is to address the current shortage of skilled people to work in physically demanding, difficult and dangerous situations that occur in harvesting on steep terrain and to find ways of eliminating the most dangerous and physically demanding jobs and making the work more attractive to people. Increased mechanisation of steep country harvesting will provide work functions that are safer and of a higher quality (machine operation is highly regarded as the top role in logging crews) and the resultant increases in productivity and profitability will result in an enhanced ability for employers to pay higher wages. This will lead to improved role attractiveness and job satisfaction in the logging workforce.

Programme Scope

The forestry value chain involves many interlinked activities with each step impacting on subsequent steps as part of an integrated chain from standing trees to delivery of that fibre to customers. It is therefore important that the scope of this research programme was defined clearly so that the boundaries of each projects were well established at the outset as shown in the Figure 2 below.

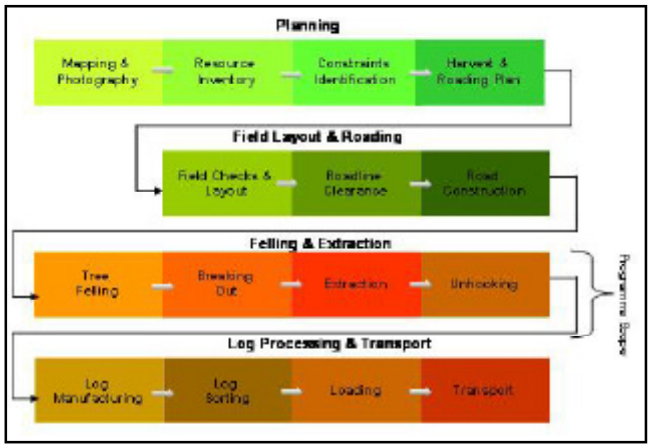

Figure 2: Scope of Research Programme

The programme will focus on harvesting on steep terrain and in particular on the felling, breaking out and extraction phases of harvesting. This is because we believe this is the area with the greatest potential to deliver benefits to this part of the value chain.

Work Programme

The programme vision is low cost steep country harvesting operations carried out in safer and better working conditions by a well trained, highly motivated workforce using sophisticated technology.

To achieve the vision we need to develop a paradigm changing new system for the extraction of stems and/or logs from steep country. The focus of the steep terrain programme will therefore be:

- Developing alternative tree felling systems with the aim of eliminating manual chainsaw felling. This will require a machine capable of carrying a felling and/or delimbing head that can be operated remotely on steep terrain and hence have the lowest environmental footprint and have a zero hazard risk to the operator.
- Evaluating alternative systems for improving payload with the aim of eliminating manual breaking out and unhooking roles. The ability for logs/stems to be located by a high speed automated grapple system then rapidly connected to the hauler will be developed.
- Evaluating opportunities to improve hauling productivity through new systems or techniques including automation, vision systems, remote control.
- Ultimately designing an alternative cable hauling system to increase speed of recovery, such as developing an 'endless loop' cable system for for continuous extraction (as opposed to the existing inhaul-outhaul extraction system).
- Evaluation of a change to cut-to-length (CTL) options once log making prior to extraction becomes feasible through widespread application of machinery on steep terrain.

This is a long term vision that may involve further innovation programmes beyond this initial 6 year Programme. Successful concepts and their development will be supported through other investments as risk is quantified.

The Programme has been divided into three interrelated Objectives:

1. Mechanisation on steep terrain.
2. Increased productivity of cable extraction.
3. Development of operational efficiencies.

Each Objective is designed to contribute to achieving the overall Programme vision through a number of projects each providing short term outcomes and also increasing in technological stretch:

Objective 1 - Mechanisation on Steep Terrain

This Objective will focus on improving capability of machines to operate on steep terrain. Felling on steep country is one of the most dangerous and physically demanding roles in harvesting, and mechanising the felling on steep terrain will eliminate this dangerous role and allow the felled stems or logs to be better accumulated and presented for attachment to the grapple/carriage. A critical component in cable yarding productivity is the time taken for an optimum load to be secured to the cable, and mechanised felling and bunching can lead to significant improvements in this area.

Project 1.1 Load Accumulation and Stem Presentation to Grapple/Carriage is aimed at further development of the tractive capacity of ground based machinery on steep terrain to enable bunching and presentation of wood to the hauler grapple/carriage. The prototype steep slope harvester designed by programme co-investors Kelly Logging Ltd and Trinder Engineers, is capable of operating on slopes up to 45 degrees on a range of soil types.

Project 1.2 Tele-operated Machine for Steep Country Harvesting will aim to employ remote control (teleoperation) where terrain, ground roughness or soil type limits manned felling and bunching machine operation.

Figure 3: New grapple design from Eagle Inc.(USA).

The project will develop a remote controlled feller-buncher capable of felling and/or delimbing and bunching trees on steep terrain. Remote operation will enable the removal of the operator from a dangerous area and minimise ground disturbance through lighter weight and a lower centre of gravity than existing felling machines. Technology from other industries will be utilised in addition to harvesting technologies developed from other countries with smaller tree size and flatter terrain.

Objective 2 - Increased Productivity of Cable Extraction

Cable yarding system productivity is determined by: yarder type, yarding distance, stem volume and bunching strategy. The rate limiting step in cable yarding is the speed at which wood can be extracted from the point of attachment to the landing site where it is unhooked from the hauler. This Objective is designed to provide technology which improves the productivity of this phase of the operation and ultimately to develop alternative systems to those that have traditionally been used to extract wood from steep terrain.

Project 2.1 Advanced Hauler Vision Systems is aimed at improving the visibility of the breaking out operation to the hauler operator. Climate and hilly terrain often means the operator is working blind. The project will investigate utilising equipment used in other industries, e.g. mining, to improve operator visibility and increase productivity. This would eliminate the role of the manual "spotter" in the case of conventional grapple yarding operations and encourage the more effective use of grapples to displace the use of carriages with strops which require manual "breaking out" - hence removing one of the most hazardous roles in cable logging.

Project 2.2 Development of Improved Grapple/ Carriage Control Systems will aim to develop a cost effective high load capacity system for automated return of the grapple/carriage to the next load. In addition the project will investigate the remote control of the grapple/carriage from the feller-buncher operating on the slopes. This project would be a step towards development of a fully automated intelligent grapple system.

Project 2.3 Innovative Yarding System will investigate alternative new extraction systems based on a high speed, mobile, long span yarder capable of high volume productivity at low cost. Use of alternative methods to provide lift and/or intermediate support and innovative new aerial cableway yarding systems will be explored. One example concept to be developed is a continuous loop cableway system using multiple grapples. Current systems utilise "outhaul" and "inhaul" functionality which is potentially slower than a continuous hauling system such as those used in mining and transportation (e.g. gondolas or ski lifts). This system has the potential to eliminate much of the interactive delay time inherent in conventional cable yarding. More constant power and continuous loading will also reduce wear and tear on engines and reduce fuel consumption. Another example concept is an integrated "Feller-Buncher-Yarder" system where the feller-buncher is designed to form an "intermediate support" for the cables running out to a mobile tail hold. As each tree is cut and extracted the "intermediate support" moves to the next tree thus ensuring the grapple/carriage will always return close enough for extraction of the next trees felled.

Objective 3 - Development of Operational Efficiencies

In addition to development of new technology solutions, the harvesting research design will adopt a systems approach which includes integration of system components and harvest system design. In this Objective two projects have been included as system feasibility studies on the basis that future operational developments may drive cutting stems to log length prior to extraction; and regulatory pressures over accumulation of residue material and dispersal in the forest may also drive change.

Project 3.1 - Feasibility of Delimbing/Cut to Length on Slope will capitalise on Objective 1 (in terms of capability of machinery on steep slopes) to investigate the feasibility, costs and benefits of mechanised delimbing on the slope, including impact on subsequent operations. This concept ensures residues (tree limbs and tops) produced are dispersed around the harvesting area creating a mat for machine travel thus substantially reducing the environmental footprint. The feasibility of cutting to log length using log optimisation processes on the slope will also be investigated as hauling smaller pieces at a faster rate would permit the use of lighter and cheaper yarding equipment and eliminate the residue problem on the landing. The obvious tradeoffs here against the advantages of assembling all the value-adding tasks in a more controlled environment, such as a landing or log yard, will be evaluated.

Project 3.2 - New Hauler Technology & International Monitoring will investigate new yarder technologies internationally and support the development of other projects including the integration of other functions, such as processing, into the materials handling functions of the hauler machine to utilise existing production down time and spare engine capacity of the hauler.

PROGRAMME FUNDING

The FFR vision is to ensure a prosperous future for New Zealand's plantation forest industry through innovative, well focused research of a world class standard. This programme, in the Harvesting Theme, spans a six year period at a total cost of $6.52 million. A Programme Steering Group has been formed to provide project oversight, strategic direction and to ensure the valuable end-user research interface continues to be strengthened. It will include the CEO of FFR (Chair), representatives from industry investors and the Ministry of Agriculture and Forestry, the FFR Theme Leader and Scion Programme Leader. Recognising the need to move well beyond business-as-usual approaches in harvesting, the technical team incorporates diverse skills, such as mechatronics and engineering design and manufacturing specialists, assembled from Scion, University of Canterbury, engineering and manufacturing companies and consultants.

The FFR Harvesting Theme has 25 members with most of the significant forest owners and forest management companies in New Zealand participating. In addition the key forestry educational and training organisations, the Ministry of Agriculture and Forestry and a number of Regional Councils and District Councils who are forest owners are members, along with industry advisers, service providers and engineering companies.

Because forest contractors are key to successful technical transfer/research uptake, FFR has an associate membership category for harvesting contractors. FFR also maintains close contact with the Forest Industry Contractors Association (FICA) and their members are regular attendees at FFR regional technical meetings and workshops. More information on communication and technology transfer is available via the FFR website (www.ffr.co.nz).

Committed industry funding for the existing FFR harvesting theme is already some $350,000 cash per annum (2010/11) with significant in-kind support through forest company staff time, contractor assistance with plant and equipment for operational trials, engineering design and evaluation, data in the form of harvest plans, crew productivity and performance data, forest inventory and GIS information. It is anticipated that this in-kind support will increase to approximately $100,000 per year over a two year period.

The intention is to grow the industry cash contribution from the current level to $500,000 per year over a two year period by enlisting the support of the few major companies who are not currently involved in the FFR Harvesting Theme but who stand to benefit from productivity improvements on steep terrain, or by increasing member company contributions.

The total industry contribution (cash plus in-kind) is matched by Primary Growth Partnership (PGP) investment, to give the total annual projected research funding for the programme of $1.2 million.

If Journal readers would like more information on the FFR Harvesting Theme or this research programme, please contact Keith Raymond at Future Forests Research, or email keith.raymond@ffr.co.nz.