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In this issue

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– Te Pūtahi Ngāherehere o Aotearoa Incorporated –

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– Te Pūtahi Ngāhere o Aotearoa Incorporated –

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Front cover photo: Innovative forest engineering – the Falcon felling carriage. Photo courtesy of Dale Ewers, DC Equipment Ltd

Back cover: Top – Sumatran macaque. Photo courtesy of George Kuru and Tony Wood; Bottom – A cut slope on a newly-constructed road that has slumped following a rainfall event in Gisborne. Photo courtesy of Kris Brown and Rien Visser

Nelson 2018 conference

Chris Goulding

This issue includes a short report on the AGM, the Forester of the Year and Thomas Kirk awards, and the 2018 NZIF conference held at Nelson in July. Andrew McEwen describes the activities of the NZIF Foundation including the 2018 awards – 'more awards, more applications and a record level of distributions' ($44,500). Peter Wilks of the conference organising committee provides 'The last word'. He comments that in the 30 years since he graduated many new wood products have been discovered; in his local hardware store sawn '4 by 2' at $6.45/linear m is in competition with engineered laminated veneer lumber (LVL) at $6.20/linear m.

The opening address of the conference was given by the Minister for Forestry, the Hon Shane Jones. After the extended period of years when the production forest sector relied entirely on market forces, it is a pleasure to have a Cabinet Minister with an interest in forestry. This interest is not for forestry itself, but rather for what it should be able to do for the benefit of the regions and for New Zealand. However, the Minster warned that the plantation forest industry's licence to operate is totally dependent on the opinion of the general public, opinion that will turn against pine forests should there be more of the logging debris disasters, as at Tolaga Bay. In 1987, it was evident that opinion had turned against the NZ Forest Service. I have always thought it ironic that Ronald Reagan, Margaret Thatcher and recently Caroline Spelman (Conservative, UK) were unable to disestablish their equivalent public service organisations, nor were they able to sell off their state-owned forests thanks to public opinion, whereas a New Zealand Labour government did so with hardly a murmur of public protest.

The lead paper in the issue is from Julie Collins, acting head of Te Uru Rākau (Forestry New Zealand) which is now up and running, re-establishing a government forestry service to support and promote forestry. She stresses that this starts with 'a shared vision to transform our future', with the organisation providing focus for the government's forestry goals.

Forests and wood do have a great deal to offer. The May issue featured a paper from British Columbia on the construction of an 18 storey, 54 m tall mass-timber building demonstrating the new potential of wood in high-rise buildings. The NZIF conference field trip culminated in a visit to the new Nelson Airport Terminal under construction that uses LVL and plywood in combination to provide a striking building, somewhat more inspiring than the corrugated iron cladding of the airport terminal in the Editor's former home town of Rotorua. The construction of the Nelson terminal is described in a paper by Novak et al., which the authors hope will increase producer awareness of the issues of using engineered timber in buildings.

Similarly, the drive towards mechanisation of forest operations has not only resulted in increased productivity, but also increased safety and a reduced rate of severe accidents. It has also stimulated a New Zealand-based, high technology machinery manufacturing industry with a thriving export component. There were two presentations at the conference on this subject. Dale Ewer described a mission to change logging, to fell and retrieve a tree at the push of a button, illustrated by the Falcon felling carriage shown on the front cover.

Keith Raymond's paper describes the Steepland Harvesting research programme. He notes that collaboration between research, industry and government through the Primary Growth Partnership improved commercialisation and reduced the investment risk to logging contractors. This innovative machinery development is only possible now that the level of the New Zealand harvest is sufficient to provide a substantial base home market for the products.

The paper about forestry in Indonesia by Kuru and Wood should be read with more than passing interest. Their forest industry is changing rapidly, with significant problems to overcome. Disease and pests have caused 500,000 ha of *Acacia mangium* plantations to be transitioned to *Eucalyptus pellita* in a very short time. Management of peatland soils is contentious with the proposed retirement and restoration of four million ha significantly affecting wood supply. Although the forest land is government owned, in reality all plantation forestry in Indonesia is community-based and each forestry company has a department devoted to community relations that must work with locals for the management and protection of the concessions. With pulpwood plantations totalling 2.5 million ha, five to seven-year rotation lengths and mean annual increments of 23–25 m^3/ha/year, and a further equal area of rubber and teak plantations, this 'developing' country exported a grand total of 59,000 m^3 as unprocessed logs. Almost all the log harvest is processed within Indonesia.

Each of the Indonesian problems above has its parallel in New Zealand conditions, even if the risk to the health of radiata pine is currently only a risk. The Minister for Forestry has stated that increasing the amount of domestic processing at the expense of log exports is a key objective, perhaps not to the low level of log exports as in Indonesia. Reconciling the competing interests between forest growers and landowners anxious for the best possible net log price with forest processing companies hoping for competitive log supply costs will occupy the thoughts of Te Uru Rākau. The industry itself is on notice that it must greatly improve its community relations, and not just for logging debris or merely through a PR assault.

Reclaiming our forestry heritage together

Julie Collins

A strong processing sector is an important part of achieving the government's wider economic development, environment, sustainability and employment objectives. It will also support the domestic building industry

Whakapūpūtia mai ō mānuka, kia kore ai e whati.
Cluster the branches of the mānuka, so they will not break.

Forestry means different things to different people – and that's a good thing. It's about harnessing those ideas, values and visions to create one shared goal – a cluster of branches, if you will – that will provide the foundation for what success will look like for the industry over the next 100 years and beyond.

Opportunities we take up now will enable the forestry industry to diversify, innovate and grow to deliver further social, environmental and economic benefits across the country. We also have the chance to see forestry plays a significant role in moving New Zealand towards a low emissions economy. How will we do this?

Creating a shared vision

It starts with a shared vision to transform our future, which the government has instructed Te Uru Rākau (Forestry New Zealand) to lead with the One Billion Trees programme. The aim is to see at least one billion trees planted over the next 10 years. Among other things, we will see diversity of income for landowners, improvements in land productivity, environmental issues like erosion, water quality and climate change addressed, and increased habitats for a range of native species, enhancing our natural landscapes and creating real jobs in the regions.

Te Uru Rākau will play a key role in achieving this goal, providing the leadership and direction to solidify a strong and clear focus on forestry and its wider benefits across the country. I very much see our role as one of enablement, providing the necessary support to see increased planting of a wide range of both native and exotic species that create real benefits for all New Zealanders. To do that, we need to help lower the barriers currently faced by landowners and improve incentives for planting.

Our forestry heritage is part of the fibre of this country – in 1840 around two-thirds of the land was still covered in forest before the rapid deforestation of our indigenous trees occurred. The significant consequences of this continuing, for both our environment and our ability to advance our economy, were recognised early on. It took a vision to transform the approach to our forestry resource and lead, with government support, the transition towards afforestation and commercial exotic forestry success. This vision paved the way for what is today one of our most successful industries, which directly employs around 20,000 people and contributes around $6 billion a year to our economy.

Plantation forestry is a long-term investment and a range of government work programmes will impact on the decisions that commercial foresters make

Now, the government has signalled the importance of a new vision that will build upon that success and create an even brighter future. The government's commitment with the establishment of Te Uru Rākau, and access to the Provincial Growth Fund, is cause for confidence for an industry that has been under-valued. The opportunity over the next 10 years is to create the conditions for a sustainable sector that has momentum to grow and adapt.

The government is looking for forestry to: enable Māori to reach their economic and cultural development aspirations; support sector and regional productivity increases to capture full market value; maintain a stronger domestic market for wood products and security of supply for wood processors; build a strong, stable and reliable labour market that enables safe and rewarding lifetime careers in forestry; develop better environment and climate change outcomes for New Zealand; ensure a stable investment environment, enabling greater investment confidence in the forestry sector; and facilitate the transition to a low carbon economy through the replacement of petroleum-based products with wood-based products and the enablement of carbon farming. The sector, with existing and new players, can meet the challenge.

Te Uru Rākau will walk alongside the industry and provide increased leadership and focus for the government's goals for forestry. We will look to harness and build on the afforestation and land management work already underway with landowners, Māori, iwi, regional councils, community organisations and local communities. We also need to be working in partnership with the industry to better tell the New Zealand forestry story, including the wider positive environmental outcomes.

We are a country known for our 'number 8 wire' mentality, and we will look to partner with innovators to explore new forms of forestry that can deliver a viable commercial return, to help diversify the plantation estate and provide alternative options for landowners (e.g. indigenous commercial forestry, specialist timber and mānuka extracts). There will also be targeted programmes and resources to support Māori landowners, and an expanded outreach service to farmers and landowners to improve awareness of the benefits of planting trees and the assistance available to do so. All of this will be developed into a 'future of forestry' strategy for discussion early next year.

Capturing value

We know that the commercial forestry sector is projected to plant more than half a billion trees in the next 10 years. We also know that because plantation forestry is a long-term investment, a stable investment environment is important for providing confidence to the sector to plant new trees. A range of broader government work programmes (e.g. tax policy and measures to support the wood processing sector) will impact on the decisions that commercial foresters make.

Of note are the amendments to the Overseas Investment Act 2005, which have just come into effect. The changes provide for new simplified screening options for overseas investors seeking to buy existing land or forestry rights or convert land to forestry. This is intended to direct desirable overseas investment towards forestry and we will monitor the impact on new planting over the next two to three years.

Add to this an increase in global demand for wood, our efficient supply chains already in place, stable log prices and high carbon credits, and we are seeing a very favourable environment for investment in forestry here. What we want to avoid is a forestry processing industry (like in the UK) that is increasingly dependent on the government to step in and resolve supply issues. The reality is that every sector needs to be able to ride the highs and lows that inevitably occur. We want to grow a sustainable, enduring forestry future that is sector and community-led, not state-led.

That's why we want to support the growth and innovation of the domestic wood processing sector. A strong processing sector is an important part of achieving the government's wider economic development, environment, sustainability and employment objectives. It will also support the domestic building industry. Te Uru Rākau will need to work closely with the sector to determine how we can achieve this. Lifting the use of wood in the New Zealand economy, ensuring security of domestic log supply, and growing domestic wood processing will secure better returns from our forests and encourage investment in processing plants that will allow a transition from lower value log exports to more valuable wood products. This will benefit the New Zealand economy and our regions by strengthening market resilience and supporting higher levels of investment in afforestation.

In terms of the government's goal to transition to a low emissions economy, this programme has a key role in helping to achieve this. In total, planting one billion trees could remove an additional 10 to 30 million tonnes of CO_2 from the atmosphere by 2030. Improvements to the emissions trading scheme (ETS) – our main tool for reducing greenhouse gas emissions – are another way we can strengthen the long-term economic outlook for landowners, creating more appetite for tree planting. A lot of this tree planting will be permanent, but many may also plant for timber.

The ETS needs to be able to deliver effective emissions pricing and incentivise businesses to reduce emissions, innovate and invest in low emissions solutions. Reducing the complexity of the ETS and making it more accessible for landowners could drive planting of over 150 million trees. We are looking at a simplified accounting approach, creating a permanent forest option, recognising emissions mitigation from harvested wood products and further operational changes to improve the way the ETS works for foresters.

Engaging communities

This is about leveraging all of these opportunities to rebuild one of our most important sectors and enhance opportunities for people living in regional New Zealand. Those opportunities will see more young people choosing careers in forestry. Over the next few years, we will support and encourage greater participation at all skill levels and look at opportunities to tackle some of the cross-cutting issues that impact on forestry as a career choice. We will be developing low skilled employees to ensure a sustainable employment and career pathways, will look to overcome seasonality issues through a year-round employment pilot scheme, and investigate accreditation of qualifications and transferable skills.

Julie Collins, MPI Director General Martyn Dunne and Minister Shane Jones at the launch of Te Uru Rākau's Forestry Scholarships at Fieldays this year to encourage young people to choose careers in forestry

For highly skilled employees, we will be working with industry to develop a summer internship programme for university students, and to establish a professional forestry employment scheme similar to the rural veterinarians' voluntary bonding scheme.

An example of this is supporting training facilities to encourage more forestry workers. Te Uru Rākau recently announced a pilot project which will see the Eastern Institute of Technology (EIT) partnering with Train Me to deliver a new forestry school. EIT will oversee the academic work stream, while Train Me, trading as the ManaiaSAFE Forestry School, will oversee the logging operation and develop the forestry training model.

Training will focus on delivering skills to the sector that are in demand including: Level 2 and 3 work-ready training in silviculture, logging, transport, and machine operation; in-work competence development; and health and safety training for coordinators and health and safety representatives. The graduates of the course will be employment ready and will hold a New Zealand Certificate in Forest Harvesting Operations (Level 3) with strands in either tree felling, breaking-out or manual processing. We also have three additional youth employment initiatives with a forestry focus, as well as forestry scholarships, all with the goal of creating better employment opportunities in forestry.

These training programmes are also important in the context of a safe and high quality workforce across the forestry and wood product sectors. We must see collaboration across the sector, from landowners to investors, to ensure best practice is implemented in work we are supporting. Te Uru Rākau also has a role in addressing the industry's unacceptable safety record and we will be engaging with our stakeholders to increase uptake of the FISC contractor certification. With a seat at the Forestry Industry Safety Council, Te Uru Rākau is in a position to hear directly from the workforce.

Counting the numbers

Another important piece on the checkerboard is the work being done by Crown Forestry which is entering into new commercial arrangements, including lease and joint venture contracts, to develop plantation forests on privately-owned land. The aim is to diversify landowner income, improve productivity, help climate change, protect the environment and create jobs. There has been a good level of interest from landowners in joint ventures with Crown Forestry to develop plantation forests on privately-owned land. At the time of writing, seven joint ventures covering 4,645 ha have been executed and the team is currently negotiating contracts with a further 19 properties for around 6,400 ha, as well as following up new opportunities as landowners further explore this option.

Across the whole programme, we are expecting up to 260 million trees to be planted over the next three seasons. This includes approximately 150 million from existing commercial planting and replanting, 30 million from existing native planting, and 80 million from government investment in joint ventures and the new grants fund. A key focus of the latter will be on native tree planting, with a target of two-thirds going towards natives.

Building blocks

In saying all of this, work is already well underway and we are beginning to see success stories emerging. We have supported Minginui Nursery to scale up production of forestry grade native seedlings in the Bay of Plenty. As a result, the nursery will grow from a team of nine to 90. That's in an area with a population of less than 200, where unemployment is currently among the highest in the country.

I also mentioned earlier our strengthened focus on innovation within the sector. We are already seeing great examples of this from the Taranaki Regional Council, who are developing a digital tree planting tool for farmers to assess the viability of planting trees on Taranaki hill country. There is also a pilot programme underway to help us to better understand the potential for tōtara timber products which could deliver millions of dollars a year of timber and tens of millions through final products.

Yes, these are all steps in the right direction. But there is still a long way to go. What we are aiming to achieve is ownership of this programme at the grassroots level. We can support planting, but we need everyday Kiwis to roll up their sleeves and take up this once in a lifetime opportunity to transform the industry.

Now is the time to see forestry step back into the spotlight. It is an opportunity to reclaim our forestry heritage together, to see gains across our environment, our regions and our people. We all have a duty to make this work, and work well, for now and for future generations. After all, these are our billion trees.

Julie Collins is Head of Te Uru Rākau – Forestry New Zealand. Email: teururakau@mpi.govt.nz.

NZIF AGM and annual conference (9–11 July 2018)

Chris Goulding

AGM

A quorum of voting members attended the 90th AGM of the NZIF on 9 July 2018 in Nelson. The annual report and the budget for 2018–2019 were presented and approved.

Three amendments to NZIF Rules were passed at the AGM. One was to remove the restriction that the Chairperson of the Registration Board must be an elected member of the NZIF Council. The second was to further amend a number of Rules to meet the requirements of the Real Estate Agents (Exemptions) Regulations 2017, as requested by officials during the final sign off on the amendments approved at last year's AGM. The third provided a definition of eminence as guidance when a member is proposed for election as an NZIF Fellow.

A motion to alter the composition of the NZIF Council, including reducing the number of elected persons, was debated at length but failed to pass.

New Fellow

Steve Wilton

Honorary Member

Trish Fordyce

Conference theme – 'The Power of Collaboration in the Forestry Industry'

The opening address of the conference was given by the Minister for Forestry, the Hon Shane Jones, with a talk entitled, 'The Power of One, The Power of Many'. His talk had three themes: the opportunities presented by the government's proposal to plant one billion trees over the next decade; the potential for the loss of public support for the forest plantation industry due to incidents such as logging debris carried by floodwater at Tolaga Bay and Nelson; and the desirability of reducing the percentage of the harvest sold abroad as raw unprocessed logs.

Lees Seymour, Managing Director of Nelson Forests Ltd, spoke on the need for collaboration in his talk, 'Collaboration, Smollaboration – Who Cares?' He indicated its importance and highlighted good forestry examples (e.g. Safetree or the Forest Owners Association), while explaining those factors that can prevent collaboration being effective (e.g. lack of commitment and trust).

Linda Sewell, Chief Executive Officer of OneFortyOne Plantations, described how in just five years the company had grown from a single planted forest estate to a vertically integrated company in South Australia and, most recently, had acquired Nelson Forests.

Simon Hardy, Studio Pacific Architects, introduced how engineered wood was likely to transform the building industry. He spoke on the use of laminated veneer lumber (LVL) and cross laminated timber (CLT) for low carbon, environmentally-friendly buildings, which when combined with innovative engineering makes for strong structural resilience in the face of earthquakes.

The field trip the following day visited the construction site of the new Nelson Airport Terminal where these techniques were being employed, after earlier visiting XLAM and Nelson Pine Industries where CLT and LVL, respectively, were manufactured.

The increase in harvesting volume and in export log sales has placed demands on a port's efficiency. **Martin Bayley** discussed how his company, Eastland Port, Gisborne, improved their operations so that the average waiting and unloading time for trucks was reduced to 40 minutes.

That increase in harvesting coincided with an unacceptable spike in the rate of fatalities. **Dale Ewers**, DC Equipment, demonstrated how mechanisation can reduce the rate of overall severe incidents. In Moutere Logging's case, as their annual tonnes harvested doubled, their annual accident rate halved. In his presentation he showed the Falcon claw and winch-assisted logging, describing the current development of a felling carriage and a remote operator station.

This talk was complemented by that of **Keith Raymond**, Future Forests Research Ltd, on a Primary Growth Partnership, the Steepland Harvesting programme 2010-2017. The programme was a catalyst that encouraged the development and implementation of new harvesting technology, so that by today 80% of ground-based and 30% of cable-hauler operations are mechanised. The need for equipment appropriate to New Zealand conditions has resulted in a thriving, expanding local engineering industry that is now also exporting a significant proportion of its manufacturing.

Lesley Bak, Nelson Forests Ltd, spoke on engaging and collaborating with contractors to improve health and safety. **Ian Reid**, Austimber Harvesting, gave the contractor's perspective of collaboration, expanding on the impact between a tender and negotiated renewal of a contract. He suggested that good collaboration and fairly sharing any gains from increased productivity would maximise owners' value recovery from their forests.

Azwood Energy is an experienced wood energy supplier that makes the entire range of wood fuels – biomass hog fuel, wood energy chips and wood pellets. **Ben Crawford**, Operations Manager at the company, spoke on creating the market for wood residues, implementing the conversion from using fossil fuels to that of wood waste (e.g. from coal boilers to wood pellet fuel). He suggested that had there been a market for wood energy in the East Cape, the logging debris would have been extracted off the hill, thus forestalling the disaster at Tolaga Bay.

Tara Strand described international science collaboration at Scion to improve fire control and biosecurity, specifically the behaviour of particles in the air and practical applications from understanding this. **Matt Hippolite**, Department of Conservation, spoke on the control of wilding conifers spreading from plantations, re-emphasising the need for the forest sector to collaborate with the environmental sector and public at large or risk losing its licence to operate. **Euan Mason**, University of Canterbury, spoke on modelling site productivity using eco-physiology.

The potential rapidity of change that replaces long established custom was emphasised by **Peter Casey**, New Zealand Carbon Farming, showing two photos of the New York Easter Parade, asking of the one taken in 1900, 'Can you spot the car?' and of the one from 1913, 'Can you spot the horse-drawn carriage?' He quoted Sean Bennett who had commented that synthetic fibres are today the mainstay of the textiles industry with wool relegated to niche applications: 'Back in the 1950s, it's not likely many farmers anticipated that the New Zealand wool boom would end so rapidly.' The Editor asks, 'Could wood fibre be synthesised, with a similar effect on the plantation forest industry?'

Future Foresters

The official launch of the Future Foresters organisation was made on 9 July with a quiz night open to all ages and experience levels. Future Foresters is a non-profit social organisation that aims to provide a community for young forestry-minded individuals. The organisation covers the wider industry and aims to have members in all aspects of forestry.

NZIF Forester of the Year – Peter Clark

David Evison, NZIF President, presented the award to Peter Clark in recognition of an outstanding contribution to forestry for leadership, excellence and personal integrity. 'The Forester of the Year award is a fitting recognition of the contribution that Peter Clark has made to the sector over a large number of years,' David said. The award is one of the highest that the Institute can bestow.

Peter Clark is a NZIF Registered Forester and until this year was CEO of PF Olsen.

Kirk Horn – Russell Dale

The Thomas Kirk award, made biennially, was awarded to Russell Dale for his outstanding contributions in the field of forestry over his long career. The Kirk Horn Flask is the most historically valuable award of the Institute. David Evison noted that, 'Russell has proved himself to be an outstanding leader in forest management, and in the management of major industry-funded forestry research programmes, over a long and distinguished career.'

David Evison with Peter Clark – NZIF Forester of the Year

Russell Dale – recipient of Thomas Kirk award

Russell Dale is the Research and Development Manager of the Forest Owners Association and Forest Growers Research Ltd, which manages funds from private and government sources for investment in research and innovation.

Prince of Wales Award for Sustainable Forestry – David Saathoff

Subsequent to the conference, on 1 October the New Zealand Institute of Forestry announced that **David Saatoff** was awarded The Prince of Wales Award for Sustainable Forestry in 2018.

This award recognises engagement in the principles and practice of sustainable forest management including policy, planning, practice and sound science-based land stewardship. Awardees must be committed to public outreach and knowledge exchange, focusing on the wise use and conservation of forests and forest ecosystems.

Continuing Professional Development (CPD) workshop

A CPD workshop was held on the first day of the conference. Bill Liley provided a forum for discussion of 'Forest Value as an Alternative Fact', which also included an update on the current review of the NZIF Valuation Standard. Professor Tim Dare, University of Auckland, presented, 'The Role of Ethics for a Forestry Professional', indicating the increased, formal importance of ethical standards amongst NZIF members.

NZIF Foundation has record year

Andrew McEwen

The NZIF Foundation announced education and research awards totalling $41,000 at the NZIF conference in Nelson on 10 July 2018. There were more awards, more applications and a record level of distributions this year than ever before. In 2012, the first year of the Foundation's operation, there were four awards totalling $6,500.

For 2018 there were 10 award categories worth $44,500 on offer. The 29 applicants who collectively made 43 applications came from a wide range of institutions and forestry interests, with research projects in plantation forest management, harvesting and trade, social issues, indigenous forests and urban forests.

Award recipients

Foundation Chair Andrew McEwen (left) presents the Jon Dey Memorial award to Cameron Leslie (centre) and the Otago/Southland award to Rhys Black

Awards announced and recipients were:

- **Trevor Best** – a PhD student at the University of Canterbury School of Forestry, who received a $10,000 Future Forest Scholarship for his research on the way machine operators in the logging industry deal with stress within their work-life, with an emphasis on the implications for their health and safety
- **Leo Mercer** – a PhD student in environmental studies at Victoria University of Wellington received a $10,000 Future Forest Scholarship for his research examining the role native forest restoration, in association with carbon farming, can play in the development of Māori land on the East Coast of the North Island
- **Matt Curry** – a Forestry Science student at Canterbury University received the $5,000 NZ Redwood Company Scholarship
- **Logan Robertson** – a Forestry Science student at Canterbury University received the $5,000 Invercargill City Forests award, which is available to assist residents of Invercargill City in studies, research or travel in an area benefiting forestry
- The Jon Dey Memorial award assists research projects in the areas of work study or new technology aimed at improving forest engineering and harvest productivity. $3,500 was awarded to **Cameron Leslie** for his Master's project on the productivity of winch-assisted machines
- The Otago/Southland award of $3,000 went to **Rhys Black**, a University of Canterbury student, for his

analysis of the availability of bulk vessels for log exports, using data from South Port and Port Otago

- The Frank Hutchinson Postgraduate Scholarship of $1,000 went to **Yannina Whiteley** at the University of Canterbury, the University Undergraduate Scholarship of $1,000 was awarded to **Phoebe Milne**, a first-year forestry student at Canterbury, and the Mary Sutherland Scholarship of $1,000 was awarded to **Georgia Paulson**, who is in her second year of the Level 6 Diploma in Forest Management at Toi Ohomai in Rotorua
- Three forestry students from the University of Canterbury received prizes in the student poster competition at the conference. **Ben Reriti** received the first prize of $800, **Millan Visser** the second prize of $500 and **Lauchie Weston** the third prize of $200.

The Foundation Trustees were delighted with the number and quality of applications. They congratulate the recipients of the awards, and thank all applicants and encourage them to persist with their research and education and to make a career associated with New Zealand's forests, which have a vital role to play in this country's environment, economy and society.

Background to NZIF Foundation

The NZIF Foundation was established by the NZ Institute of Forestry in 2011. It is a registered charity and has its own Board of Trustees. Its purpose is the advancement of education in relation to forestry in New Zealand. This includes: encouraging and supporting forestry-related education, training and research through the provision of grants, scholarships and prizes; promoting the acquisition, development and dissemination of forestry-related knowledge and information; and other activities.

Foundation Chair Andrew McEwen presents Matt Curry (right) with the NZ Redwood Company Scholarship

NZIF provided initial funding with a donation of $85,000, plus an offer to provide administration support at no cost to the Foundation. At the same time, the Institute asked the Foundation to take over four awards (totalling $6,500 per year) that NZIF had been making for some years, a request the Trustees agreed to.

Trustees at 31 March 2018 were Andrew McEwen (Chair), James Treadwell, David Evison and Andres Katz.

Reliance on donations

The Trustees' objective is to accumulate funds to the point where they can fund the distributions they make from the earnings on those funds. With the amount so far accumulated and current rates of interest, earnings for the year ended 31 March 2018 were $7,300, clearly well short of the $41,000 distributed.

The shortfall was funded from a number of donations that are conditional on the Foundation making awards or scholarships for specified purposes. Once the donated funds are exhausted, the awards will cease. At 31 March 2018, $85,200, or 35.8% of the Foundation's accumulated funds of $238,232, were in this category.

The Trustees are very grateful to those who make the conditional donations, because they increase the profile of the Foundation and the amount available for distribution. The Foundation receives some income from the undistributed quantum of each donation. The Trustees are also grateful to those individuals and entities who have made individual donations.

Would you help?

If you have enjoyed your career or association with forestry in New Zealand, why not help the Foundation by donating and encouraging others to join you. The Trustees welcome unconditional donations and will also consider donations for specific purposes. As the Foundation is a registered charity, donations qualify for tax credits.

You can find out more about the Foundation via the link at the right-hand side of the home page at www.nzif.org.nz, or from the Charities Services website (www.charities.govt.nz – search for charity CC47691), or by emailing foundation@nzif.org.nz.

Andrew McEwen has chaired the NZIF Foundation since its establishment in 2011. Email: am.mcewen@xtra.co.nz

Nelson Airport's new terminal – overview of the design of a large-span engineered timber specialist building

Evžen Novak, Samantha Zondag, Sarah Berry and Simon Hardy

Engineered timber in the Nelson Airport Terminal under construction. Photo courtesy of David Evison

Abstract

The Nelson Airport Terminal is a new large-span building that replaces the existing terminal building at the airport. The structure and interior of the building relies on engineered timber (LVL and plywood) to achieve the open spans required and create a unique airport environment.

This paper serves to outline a significant end use for engineered timber and sets out, from a designer's perspective, the journey from initial idea to end result. The designer's perspective is clearly not the same as the producer's. In general, the designer's perspective more closely reflects the needs of the end users of the building. In providing this viewpoint, the authors hope that it facilitates a raised producer awareness of the issues facing the incorporation of engineered timber into any building and, more fundamentally, an increase in the use of engineered timber in the building stock New Zealand produces each year.

Beginning with the brief and a short description of the building, the paper goes on to discuss the design drivers for the building and how the selected drivers supported the use of engineered timber, one very major element of the design strategy. An overview of the design and construction processes, particularly dealing

with innovations such as the use of resilient slip friction joints (RSFJs) and pre-fabrication, is provided along with some preliminary learnings.

Introduction

Nelson Airport's new terminal building will be a 5000 sq m addition to the airport's aeronautical facilities and it replaces the existing terminal building first opened in 1975. At the time of writing, the first stage of the building is nearing completion while the second stage is due for completion at the end of 2019. The building uses mass timber laminated veneer lumber (LVL) and plywood in combination to provide a striking overall form to the building. Most of the terminal is on a single level, although a second level is provided at either end of the building for offices and airline lounge facilities.

The terminal building showcases timber use in a major entrance point to the Nelson region and utilises timber that is sourced locally, both to recall the place in which the airport stands and to introduce visitors to the possibilities that local industry can provide. Timber usage on this scale in airport terminals is unusual in New Zealand and rare in airport terminals around the world. Its utilisation enables the airport to differentiate itself in the most positive manner possible.

Clearly, there is evidence of a strong affinity for the creative use of timber in this building. This is not accidental at all, but has come about from a design process begun with a strong direction from both client and architect. In fact, without the support of the client to embark on a journey utilising engineered timber, nothing of the building's greatest timber features would have been viable at all.

Building starting points

The first starting point for the terminal has been the need to increase capacity to cater for the rise in passenger numbers and freight throughput at Nelson Airport. At the outset of the project in early 2015, Nelson Airport catered to approximately 800,000 passengers annually with projections of 1.2 million passengers using the terminal a decade later. The existing terminal does not have the capacity to cater for existing numbers or the projected increase in numbers. Overall predictions for growth in aviation, in New Zealand and throughout much of the world, suggest that capacity demands will further increase. Nelson Airport welcomed its one millionth annual passenger in June 2017.

Nelson Airport is served by a range of aircraft, mostly turboprops ranging from 40 to 72 seats each, although smaller aircraft are also used by regional operators. There is no jet aircraft usage and therefore no requirement for air bridges to aircraft. The number of operators at Nelson Airport has increased and now includes Air New Zealand, Sounds Air, Golden Bay Air, Originair and Jetstar. The airport caters to 46,000 flights per year and is one of New Zealand's busiest airports outside the main centres.

Initially, the design team investigated whether an expansion of the existing terminal would be feasible, or if a new terminal would best serve the airport's needs from a functional and cost perspective. The existing terminal, if it were to be kept, required such an extensive upgrade to its structure to meet modern seismic engineering codes that this option proved untenable practically and economically. The decision was eventually made by the airport to proceed with a new terminal building.

In summary, the briefed requirements for the new terminal building included:

- Design to meet the forecast demand previously outlined
- Provide a safe and functional new building
- Feature sustainability in its construction and operation
- Provide for a level of customer service better than existing
- Make extensive use of local materials
- Provide intuitive way-finding
- Maximise commercial opportunities for the airport
- Use a simple grid layout with few interruptions from columns
- Utilise a modular construction format to simplify expansion.

There are also a number of detailed operational requirements, a set of regulatory requirements related to the aviation environment, the usual Building Code compliance issues, and a number of terminal users (such as the airlines, rental car companies, food and beverage and retail providers, and others whose needs and requirements are also part of the mix).

Even at the first interview for the project we had suggested that amongst the drivers that would generate a great design to meet the needs of the airport and (most importantly) of the region the airport serves, we should use materials and products sourced from the Nelson area. One of those materials is timber. The local industry is served by extensive areas of forestry and there are well-known manufacturers (Hunter Laminates, Nelson Pine and X-Lam) domiciled in Nelson.

Making a timber building was a crucial decision. We had decided on using timber for the essential structure of the building and not merely as a decorative afterthought applied as an overlay on another structural system. Much of the conceptual development of the project then hinged on how best to utilise structural timber while meeting all the briefed needs of the project. Designing for a timber structural system became an integral part of all project processes from the outset.

Building description

The new terminal is a simple rectangular shape of 36 m width and 100 m length. It has a total floor area of approximately 5000 sq m, with an upper level at

each end of the building for offices and airline lounge facilities.

The ground floor is a concrete slab raised 600 to 800 mm above existing ground levels, to protect against flooding from the increased number of climate change generated storm events already evident and expected future rises in sea level. The building sits on a series of foundation beams and driven concrete-filled steel piles. The site is classed as prone to liquefaction and allowance has been made to accommodate the potential for this. The two upper floors are concrete on steel tray supported by the main timber structure and some intermediate steel columns.

The main structural system of the building is based on the use of engineered timber. LVL columns support the roof, and its system of three-dimensional portals using beams and rafters composed of LVL combined with plywood provide diaphragm action to create a folded structural roof plane.

The external cladding of the building is a mix of aluminium curtain wall glazing fixed to the external face of the LVL structure, both main columns and intermediate LVL mullions, and coated metal profiled cladding on timber framing. Chevron-shaped overhangs on the northern façade provide the means for air extraction and are clad in aluminium panels. The roof has an undulating form, and to provide seamless waterproofing across the changing profile it uses a thermoplastic membrane system fitted on a Securock roof board sitting over rigid insulation board, vapour barrier and base deck.

Design drivers and outcomes

The design outcome meets a set of five major drivers selected as being the most fundamental parts of the brief. Before embarking on describing the journey, we need to understand how the building meets the needs of each of these project drivers:

- Safe and functional
- Modular and flexible
- Illustrates sustainability and timber technology
- Lofty and transparent
- Has a sense of place.

Designing a *safe* and *functional* building is the first priority for an airport terminal. The safe operation of the airport's buildings is just as much an industry norm as the safe operation of an airline. It is in this respect that aviation has such an enviable record, particularly with commercial aviation where the accident and incident rate is exceptionally low compared to either construction or forestry.

Safety in design is therefore a focus. Multiple initiatives have been put in place, but two examples include plant location and the use of timber pre-fabrication. To preclude the need for regular maintenance access to the roof, plant such as chillers are located at ground level. Similarly, the sub-assemblies of the timber roof elements have been designed to be pre-fabricated to a finished level prior to their erection into the roof. Providing the ability to work in a dry and safe environment at ground level, rather than at height, minimises health and safety risks.

Erection of pre-assembled 'diamond' beams and columns

The functional needs of the terminal are relatively complex and space prevents a full description. Suffice to say that the main focus is ease of use for customers, which has been addressed with the simplicity of the planning.

This simplicity is an enabler for a *modular* and *flexible* design, as the building has a rectangular plan form with minimal internal columns. This allows for flexibility – elements within the building can change and evolve over time. The aviation industry is in a state of constant change, for instance, the check-in is now more often by cellphone and the way space is used within the building will change to match industry changes.

The terminal is designed with repetitive structural bays or modules of 15 m, so that building size can be increased when required in a modular way at either end in 15 m wide by 36 m deep increments. Thus the building has both internal and external adaptability.

A variety of strategies have been chosen to deliver on the expectations for *environmentally sustainable design*, but chief amongst these has been the use of a mass timber structure coupled with a natural ventilation strategy.

According to calculations made by Nelson Pine Industries Ltd, the building uses approximately 610 m^3 of LVL, which equates to two hectares of forestry land or three hours of growth in the production forests of the Nelson/Marlborough region. The factory production time for the LVL is two-and-a-half days, whereas the re-manufacture and CNC machining requires 62 days. This does not account for plywood use, but does indicate the

importance and added value of the re-manufacturing and fabrication process in the overall construction sequence.

Timber is a net carbon sink and the scale of the timber usage leads to the expectation that about 300 tonnes of CO_2 equivalent has been embodied in the building. A steel-framed building would require the expenditure of potentially the same level of CO_2 again. These are very, very rough calculations as the full impact has not been independently reviewed, but the scale of saving of the CO_2 equivalent in one building is considerable.

The building's ventilation system contributes to its sustainability in the same way as the use of timber. The building is designed to take advantage of the stack effect, with the building automated system (BMS) automated south side (landside) windows providing air intake and air buoyancy, driving air to the diamond-shaped windows at height in the centre of the building. These are supplemented by heat-driven solar chimneys on the north side that are incorporated into the chevron-shaped overhangs.

The chevrons provide shading, which over the course of a full year have the effect of reducing direct radiation by 23% compared to no shading. De-stratification fans are provided for mixing air within the building. A small amount of air conditioning is provided to upper floor or enclosed areas of the building – the main area of the terminal has an assisted natural ventilation scheme.

Detail of CNC shaping to LVL beam for housing metal bracket connections

The building sets out to be *lofty* and *transparent*. The loftiness enhances the customer experience and this is increased again by making the timber structure entirely visible and by emphasising the materiality of the building. The timber work is also effective beyond being structural, as the plywood ceiling panels provide visual delight, diaphragm action and, with closely-spaced drilled holes, noise attenuation within the building.

Transparency is being used to enhance way-finding for passengers and visitors. A clear path from bike, car or bus to aircraft is an easy to find navigational sequence. This complements the visible timber structure with big views of the aircraft (the central reason for the building's existence) and the distant mountains across Tasman Bay.

Providing a *sense of place* is perhaps the most ethereal of the five drivers, but actually the most crucial. Many airports are a porridge of grey, concrete, metal and glass and are often difficult to tell apart from one another. Nelson Airport wants to be the opposite of this type of standard issue. It is with a delightful sense of place that the airport wishes to differentiate itself from others and to make itself and the experience of using it positively memorable.

Nelson's Airport Terminal uses its timber materiality and its form to allude to place. Externally the roof form folds and weaves to reflect the mountains across Tasman Bay. The folds of the Arthur Range are reflected in a rhythmical series of folds in the roof itself. The repetitive folds, recognisably triangular, also have an historic reference to the triangular serrated edge plan form of the 1975 terminal building.

Externally, and particularly from the landside or city aspect, the roof appears as though multiple series of birds' wings have been joined together to reflect the soaring wings of flight itself.

Internally the warmth and texture of the timber, as well as the pattern and rhythm of the structure, is being used to create an environment that is gracious and convivial. The internal environment of the terminal is special and noticeable. It is hoped that the enjoyment of the space is such that it is relaxing in an otherwise stressful environment and that people will want to dwell longer. While an increased dwell time should also lead to better returns for the commercial operations within the terminal, the nature of the building also recognises that looking after the spirit is a fundamental aspect of the design. Timber used in this way has helped the building achieve this aim.

Design process

Design for functionality is complex in its own right. However, the terminal at a fundamental level has a relatively simple diagrammatic pattern with a check-

in and baggage handling area to one end, a lounge with food and retail opportunities in the middle, and gates to the aircraft and an arrivals area with the baggage claim at the other end. Achieving operational simplicity is the beginning and the base line for the airport operator, and much thought then went into the planning to ensure the design optimised both the passenger flows and the terminal's operations.

At the same time, investigations into the form of the building took place. In one set of design investigations, sketches of multiple possibilities were generated by the team and then modelled in Rhino, a three-dimensional free-form surface modelling software package. The software was used to print out developed elevations, which could be cut and folded to make a paper model of the roof form. Multiple roof forms were created and tested for their functionality, buildability, appearance, effectiveness in supporting a natural ventilation solution for the building, and (most importantly) their contribution to an efficient structural solution.

A combined design exercise between engineer and architect was required to establish how the engineering for the chosen roof form would work. The building has spans of 19 m and then 17 m to create the overall width of 36 m. Each span is a three-dimensional portal, with 600 mm deep beams using the depth of the triangular segment to achieve the portal action.

The building is designed in 7.5 m bays, but two bays of four triangular segments make up a self-supporting roof assembly of 15 m, so the effective building module is therefore 15 m wide.

Columns in the middle of the building support a series of diamond-shaped clerestories. Together the diamond shapes create a large moment frame to provide bracing in the transverse direction of the building. Columns at the front and back of the building, in contrast, are cantilevers supporting the roof and, along with LVL mullions, take wind face loads.

One of the most important structural elements is the use of Tectonus resilient slip friction joints (RSFJs) in the building. These innovative jointing systems are integrated into the columns. The RSFJs provide friction damping to withstand seismic activity and dissipate seismic energy. They have an inherent self-centering functionality in each of the three possible movement planes: up/down, east/west and north/south. This improves post-event resilience and is intended to eliminate the need for post-seismic event maintenance.

Tectonus describe the RSFJ as consisting of '2 outer plates and 2 centre plates with elongated holes. The outer plates and the centre slotted plates are grooved and clamped together with high strength bolts and disc springs. When the applied joint force overcomes the frictional resistance between the sloped bearing surfaces, the centre slotted plates start to slide and energy will be dissipated through friction during cycles of sliding.'

Prefabricated triangular roof sections after installation in the building

In a sense, the airport terminal is an incubator project for the use of Tectonus RSFJs. The incorporation of this new product into the structural design has made an open (relatively column-free) space viable, but it also supports New Zealand Inc as well as innovation in the construction industry.

As well as providing space in the design process to accommodate innovation, integrating a multitude of requirements required design attention. Building information modelling (BIM) was used throughout the design phases to ensure elements matched and were coordinated together. Using the models, discussions were held with Nelson Pine on supply side issues and the supply of LVL was organised.

Brief overview of construction process

A multitude of changes to all the interfaces to the terminal are required as an outcome of building a new terminal building. This includes the aircraft apron, where aircraft parking positions have changed, the services infrastructure, the pick-up and drop-off areas that have moved and the car parking, which requires an increase in size to match the terminal capacity. Also, a new control tower has been built, and while the team involved (Studio Pacific/Dunning Thornton/Gibbons) has some cross-over to the terminal team, this was an entirely separate

1200 x 300 mm LVL column with two RSFJs connected at the base

building project conducted for Airways NZ rather than Nelson Airport.

The terminal building project was combined with all the infrastructure and forecourt and car parking works into one tender package to enable full coordination across multiple project sectors. For the airport and the airlines, remaining operational is paramount and every aspect of staging needs to function to ensure safe operation continues. Four tenderers bid on the project, with the winning tender coming from a consortium composed of Naylor Love with local contractors Gibbons and civil works specialists Fulton Hogan.

As noted, the engineered timber supply had already been sourced pre-tender. However, some sub-contractors providing the timber re-manufacture, fabrication and connection brackets were formally organised after the Naylor Love/Gibbons partnership had been appointed.

Shop drawings commenced not long after the contract had been awarded. What is important at this point is the coordination of individual parts into the whole. This means the coordination of multiple sets of manufacturing information together so that the shop drawing of an individual component manufactured in one facility is assured of fitting with another component manufactured elsewhere. In using engineered timber for major structural systems, the complexity of this process can be overlooked by the inexperienced and a steep learning curve will result.

In the case of the terminal building shop drawings for the LVL, the plywood diaphragm, the Tectonus RSFJs, the metal work brackets connecting timber elements together, and the triangular sub-assemblies were required and needed comprehensive review and coordination by the contractor and consultant team.

Incorporating the newly-developed resilient fixings added another level of coordination requirements, as several cycles of prototype testing of the RSFJs were completed just as construction was commencing. Each RSFJ unit was also quality assurance (QA) proof tested for response reliability before supply to site.

The initial design called for the fabrication of two triangular roof elements together to form one roof sub-assembly for lifting into place. The contractor elected to lift one triangular sub-assembly at a time to match their craneage. This methodology resulted in design changes to connection brackets for each of the triangular sections.

At this juncture Nelson Airport and the project managers offered the contractor Hangar 3 on the airfield campus as a covered yard in which to assemble the triangular timber roof sections. Hangar 3 had been empty for a time and required some upgrading, but has proved to be a convenient place in which to work in all weathers producing the roof sub-assemblies. Each roof triangle was fully built up including the roof membrane, which had copious lap material left in place to enable jointing to the next sub-assembly. When required after hours, the sub-assemblies are transported to the site across the airport taxiways and can be delivered just in time for their incorporation into the building.

Each sub-assembly is essentially a finished product, with all services such as lighting and fire protection systems already installed and integrated. This requires considerable effort and coordination both with design and construction. Once erected and installed this finished product requires very little further work, but remains vulnerable to the elements until full enclosure is achieved.

LVL columns were re-manufactured by Nelson Pine using a cold press to create the required section thickness, typically of 90 mm or 300 mm, the latter several times thicker than standard billets. The incorporation of the RSFJs occurred on the ground and the columns were lifted and propped ready to receive roof sub-assemblies. With the install of LVL mullions between columns, follow on with curtain wall installation could occur. Where metal cladding was to be installed, full LVL/timber framing came first.

While it is relatively quick to put together columns and roof elements on-site, this is only possible after a considerable amount of time has been spent making each element first. This may seem self-evident, but the constraints are the need for covered space and carpentry resources to assemble multiple sub-assemblies at once and then the need for more covered space to store them prior to site installation. The advantages

of pre-fabrication, and these are worthwhile obtaining, presume then that some logistics needs are overcome first.

Timeline

The project commenced in mid-2015 with the comparative investigation – extend and refurbish the existing terminal or build new. By the end of 2015 the decision to build new had been made and first concepts had been produced and broadly approved. Proof of concept followed in May 2016. The developed design and detailed design work leading to building consent lodgement and a construction tender was completed by January 2017. The Naylor Love/Gibbons/Fulton Hogan partnership, having won the tender, was awarded the contract and began construction in May 2017. Stage A of the terminal is due for completion in October 2018 and Stage B, the balance of the building, in late 2019.

Lessons

As with any project, there are changes that would be made if it were to be commenced again. Without construction being finished completely it is too soon to be conclusive about lessons learned. Also, further research would be needed to validate conclusions from the evidence to hand, much of which is segmented by the project roles held within the project.

Some initial reflections include:

- Client interest and commitment to a timber design strategy from the outset is of key importance, particularly because the level of innovation required may be quite high and the level of expertise in the timber industry and associated industries is not yet widespread and instantly available
- Also, crucially, the increased use of engineered timber in commercial construction will need further upskilling and coordination throughout the supply chain from log production through to building handover
- A more comprehensive use of BIM with better transfer protocols to sub-contractors would have helped services integration, potentially sped up shop drawing production for timber components and connection assemblies, and provided opportunities for visualised programming
- The use of pre-fabrication in an indoors controlled environment has clear benefits for quality control and should speed up on-site construction and reduce risk from timber exposure to the elements
- Protection of pre-fabricated timber construction exposed to the elements is an issue after erection in an open working site and it requires careful forward planning. The finished LVL had a sacrificial coating of Resene Lignaguard to provide a limited amount of protection from moisture, but the protection is time limited.

Conclusion

The use of timber as structure and form-giver is integral to the aims of the designers in showcasing: Nelson as a special place; innovation and New Zealand Inc; building in a sustainable way; the local timber industry and the potential for timber products in New Zealand building; and a space inside that exudes calm, warmth and beauty, especially for the travelling public.

A combined architectural idea and clever structural system creates the building form in this airport terminal and the building form does most of the work of creating a special identity within and a sense of place throughout the terminal. Initial reaction from the small number of visitors able to view the building prior to its early October first stage opening supports the idea that a special sense of place has been created, particularly inside the terminal.

As designers, there is an almost measurable benefit for us in coming to work to help make an object of beauty. If the generations of building occupants, users and visitors feel their spirits lifted after we and the builders have finished crafting, particularly the natural materials, then the building will have achieved well beyond its intended aim to showcase timber and its Nelson sources.

Acknowledgements

Client – Nelson Airport Ltd; Architects – Studio Pacific Architecture; Structural engineer – Dunning Thornton Ltd; Building services engineer – eCubed; Project manager – Aesculus;

Fire engineer – Aurecon; Quantity surveyor – BBD; Façade engineer – Mott McDonald; Acoustic engineer – Acoustic Engineering Services; Geotechnical engineer – CGW; Contractors – Naylor Love in partnership with Gibbons Nelson and Fulton Hogan; LVL suppliers/re-manufacturers – Nelson Pine; Timber assembly shop drawings – Off Site Design Ltd; Resilient Slip Friction Joints – Tectonus; Plywood re-manufacture and CNC preparation – Cooper Webbly; Timber structural roof assemblies – Gibbons.

Content for the paper was sourced from Studio Pacific Architecture, Dunning Thornton Ltd, eCubed and Nelson Airport Ltd, the clients, owners and operators of the facility. A wider team is of course a necessity in building at scale and we acknowledge as well the contributions of the others who have been cited here.

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PGP Steepland Harvesting – a collaborative research and development programme

Keith Raymond

This paper is an overview of the collaborative forestry research and development (R&D) programme called Steepland Harvesting which started in 2010 and was completed in September last year. This overview was presented to the NZ Institute of Forestry conference in Nelson on 10 July 2018.

Introduction

Since 2007, the forest industry's R&D effort has been coordinated by an industry research company, Future Forests Research (FFR). In 2016 FFR changed its name to Forest Growers Research (FGR) to align more closely with the Forest Growers Levy Trust, the principal industry funder of forest growing and harvesting research since the commodity levy was introduced in 2014. In 2018, out of the $8.8 million of levy funding, over 60% was allocated to research, science and technology programmes (totalling over $5.4 million).

FGR's overall R&D aspirations are to improve profitability, create value and enhance sustainability. The aim is to improve forestry as a sustainable, profitable and internationally competitive sector for the economic and social benefit of New Zealand as a whole.

In addition to long-term programmes managed by Scion and funded by both the levy and Ministry of Business, Innovation and Employment (MBIE), there are two R&D partnerships at FGR: the Harvesting and Logistics Programme and the Specialty Wood Products Partnership. When it was formed in 2007, FFR created the Harvesting and Logistics Programme through a recognition by the industry of the need to address the main issues confronting forestry at the time – and to a large extent still face forestry today. The drivers for a major R&D effort in harvesting were the needs to address:

- Rising harvesting costs, especially in steep country
- Low productivity compared to other forestry countries, such as Canada and Sweden
- Improved safety.

Reducing supply chain costs for both ground-based and hauler operations is important to improve the profitability of harvesting our forests, especially the smaller and more isolated forests that are coming on stream in many regions. Safety was (and still is) an issue, especially felling and breaking-out roles in cable logging crews. In 2017, the New Zealand industry suffered seven fatalities and 75 serious harm incidents.

The industry at the time had no harvesting research organisation since the closure of the Logging Industry Research Organisation in 2000. An industry Strategic Summit was held in July 2008 to provide a pathway to achieve these goals.

Programme goals

After two earlier attempts to secure MBIE funding, in 2010 FFR (as it was then) was successful in forging one of the first Primary Growth Partnerships (PGPs) called the Steepland Harvesting programme. Steepland Harvesting was an alliance between the New Zealand forestry sector, Scion and the University of Canterbury, with forest engineering and machinery companies and the Ministry of Agriculture and Forestry (later the Ministry for Primary Industries – MPI), through the PGP. At the start of the programme these goals were set:

- Improve productivity. This could be achieved by mechanising harvesting operations on steep country, especially in tree felling and extraction, to gain the benefits that had been achieved over the previous decades with mechanisation on easy country, and to create opportunities to attract the 'workforce of the future' into harvesting
- Reduce steepland harvesting costs by 25% (or $8/$m^3$ of wood produced). This was a 'big hairy goal', but one that was thought achievable
- Improve safety by eliminating hazardous manual roles in tree felling and breaking-out. Mechanisation of felling and extraction would put workers into machine cabs and take breaker-outs off the slope
- Grow the forestry machinery manufacturing sector by creating new felling and extraction technology for domestic and export sale. The industry needed to build technical capability in harvesting machinery development to future-proof the growth of the industry, given the closure at the time of most of the North American manufacturers of harvesting equipment that was used in New Zealand.

Programme partners

At the time the FFR Harvesting Theme had about 25 members, with most of the significant forest owners and forest management companies in New Zealand participating. Several forest machinery manufacturers, harvesting contractors, the key forestry educational and training organisations, forest industry consultants, and some regional councils and district councils that owned forests have also joined. The membership later grew to about 35 members as more companies came on board after seeing the benefits from productivity and safety improvements on steep terrain.

Later FGR continued to represent the many different groups from across the industry coming together for a common purpose. The benefits were not only the wide range of views and representation, but also a variety of skills on which to draw. Such extensive representation also assisted in the promotion of results and the uptake of the outputs of the programme.

Governance

Governance of the programme was via the Programme Steering Group (PSG) made up of representatives of FGR Ltd and MPI. Programme management was via a Technical Steering Group, which directed the projects and provided recommendations on funding and programme direction to the PSG.

Committed industry funding for the programme came from both cash and in-kind contributions from FFR industry members. Cash funding started at about $350,000 p.a. in 2010/11. Significant in-kind support of approximately $100,000 p.a. consisted of:

- Forest company staff time, data in the form of harvest plans, crew productivity and performance data, forest inventory and GIS information
- Individual manufacturers' time in engineering design
- Contractor assistance with plant and equipment for operational trials and evaluation.

This in-kind support was essential as small business enterprises could not afford to put cash into the programme. Later in the programme the Forest Grower Levy Trust contributed funding to it from 2015.

Outcomes of the programme

The major outcomes of the programme (and other sector-wide activities) over the period 2010 to 2017 have been:

- A major increase in the level of mechanisation of harvesting operations
- Sector-wide cable harvesting productivity increases
- Safety benefits
- Forest engineering developments.

Rise of mechanisation

The New Zealand forest industry has seen a massive increase in the mechanisation of harvesting since 2013. The sector-wide benefits from the adoption of new mechanised felling technology is highlighted in Figure 1. From the FGR benchmarking database, mechanised felling is now used in over 80% of ground-based harvesting and almost 30% of hauler operations. Of course not all of these developments are attributable to the Steepland Harvesting programme, but it has acted as a catalyst to encourage, support and adopt new felling and extraction technology.

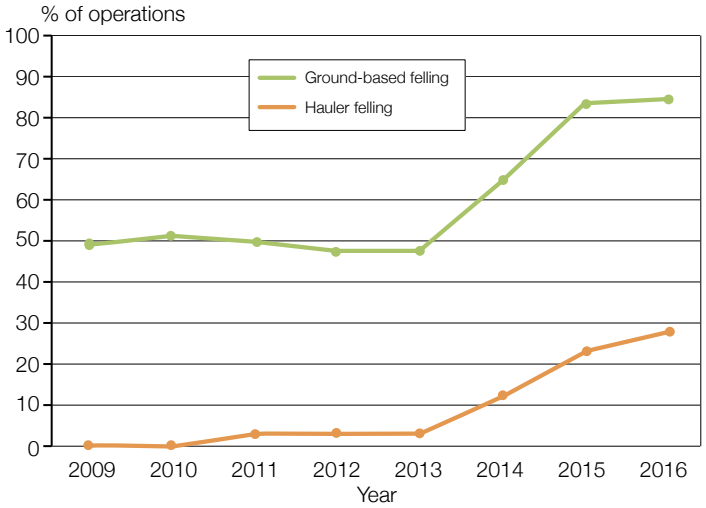

Figure 1: Increase in mechanisation of harvesting in New Zealand, 2009–2016

Sector-wide increase in productivity

The widespread uptake of mechanisation has seen a 25% improvement in operational productivity in steep country operations (Figure 2). Cable harvesting productivity has increased from 23.4 tonnes/scheduled machine hour (SMH) in 2013, when winch-assist machines were first introduced, to 29.4 tonnes/SMH in 2016 (Source: FGR Benchmarking).

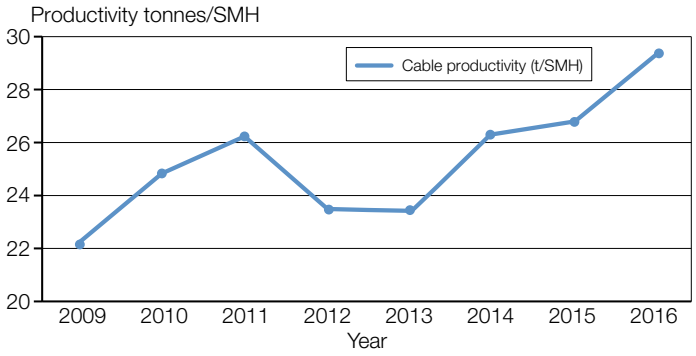

Figure 2: Increase in cable logging productivity (tonnes produced per scheduled machine hour), 2009–2016

Safety benefits

There have been many safety initiatives undertaken across the industry as a result of the Independent Forestry Safety Review in 2014 and the Health and Safety at Work Act 2015 (HSWA) such as:

- Establishment of the Forest Industry Safety Council, including worker participation
- Setting clear and common standards, especially for safety-critical roles
- Increased WorkSafe inspections
- A focus on improved safety culture
- Certification for harvesting workers and contractors
- Improved information sharing through the Safetree website.

Since 2013, we have also seen a major uptake in new technology such as winch-assist feller bunchers, hydraulic grapple carriages and camera systems that has had a safety benefit. Data from WorkSafe NZ shows that as a result of all these initiatives there has been a 60% reduction in serious harm injuries (SHIs) from 188 incidents in 2012 to 75 incidents in 2017.

The rate of SHIs/million m^3 of wood production has dropped from 7.2 in 2012 when New Zealand was harvesting just over 25 million m^3, down to just 2.4 SHI/million m^3 in 2017 when the harvest increased to over 30 million m^3 (Figure 3). Also, over 200 workers have been removed from hazardous manual felling and breaking-out roles.

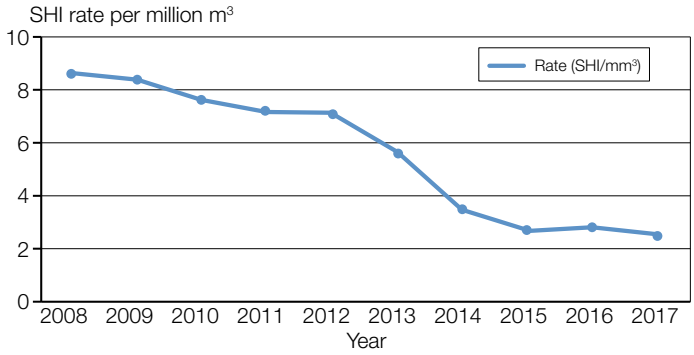

Figure 3: Reduction in serious harm incidents per million m^3 production

Forest engineering developments

Focusing on forest engineering developments, the latest to occur from the industry over the last five years or so have been in these areas:

Winch-assisted felling

Improved mechanised tree felling using feller bunchers with winch-assist (see first photo). It is estimated that over 90 of these types of machines, from at least six different manufacturers, are now operating in New Zealand.

Winch-assisted felling with the ClimbMAX steep slope harvester

Teleoperated felling

The potential for improved safety with remote control and teleoperation was explored with the full teleoperation of a John Deere 909 feller buncher-controlled from a remote operator console.

Operator console for teleoperation of the feller buncher

Grapple carriages

Improved grapple yarding with remote-controlled hydraulic grapple carriages. There are now three manufacturers selling grapple carriages, ranging from the non-motorised Alpine grapple carriage to the fully motorised carriages, such as the Falcon Claw and the Hawkeye. About 75 grapple carriages are now operating in New Zealand.

Alpine grapple carriage

In-cab vision systems

Hauler vision, navigation and tension monitoring systems are designed to give the machine operator a better view of operations and range from the HarvestNav on-board navigation system, to the Falcon tension monitoring 'app' and the CutoverCam hauler vision system.

CutoverCam hauler vision system

Skyline shifting

Improved skyline shifting developments ranged from remote-controlling a mobile tail-hold machine to the Skyshifter, an innovative tail-hold carriage.

Skyshifter remote-controlled tail-hold carriage

Processing and loading

Multi-function processing and loading using a quick coupler. The final product from the Steepland Harvesting programme is the Doherty automatic quick coupler (Figure 4). This attachment to the stick of a knuckle boom loader enables the operator to rapidly switch from a grapple processor to a loader grapple at the flick of a switch without leaving the cab.

Figure 4: Doherty automatic quick coupler

Sector-wide commercial outcomes

Overall, the commercial outcomes over the whole sector have been very successful. There are now many new mechanised felling and extraction operations that did not exist five years ago.

These innovations include many new winch-assisted felling machines, grapple carriages with cameras, and on-board vision systems.

There are now four major machinery manufacturers exporting winch-assist products to North America (EMS Ltd, DC Equipment Ltd, ClimbMAX Equipment Ltd and Rosewarne & May Ltd). Over 180 new winch-assist felling units have been sold, including over 90 machine exports to North and South America. About 75 new grapple carriages have been sold, including Falcon Claw, Hawkeye and Alpine.

Over 100 new camera systems have also been sold and more than 20 HarvestNav navigation systems are in use. Sales of new harvesting machinery and equipment since 2012 have totalled over $110 million. Contractors who have adopted this new technology have seen operational cost savings. The sector-wide net harvesting cost benefits to date are estimated at over $115 million.

Conclusion

The results of the forest engineering developments across the sector over the last five years include 20 new products developed that are suited to New Zealand conditions. Sixteen of these products have been commercialised and four are still in the prototype stage.

The collaboration of forestry companies, contractors, machinery manufacturers and the government through the PGP has improved the way innovations are commercialised and has de-risked this investment by contractors. This has seen significant growth of New Zealand machinery manufacturers and technology developers, which future-proofs the growth of the forest industry and continues to catalyse new innovations in harvesting operations.

This collaboration has also speeded up the uptake of products and the delivery of significant productivity and safety benefits. The PGP Steepland Harvesting programme has therefore been an excellent example of the power of collaboration in the New Zealand forest industry.

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A wood residues circular economy

Ben Crawford

Wood energy chip for small-to-medium energy requirements

Azwood Energy is an example of a company cleaning up forestry slash and using it as a low emission energy source to power industry and heat New Zealanders. The residues are then used to give back to the land – all helping to supercharge the economy while creating an alternative to fossil fuels.

The company works in partnership with forestry, providing an environmental clean up of wood waste from skid sites, helping to prevent erosion and protect waterways. It uses this residue to produce low emission replacement energy for fossil fuels.

The circular economy is created when healthcare facilities, schools, businesses and organisations (including wood processing) heat their people and operate their processes using the low emission wood fuel produced from this residue. The fulfilment of the circular economy is turning forestry residue into wood fuel and compost. To close the loop, in many cases ash from burned wood fuels is further utilised, and added to other forestry residues to produce composts and other organic growing media, thereby giving back to the earth.

The widespread implementation of such a sustainable circular economy could combat the impact of severe weather events, like Cyclone Gita in Tasman, preventing forestry slash damage like that also recently seen in Tolaga Bay. It may be of no comfort to those affected, but had this circular economy been operational in Tolaga Bay and able to create a local market for its wood energy, the environmental disaster may have been averted.

In that scenario, it is very likely that the slash and logs that were washed down in that wall of wood would have been burned long ago to provide process energy to heat plants in place of environmentally damaging fossil fuels like gas and coal.

There is a place for residue wood fuel in responsibly powering New Zealand, with a huge resource sitting there, ready to be used. If companies such as Azwood Energy can work alongside proactive forestry companies to reduce industry impact then it is a win-win for New Zealand.

The Labour Coalition government has set a goal to plant one billion trees over the next 10 years. This initiative will enhance forestry's role in reducing the effects of climate change by storing more carbon in building materials, as well as providing more wood residue fuel for heat plant conversions, helping New Zealand transition to a low emissions future.

Fossil fuels like gas and coal supply 60% of this country's energy for process heat, and this contributes 9% of its gross greenhouse gas (GHG) emissions. EECA and the Ministry of Business, Innovation and Employment are working on a process heat action plan to improve the energy efficiency of using process heat and increase the amount of renewable energy used in its supply.

A recently published report by PwC, commissioned by EECA, identifies how and when businesses spend money to reduce energy use and carbon emissions in some manufacturing processes. EECA's Chief Executive Andrew Caseley says, 'The PwC report makes it clear that strategic focus at senior levels to champion energy efficiency and carbon reduction projects, and improved access to capital, enables the success of such projects.' He notes that as well as making equipment more efficient, woody biomass technologies are increasingly becoming viable alternatives to fossil-fuelled boilers when investment in new plant is being considered.

Azwood Energy is a wood energy supplier and manufactures the entire range of wood fuels – biomass hog fuel, wood energy chip and wood pellet fuel. In the energy sector for 40 years, it began in coal supply, switching in the mid-1990s to wood energy. The company has been recognised by the Bioenergy Association as the national leader in range of product and extent of business, successfully re-purposing more than 1.2 million m^3 of wood residues each year.

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Adoption of emergent technology for forest road management in New Zealand

Kris Brown and Rien Visser

Abstract

A targeted survey of active forest roading managers was completed in April 2018 to better understand the characteristics of the forest industry's current road construction programme, practices used in forest road planning and management, and uptake of emergent technologies applied to forest roading problems. The 18 survey responses represented an annual harvest volume of 10.2 million m^3 and length of new road construction of 426 km.

About 180 km of this new road construction (42%) will be built on highly erodible terrain as defined by the Erosion Susceptibility Classification (ESC) system within the new National Environmental Standards for Plantation Forestry (NES-PF). Spur roads represent almost two-thirds of the new road length. In terms of road pavement construction, vibratory rollers were the most commonly used machines for compaction and total aggregate thickness (i.e. basecourse plus topcourse) averaged about 300 mm.

Respondents identified major challenges in managing their roading programmes, including planning, designing and constructing infrastructure well in advance of harvesting crews (e.g. six months) and controlling construction costs in steep terrain. On average, spur and secondary roads cost $72,000/km and $90,000/km respectively, with gravel and excavation representing the greatest cost components.

Emergent technology, such as the integration of LiDAR-based digital terrain models (DTMs) and geometric design software, is playing a key role in addressing these challenges. Managers indicated that full geometric designs were associated with particularly difficult road sections (i.e. steep and/or unstable slopes and switchbacks), and they emphasised the utility of LiDAR data and geometric design software for these situations.

Managers have also been able to test the feasibility of multiple road routes in the office with a high level of detail. They can perform complete geometric designs, and estimate earthwork volumes (a requirement under the NES-PF) and costs. While the office-based designs still require field validation, the benefits include more targeted field surveys, reduced construction costs and improved environmental performance. However, many managers indicated that few roads required a full geometric design, and in most cases marking of the road centreline was often sufficient for roading contractors to build the road.

A cut slope on a newly-constructed road that has slumped following a rainfall event in Gisborne

This study demonstrated that New Zealand's roading managers are utilising emergent technologies. Almost half (44%) of roading managers frequently used LiDAR-based DTMs to plan and design forest roads. Sixty-one percent of roading managers used a software package to aid road location planning and design. Softree RoadEng was the most commonly used program. The most common applications of unmanned aerial vehicles (UAVs) included monitoring stockpile volumes at in-forest quarries (39% of managers) and road impacts on waterways (17% of managers).

Introduction

While forest road construction occurs on a range of terrain, in New Zealand a lot of new roading is on steep and inherently erodible land (see first photo).

There has been a clear trend toward more mechanised and productive harvesting systems, which require a more secure infrastructure network to remain cost-efficient. The commencement of the NES-PF in May 2018 introduced new requirements such as detailed harvest and earthworks management plans. Concurrently, technological advancements such as LiDAR and UAVs are changing the way forest roads are planned, designed and monitored. However, little is known about the extent of emergent technology adoption by forest roading managers in New Zealand.

The objectives of this study were:

1. To document current practices used by the New Zealand forest industry to plan, design and monitor roads.
2. To highlight examples of industry adoption of emergent technologies to improve forest road management, including environmental performance.

Demographic information

A targeted survey of active forest roading managers was conducted from January to April 2018. In total, 34 managers were contacted and 18 responses were received for a response rate of 53%. The survey response represented 650,000 ha of managed plantation forest spanning the following regions: Northland, Auckland, Central North Island, East Coast, Hawke's Bay, Southern North Island, Nelson/Marlborough, West Coast, Canterbury, Otago and Southland.

Of the 18 roading managers surveyed, 15 specialised in larger commercial forests, as opposed to smaller woodlots. The companies responding to the survey represented a total annual harvest volume of 10.2 million m^3 or about one-third of New Zealand's total annual harvest volume in 2017. The associated annual road construction, including all new road construction for trucks but excluding skid trails, was 426 km. This suggests that New Zealand forest management companies oversee the construction of about 1,300 km of new forest road each year, which is consistent with previous estimates by Neilson (2012) and Fairbrother (2012).

It should be noted that this survey is a snapshot; annual road construction requirements are not continuous. For example, a company managing harvesting operations in second rotation forests will require fewer kilometres of new road construction than that of first rotation forests.

Types of roads being built

Roading managers were asked to estimate the proportion of new road construction for different road standards (spur, secondary or arterial roads) as defined in the *New Zealand Forest Road Engineering Manual* (NZFOA 2011, Table 1). Of the new road construction, 63% will be lower standard spur roads and 34% will be higher standard secondary roads, with only 4% built as arterial (highest standard) roads.

Terrain erodibility

Roading managers were asked to estimate the proportion of new road construction occurring on land with varying levels of erodibility as defined by the ESC. The ESC is based on a Land Use Classification system that considers the dominant erosion process, rock type and topography. For more information visit www.mpi.govt.nz/growing-and-harvesting/forestry/national-environmental-standards-for-plantation-forestry/erosion-susceptibility-classification/.

Table 1: Total length of new truck road construction per year by road class

Road class	Total road length (km)
Spur – short term, typically defined as serving just a few landings, carrying fewer than 20 hvpd*	267
Secondary – typically services multiple operations, carrying 20-80 hvpd, but not in use all of the time	144
Arterial – typically defined as a road that is likely to always carry truck traffic, with more than 80 hvpd	15
Total	**426**

* hvpd = heavy vehicles per day

Together with risk assessment tools related to fish spawning and wilding trees, the ESC is used in the NES-PF to determine which forestry activities (e.g. afforestation, replanting, harvesting and earthworks) are permitted with certain conditions and which require a resource consent (MPI, 2018). Based on the survey response, 58% of new road construction will occur on low to moderately erodible terrain (Table 2). About 42% of new road construction will occur on high to very highly erodible terrain (180 km).

Table 2: Total length of new road construction within each erosion susceptibility class (ESC)

ESC	Total road length (km)	% of total
Low (green)	117	27%
Moderate (yellow)	130	31%
High (orange)	140	33%
Very high (red)	40	9%
Total	**426**	**100%**

Roading costs

Roading managers were asked to estimate the average cost to build roads and to consider all costs, from planning and vegetation removal through to drainage and surfacing. Spur roads cost on average $72,000/km, ranging from $10,000/km to $150,000/km. Secondary roads cost $90,000/km on average, ranging from $35,000/km to $150,000/km. The wide range in roading costs reflects variability in terrain steepness, requirements for road drainage and stream crossings, access to rock for road surfacing, and road design standards related to harvest volumes (e.g. woodlots versus larger commercial forests).

For example, in three of five cases where spur roads cost at least $100,000/km the location was Gisborne, which is characterised by steep, highly erodible terrain with long cartage distances for road surfacing materials. The lower cost spur roads (i.e. $40,000/km or less) were largely characteristic of woodlot roads or sites

with pumice soils, such as in the Central North Island. Pumice soils are well-drained with a high bearing strength and construction costs are generally lower as they require little or no gravel surfacing.

To enable better understanding of roading costs, forest managers were asked to rank the following cost components (1 is most expensive, 8 is least expensive): office planning, field surveying, clearing and piling (i.e. roadline salvage), excavation, grading and compaction, gravel (or aggregate) surfacing, drainage, and stream crossings. Ranked data were averaged by road cost component for comparison (Table 3).

Table 3: Average cost ranking for different road cost components (n=18) – 1 is most expensive and 8 is least expensive

Cost component	Average rank
Gravel (or aggregate) surfacing	2.0
Excavation	2.1
Stream crossings	4.3
Grading and compaction	4.6
Clearing and piling	4.6
Drainage	4.8
Field surveying	6.8
Office planning	6.9

Gravel surfacing and excavation (i.e. earthworks requirements) had the highest rankings, indicating that they are the major drivers of road construction cost. Interestingly, for spur roads costing around $40,000/km or less (i.e. representative of woodlot roading), the greatest cost components were excavation and stream crossings.

Forest road pavement design and compaction

Vibratory rollers were the most commonly used machines for compacting the subgrade (i.e. in-situ soil and rock) and the overlying 'improved' layer, which usually consists of a single layer of basecourse aggregate and sometimes a thinner layer of topcourse aggregate. Sheepsfoot rollers were also commonly used to compact subgrades. Track rolling with an excavator or bulldozer was another common compaction technique, although it was used less extensively than vibratory rollers (see second photo). Compaction techniques will vary depending on local soil type and geology, as well as different road standards that correspond to traffic volumes, types and loads, and the duration of road use.

One company used a range of machines for compaction, including a vibratory roller and rubber-tired machines (e.g. skidders and dump trucks). In this case, they used a practical test to determine if the required level of subgrade compaction had been achieved, whether or not a loaded dump truck left an impression on the subgrade. Forest engineers will typically utilise a dynamic cone penetrometer to assess subgrade strength once it has been graded, shaped and compacted, and a

Summertime landing construction in Canterbury. Compaction involved track rolling the landing with a Komatsu D65 EX bulldozer (left) prior to vibratory rolling with a Sakai SV512TF (right)

Newly-constructed secondary road on the East Coast

Clegg hammer to assess overall pavement strength once aggregate has been spread and compacted. One company uses a minimum California Bearing Ratio (CBR) of 7% for the subgrade and 40% for the improved aggregate layer.

For spur roads, the compacted thickness of the basecourse layer averaged about 220 mm, ranging from approximately 130 to 310 mm (Table 4). The upper (topcourse) layer averaged about 75 mm thick, ranging from 50 to 135 mm. Maximum particle size diameter for the basecourse and topcourse was approximately 150 and 60 mm, respectively. Interestingly, these pavement design characteristics were similar for secondary roads, showing that typically forest road managers are applying very similar standards to both road types.

Table 4: Descriptive statistics related to the compacted thickness (mm) and maximum particle size diameter (mm) used in the basecourse (aka improved layer) and topcourse layers of forest road pavements in NZ

	Basecourse		Topcourse	
	Layer thickness (mm)	Maximum rock diameter (mm)	Layer thickness (mm)	Maximum rock diameter (mm)
Spur roads				
Mean	216	151	76	59
Median	200	120	70	65
10th percentile	133	73	50	40
90th percentile	310	260	135	69
Secondary roads				
Mean	232	140	81	61
Median	225	120	65	65
10th percentile	150	73	50	43
90th percentile	324	220	141	69

The third photo shows a recently compacted forest road pavement from the East Coast. The road formation is 9 m wide and it was compacted using a 12 tonne drum roller with a vibratory option. It is common practice to use a sheepsfoot roller for the subgrade and vibratory roller for pavement. The basecourse consists of rotten rock and soil with a compacted thickness of 100 to 150 mm. The topcourse (highlighted in the inset photo) is 150 mm of crushed river run with maximum particle size of 50 mm (aka General All Passing 50 or GAP50).

Terrain maps for road planning

Roading managers were asked about the terrain maps that they use to plan and design forest roads. Of the 18 managers, 14 said that they use a map scale of about 1:5000 for preliminary planning (e.g. initial layout and route feasibility), depending on the size of the block. These maps were sourced predominantly from in-house ArcGIS systems. A few managers used Google Earth Pro and publicly available maps. For advanced road planning and design (e.g. horizontal alignment and drainage requirements) roading managers generally used a map scale of 1:5000 or finer resolution, depending on the situation.

Of the 18 managers, eight frequently use LiDAR-based DTMs in forest road planning and design (i.e. 'often' or 'always'), whereas 10 of the managers do not use them very often (i.e. 'sometimes', 'rarely' or 'never'). LiDAR-based DTM usage is highly dependent on availability (i.e. those who have them use them). Notably, four roading managers with limited LiDAR availability in their forest estates indicated that their companies have purchased or plan to purchase LiDAR data in the near future. To put these results into context, Morgenroth and Visser (2013) found that about 18% of New Zealand forest management companies were regularly using LiDAR data just five years ago.

Roading managers were asked to fill out a table indicating how they use LiDAR-based DTMs (Table 5).

Table 5: Uses for LiDAR-based DTMs

What are LiDAR-based DTMs used for?	Responses (no.)
Preliminary planning of new roads (i.e. initial layout, route feasibility)	10
Identification of existing roads	9
Advanced planning of new roads (i.e. road template specification, horizontal and vertical alignments, balancing earthworks, water controls)	8
Identification of stream channels	7
Identification of unstable slopes	7
Mapping Topographic Wetness Index (TWI) or Depth to Water Table (DWT) (i.e. wet areas to avoid)	1

In terms of preliminary planning, DTMs were used to locate features such as rock outcrops and archaeological sites, and to measure widths of existing roads and trails. One company used colour-coded slope maps in 10% increments (Figure 1) to identify areas where sidecast (typically up to 40% slope) or bench-and-fill road construction (typically 40% to 70% slope) was feasible, or conversely where end-haul road construction was necessary (typically >70% slope). In one case, 0.5 m contour lines were used to assess stream crossing feasibility by measuring stream channel dimensions and road approach slopes.

One manager said, 'As we have become more efficient with using what is now very high-quality LIDAR data, I am finding that the old days of extensive forest walking and survey are not required as numerous checks are finding that the LIDAR data is extremely accurate.' He explained that LiDAR-based DTMs are used for first (and often final) road alignments in easier terrain, while full LiDAR-based RoadEng designs are used for roads requiring substantial earthworks in steep terrain.

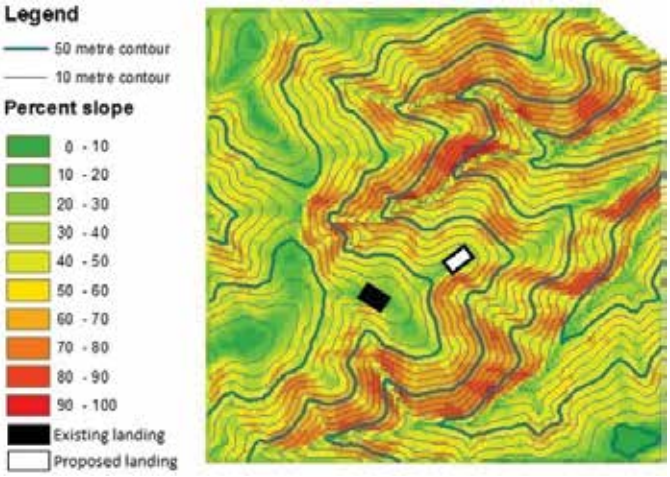

Figure 1: LiDAR data was used to create a DTM using ArcGIS and a heat map was used to depict slope steepness. In this example, a spur road is needed to connect the existing landing with the proposed landing further downslope

Forest road surveying and design

Of the 18 roading managers, 10 mainly used in-field surveys to obtain the information necessary to design and construct a road, whereas eight managers used a combination of LiDAR-based terrain models and in-field surveys. For example, one manager said that on easier terrain they run gradelines in the field, but in steeper terrain they used LiDAR data to generate RoadEng designs.

Most roading managers (15 of 18) indicated that for spur roads, few (0% to 25% of roads being built) required a full geometric design. The results were similar for secondary roads. A full geometric design was defined as applying most of the following geometric standards to produce a specific road geometric design: cut bank and fill slopes, ditch depth and width, road width and camber, curve radius, curve widening, fill widening, road slope, and sight distance.

Computer-assisted road planning and design

Sixty-one percent of roading managers use a software package to aid road location planning and design. The most popular software package was Softree RoadEng. Several roading managers emphasised its utility for road design and layout on steep and difficult sections, such as heavy earthworks requirements and switchbacks (Figure 2). While the use of RoadEng is not new, the integration of LiDAR data and RoadEng enables managers to test the feasibility of multiple road routes in the office. The benefit is that managers can allocate time that would otherwise be spent in road planning to other tasks, such as harvest planning and liaising with logging and construction crews.

RoadEng was used to determine road gradients that could be achieved after balancing cut and fill volumes. Design hardcopies, including the road plan, profile and cross-sections, could then be provided to supervisors and equipment operators along with

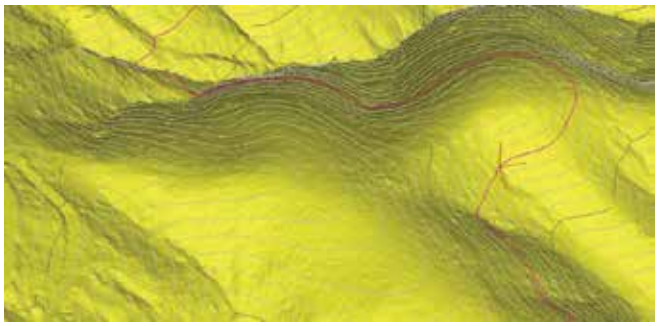

Figure 2: Three-dimensional view of a LiDAR-based DTM created using RoadEng 7. Using this DTM, the user can test the feasibility of multiple road routes in the office with a high level of detail

GPS points that marked the location of cut points. Training resources, such as RoadEng webinars and tutorials, are available on Softree's Youtube channel (www.youtube.com/user/SoftreeSoftware). This one demonstrates how to import LiDAR data, generate a DTM, and peg out a proposed roadline (www.youtube.com/watch?v=zWFkPCyuO38&list=PLwOM-Z0fbkzckAzyGDzw9nn3wGUXo7Dcy).

In another example, a roading manager used ArcGIS desktop to plan preliminary road routes, which were exported as PDFs for use in the field via a program called Paper Maps (www.paper-maps.com). Another program, Collector, was used for mapping the final as-built alignment and then this was used to update ArcGIS desktop.

Three roading managers indicated that they had at least attempted to use a cost optimisation tool; in all cases RoadEng was used. However, one manager noted, 'It's hard to find time to do it (cost optimisation) and quantify the benefit.' Conversely, another manager said that he uses a simple costing spreadsheet once he has taken the roading contractor out to the field to determine costs together.

Marking aids to road construction

Of the 18 roading managers, 14 indicated that most spur roads (>75%) require marking of the centreline only as an aid to road construction operators, which was similar for secondary roads. One manager explained, 'We have moved from steep, first rotation to easier, second rotation forests, so these numbers have changed. We also have competent equipment operators, so I am confident in marking the centreline only.' Another manager indicated that spur roads may be unmarked, saying, 'We have short spur roads here due to the terrain. We have experienced equipment operators that can make the benign grade to the skid (landing).'

Similarly, 16 of 18 roading managers indicated that few spur roads (0% to 25%) required marking of multiple components of the road formation (i.e. top of the cut slope to the bottom of the fill slope; P-Line plus cut height). This indicates that once the road location has been decided, a manager can flag the centreline and rely on operator experience to build a good road. However, the cost-efficiency of operator-based designs cannot

be assessed if no-one is checking. Therefore, it would be prudent to compare full geometric designs with operator-select construction for a variety of performance indicators, such as total earthwork volume, whether or not cut and fill volumes are balanced, efficiency of machine movements, minimum switchback radius, and maximum adverse gradients achieved.

Monitoring road surface conditions and road impacts on waterways

Roading managers were asked, 'In addition to simple inspection routines, do you use any other tools (e.g. Benkelman beam, vehicle-based LiDAR) or methods (i.e. cross-sectional surveys, road user reports) to monitor the condition of the road surface (i.e. ruts, potholes, corrugations etc)?'

Of the 18 roading managers, 16 indicated that they use mostly simple inspection routines. Two managers use road user reports and requests for service. Another manager said that the trucking suppliers have an app to report road surface issues.

None of the roading managers surveyed have used UAVs or LiDAR to monitor road surface conditions as described by Pierzchala et al. (2014), Talbot et al. (2017), and Hrůza et al. (2018). However, 17% of roading managers have used UAVs to monitor road-related impacts on waterways. One manager said that a UAV is used to inspect roads following storm events.

Application of emergent technologies to roading problems

Managers were asked to list examples of emergent technologies that they were interested in applying to their tasks in road planning, design and management. The integration of LiDAR data and geometric design software (Neilson, 2012), as well as the use of UAVs to monitor quarry stockpile volumes (Arango & Morales, 2015), generated the most interest, which is not surprising as these are the main emergent technologies being used by New Zealand's forest roading managers to date. For example, seven respondents used UAVs to estimate stockpile volumes at in-forest quarries and borrow pits (see fourth photo).

Other UAV applications included surveying bench heights for safety reasons and estimating solid rock volumes available for blasting calculations to create a quarry plan.

Also, three managers discussed the utility of displaying an advanced road alignment on a tablet computer in the cab of an excavator or bulldozer. The tablet would show the final road design, DTM and corresponding location of the machine to facilitate road construction in the correct location and to minimise earthworks. Finally, managers expressed interest in using UAVs to collect LiDAR data in woodlots and to measure cut and fill volumes after road construction.

Example of an in-forest quarry in Canterbury

Challenges in managing a forest roading programme

Roading managers were asked to describe the biggest challenges they face in managing a forest roading programme. A summary of the common themes is provided below:

- **Keeping ahead position**

  Ideally, companies will attempt to clear the roadline and build roads during the summer and at least six months ahead of planned harvesting activities. This helps to promote a natural firming of the road. However, harvesting crews may be forced to shift to green infrastructure on short notice due to windthrow or wildfires that require salvage logging. Also, changing market conditions could cause a shift in harvesting position and this so-called 'just-in-time' roading can result in a greater risk of road failure

- **Roadline salvage**

  Several managers discussed the challenge of managing resources to gain efficiency in constructing roads while the road line salvage crew is simultaneously clearing the wood

- **Cost control**

  Examples include efficient use of machines and accuracy of contractor payment systems

- **Managing clean-up of storm events**

  For example, in regions such as the Bay of Plenty, Gisborne and Nelson/Marlborough

- **Contractor labour skills**

  Managers noted that it can be hard to keep the good contractors around. It is important to note that this finding contrasts with the practice of marking road centrelines and relying on operator skill to build a good road

- **Supervising construction related to quality control and environmental compliance**

  This includes checks to ensure that construction has met design specifications related to benching and compaction, sidecast containment, road grades and switchback radius

- **Gravel resources**

  For example, access to sufficient volumes of quality aggregate

- **Steep terrain road construction**

  For example, when 70% to 80% of road construction is end-haul, things can get expensive quickly and finding suitable dump sites for spoil material can be difficult. An additional challenge in steep terrain is upgrading poorly engineered (legacy) roads and trails, which may require extensive regrading, realignment, or retaining walls to fix collapsing fill sections.

Conclusions

The survey responses from 18 currently active forest roading managers in New Zealand were used to provide a detailed snapshot of the industry's current road construction programme, practices used in road planning and management, and uptake of emergent technology. The survey response represented an annual harvest volume of 10.2 million m^3, roughly one-third of New Zealand's annual cut in 2017. The corresponding length of new road construction was 426 km. As such, this study estimates that companies are currently building about 1,300 km of new roads each year, two-thirds of which are lower standard spur roads that provide on-highway truck access to landings during harvesting operations. About 42% of this new road construction is planned to occur on highly erodible terrain.

Roading managers desire ready access to highly-detailed terrain information to ensure that the road systems they plan and design are stable, safe and cost-efficient. Most notably, this study showed that 44% of roading managers frequently use LiDAR-based DTMs in combination with in-field surveys to provide the information necessary to design and construct forest roads. The integration of LiDAR-based DTMs and road design software enables managers to test route feasibility, complete geometric designs, balance cut and fill volumes, and estimate construction costs efficiently. One manager said, 'I would say that having accurate LiDAR-generated coverages is the biggest jump forward in forest planning that has occurred in the last 20 years.'

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New Zealand School of Forestry Survey of BForSc Graduates and Their Employers – summary of 2017 survey results

Thom Erdle

Abstract

The New Zealand School of Forestry (SoF) seeks to continuously improve the quality and relevance of its Bachelor of Forestry Science degree. In support of this ongoing effort, the SoF conducted in 2017 a survey of all recent graduates of that degree and their employers in forestry and allied sectors. The survey was designed to assess how well the degree prepares graduates for their professional careers and to gain insight into improving the educational experience offered by the SoF. This article summarises the key findings of that survey and offers suggestions for improving that degree, which is already held in high regard by graduates and employers alike.

Background

In April 2017, the SoF conducted a survey of all recent Bachelor of Forestry Science (BForSc) graduates and their employers in forestry and allied sectors to: (a) assess the value of the degree in preparing individuals for professional careers; and (b) gain insight into opportunities for improving the degree programme. The survey focused on four key areas: knowledge base, technical skills, professional abilities and personal traits. These areas are well accepted as important in evaluating educational programmes in professional disciplines (e.g. Bullard et al., 2014; Fox et al., 1998).

The survey was designed to acquire employers' and graduates' perspectives about: (a) the importance in the work environment of these four areas; (b) the competence level attained in these areas by BForSc graduates; and (c) the degree to which the SoF experience contributed to that competence. Surveys were sent electronically to 53 employers in 30 forestry sector organisations and to 107 recent BForSc graduates (2010–2016 inclusive). Sixty-four percent of employers responded, representing 77% of employer organisations, and 59% of graduates responded. Of the latter, 82% were employed in the forestry sector, 8% were employed in other professions and 6% were pursuing advanced education. (Sample sizes shown in figures reflect graduates employed in the forestry sector and exclude non-responses to questions.)

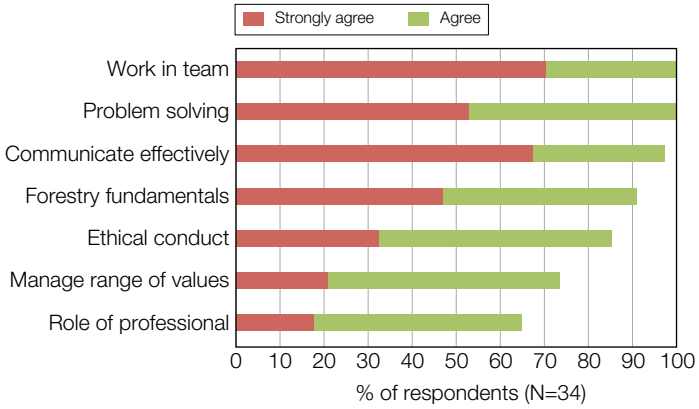

Figure 1: Employers' assessment of graduate profile

Findings

Graduate profile

The SoF has defined a desired graduate profile characterised by seven overarching abilities and traits it works to impart in its graduates. Seventy-five percent or more of employers agreed or strongly agreed that six out of the seven profile elements met their requirements (Figure 1), while over 80% of the graduate respondents agreed or strongly agreed that all seven do so (Figure 2). These results reveal general agreement that the profile is appropriate from both perspectives. It is noteworthy that the employers placed the highest importance on the ability to work effectively in a team, and that the three most strongly endorsed profile elements are not forestry-specific, but rather are abilities important in any profession.

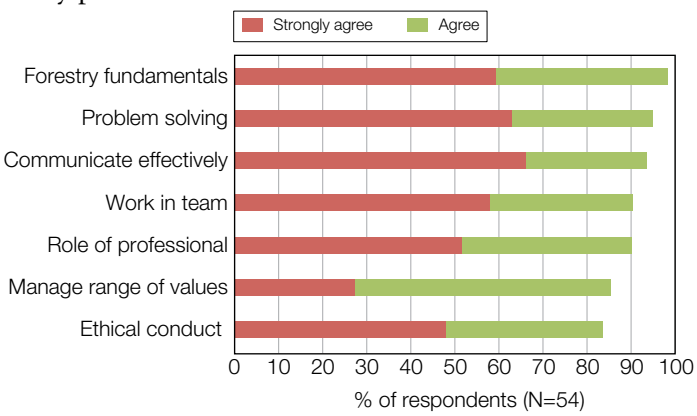

Figure 2: Graduate versus employer competence rating – knowledge base

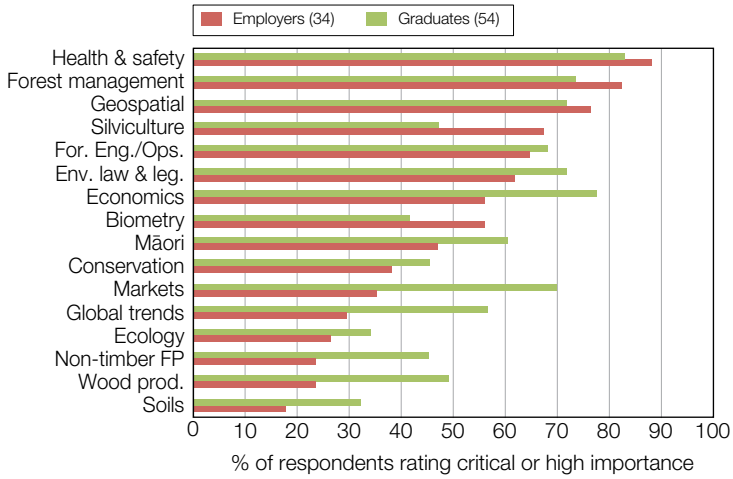

Figure 3: Graduate versus employer importance rating – knowledge base

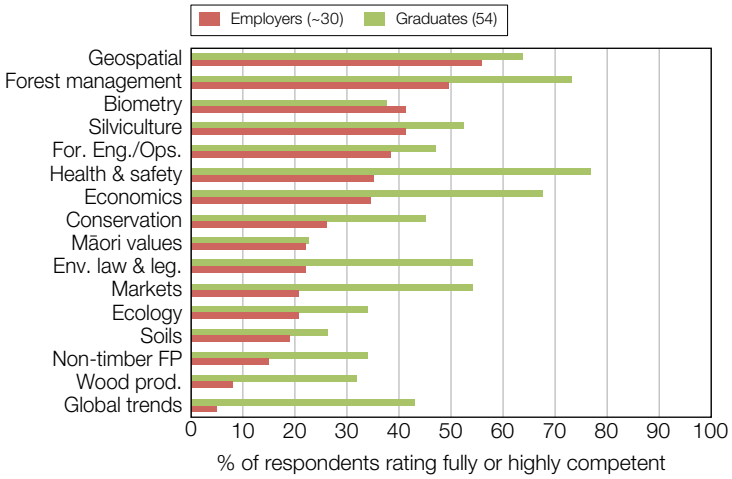

Figure 4: Graduate versus employer competence rating – knowledge base

Knowledge base

Knowledge base was defined in the survey as the collection of 16 discipline-related subject areas comprising information the graduate knows, understands and can effectively apply in forestry practice. Leading the list, with near unanimity amongst employers, is the high importance placed on knowledge of health and safety (Figure 3). This was followed by forest management, geospatial technologies, silviculture, forest engineering and operations, environmental law and legislation, economics and biometry, all of which were rated as important by over 50% of respondents.

Like employers, graduates rated health and safety as the most important element in the knowledge base (Figure 3). This was followed closely by economics, forest management, environmental law and legislation, and geospatial technology.

In many cases, employers and graduates rated the importance of knowledge elements similarly (Figure 3). This is especially noticeable in elements of highest importance, namely, health and safety, forest management and geospatial technologies.

Employees were deemed fully or highly competent in 14 of the knowledge base subjects by less than 50% of employers, with only geospatial technology and forest management exceeding this level (Figure 4). Few employers assessed graduates as fully competent in any subjects.

Few graduates (<25%) deemed themselves fully competent in any elements of the knowledge base, which is understandable given their recent entry into the working profession (Figure 4). However, two-thirds or more of graduates deem themselves highly competent in four knowledge elements (i.e. geospatial technology, forest management, health and safety, and economics), all of which they rated as of critical or high importance (Figures 3 and 4).

Interestingly, graduates rated their competence generally much higher than did their employers (Figure 4). This is most notable where nearly 80% of graduates deemed themselves to be fully or highly competent in health and safety; only one-third of employers agreed.

Technical skills

Technical skills comprise those forestry-related capabilities one must possess to function competently as an effective forester.

Implementing health and safety protocols, conducting financial analysis, applying GIS, environmental management and monitoring, data analysis, and field sampling and measurements, top the importance list of technical skills (Figure 5) in the view of employers, over two-thirds of whom rate these as critically or highly important. Health and safety stands out, with 85% of respondents rating it of critical importance. With the exception of forest health and site quality assessment, all other skills are rated as highly or critically important by 40% or more of employers.

Graduates rate health and safety, financial evaluation, applying GIS, data analysis, and environmental management and monitoring, as the five most important technical skills (Figure 5). Use of LIDAR rates lowest, but still over one-third of graduates deemed it critically or highly important.

Less than 20% of employers ranked graduates as being fully competent in technical skills. In five areas (sampling and measurements, GIS application, GPS use, data analysis, and financial evaluation) graduates were rated as fully or highly competent by 50% or more of employers (Figure 6). In five other skills, relating to harvest systems, silviculture prescriptions, site assessment, road layout, and forest valuation, less than 25% of employers rated graduates as fully or highly competent.

As with knowledge base, graduates' and employers' ratings of importance are in close agreement. This is true both in absolute and relative terms, as graduates' and employers' assessments are remarkably similar in both the rating and ranking (Figure 5).

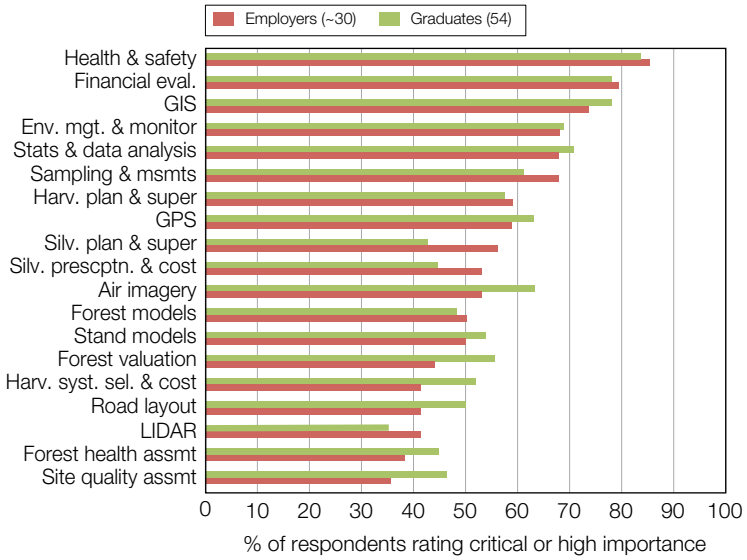

Figure 5: Graduate versus employer importance rating – technical skills

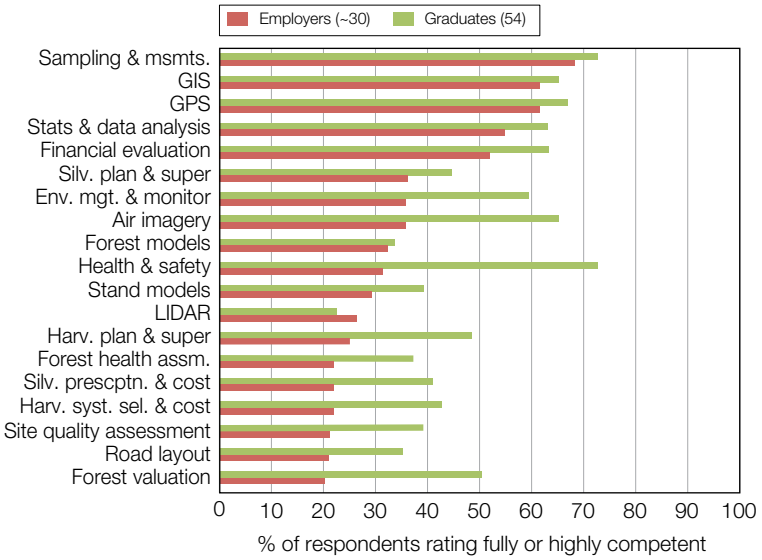

Figure 6: Graduate versus employer competence rating – technical skills

Level of agreement in competence, on the other hand, is mixed. Ratings and rankings are very similar for the five skills, with highest employer-assessed competencies being sampling and measurements, GIS, GPS, data analysis and financial evaluation (Figure 6). In other areas, notably health and safety, graduates rate their competence significantly higher than do their employers. This may reflect bias in self-assessments or the different performance benchmarks of the two parties.

Professional abilities

Professional abilities comprise those generic, enabling abilities one must possess to function competently in any professional discipline. Almost all of the 13 professional abilities listed were deemed highly important by employers. However, communication stands out, with 100% of respondents deeming listening, writing and speaking as critically or highly important (Figure 7). Negotiation and leadership were deemed important by fewer employers, but still by two-thirds of them. Graduates were nearly unanimous in rating time management and problem-solving as most important (Figure 7).

Graduates and employers assessed professional abilities almost identically, both in rating and ranking of importance (Figure 7). Only moderate variances were evident in the three lowest rated abilities (negotiation, leadership and public engagement), where graduates assigned higher importance than did employers. Interestingly, both employers and graduates placed overall higher importance on professional abilities than on forestry-specific knowledge and skills (Figures 3, 5 and 7).

Two-thirds of employers rated graduates as highly or fully competent in communication, data analysis, time management and problem-solving (Figure 8). However, very few employers (less than 20%) felt employees were fully competent in any of these professional abilities.

Graduates rated themselves most competent in problem-solving and written communication, with nearly 90% believing they are fully or highly competent in these areas (Figure 8). Competence in negotiation and public engagement were rated much lower, with about 55% of graduates believing themselves to be fully or highly competent in these abilities.

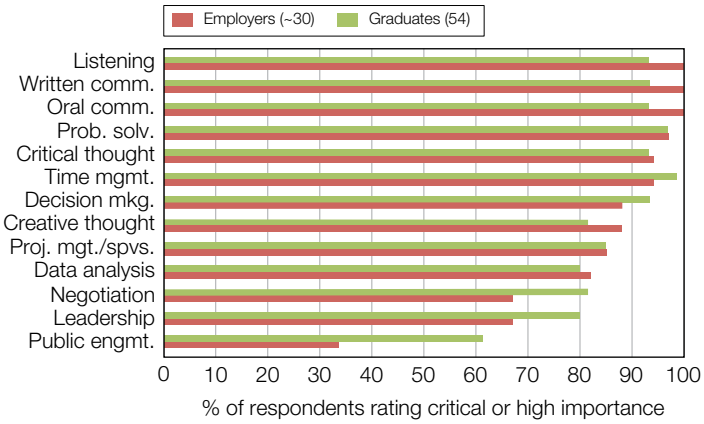

Figure 7: Graduate versus employer importance rating – professional abilities

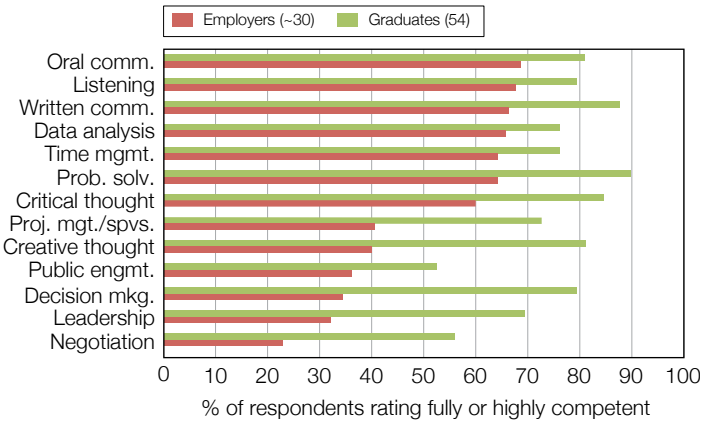

Figure 8: Graduate versus employer competence rating – professional abilities

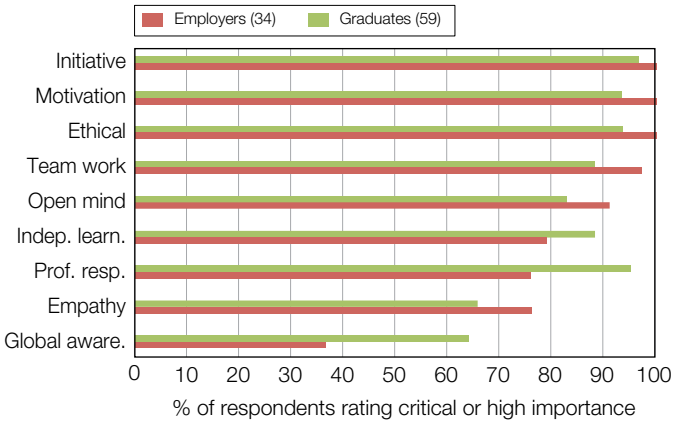

Figure 9: Graduate versus employer importance rating – personal traits

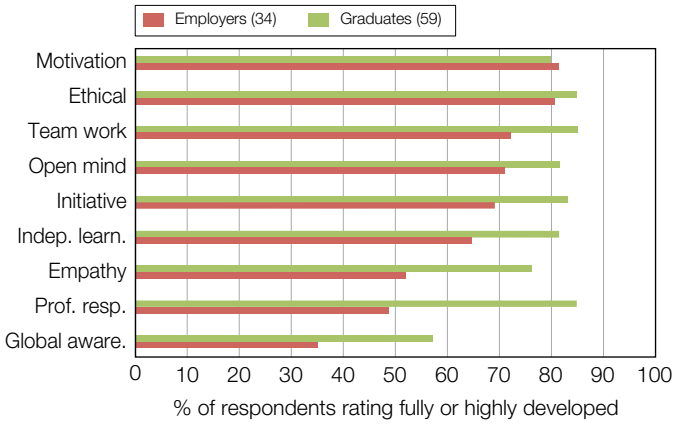

Figure 10: Graduate versus employer development rating – personal traits

In all professional abilities, graduates see themselves as more competent than did their employers (Figure 8). This repeats the pattern seen with knowledge base and technical skills and, as suggested earlier, may reflect bias in self-assessments or the different performance benchmarks of the two parties, or both.

Personal traits

Personal traits are characteristics of an individual, reflected in their behaviour, that are influential on their performance in a work setting. All employers rated ethical behaviour, motivation, initiative and team work as of high or critical importance (Figure 9). More than 90% of graduates rated initiative, professional responsibility, motivation and ethical behaviour as highly or critically important (Figure 9). Employer and graduate importance ratings were very closely aligned, with almost perfect agreement in the extreme importance of initiative, motivation and ethical behaviour (Figure 9).

Few employers felt that personal traits were fully developed in their employees, but 80% said that motivation and ethical behaviour were at least highly developed (Figure 10). Empathy, professional responsibility and global awareness were seen to be least developed, as less than 50% of employers felt these traits were fully or highly developed in employees.

Graduates self-assessed their degree of development as relatively high in almost all personal traits. Over 80% of graduates felt their personal traits, save empathy and global awareness, were highly or fully developed (Figure 10). As with knowledge base, technical skills and professional abilities, graduates rate their development of traits higher than their employers do (Figure 10).

Curriculum contribution

Graduates were asked to evaluate the contribution of the BForSc curriculum to their development in the four areas assessed in the survey. Graduates rate economics, forest management, forest engineering and operations, geospatial technology, and silviculture as the areas in which the curriculum made high or critical contribution to their knowledge base (Figure 11).The curriculum made the least contribution about health and safety, environmental law and regulation, global trends, and Māori values and culture.

Graduates generally deemed the curriculum to have made a significant contribution to their competence in almost all technical skills. In all but three skills, over half the graduates rated the curriculum as making a critical or high contribution (Figure 12). Health and safety, rated lowest, again stands out.

Regarding professional abilities, it is noteworthy that graduates rated curriculum contribution to their competency greatest in written communication (Figure 13). This may signal the productive consequence of the SoF's recent initiative to systematically and rigorously emphasise writing and to progressively build on it through a selected series of papers across the curriculum.

The curriculum supports little student development in leadership, negotiation and public engagement. While these generally ranked low in importance relative to other abilities, they were nonetheless deemed important by a majority of graduates and over one-third of employers (Figure 7).

Of the personal traits, graduates rated the curriculum as contributing most to independent

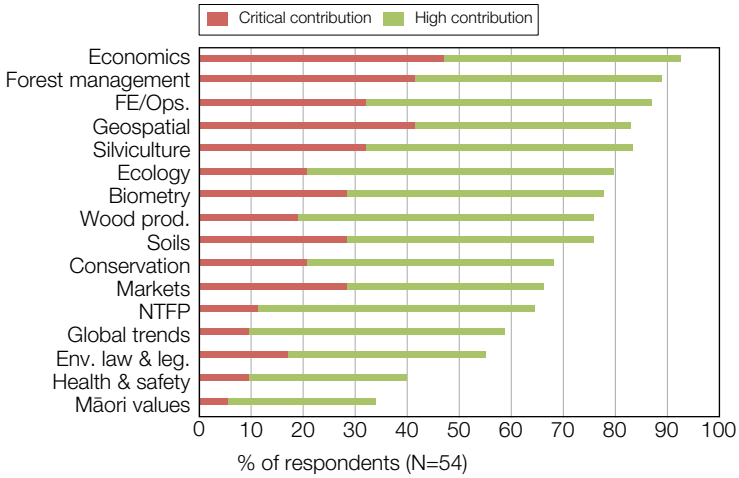

Figure 11: Graduate: curriculum contribution rating – knowledge base

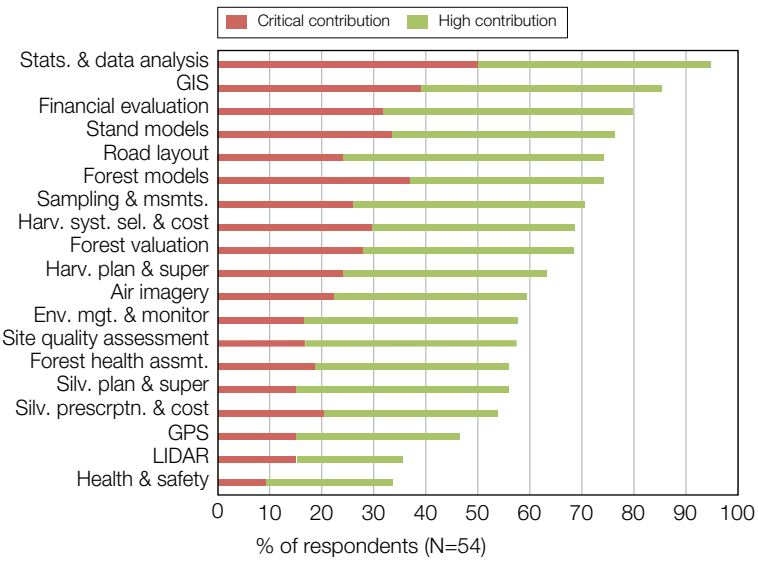

Figure 12: Graduate contribution rating – technical skills

learning and team work and least to open-mindedness and empathy (Figure 14). Of the four areas assessed in the survey, the curriculum was viewed as contributing least to personal traits. This is not surprising given that development of personal traits is strongly driven by one's upbringing, general life experiences, and a myriad of other factors outside the academic environment.

Extra-curricular experiences

Student development is affected by more than the curriculum proper, and graduates were asked to identify extra-curricular experiences that made significant contributions to their personal and professional development.

Three important experiences were cited most commonly. Field trips, social interaction, and holiday and summer work experience were deemed very important by approximately 50%, 40% and 30% of the respondents, respectively. Social interaction was described as being fostered by FORSOC (the students' forestry society), small class sizes, the open computer lab, and the generally high level of camaraderie at the SoF. Close interaction with working professionals, in guest lectures and field trips, was also deemed a highly important element in graduates' educational experience.

Overall, the responses strongly suggest the importance graduates placed on having a strong social bond, on being fully exposed to the practical and real-life aspects of forestry as a profession, and on becoming part of that profession through relevant work experience and direct interaction with working professionals.

Suggestions for improvement

In addition to the Likert-formatted questions, graduates and employers were asked various open-ended questions to solicit their views about a variety of matters relating to important abilities, areas of strength and weakness in graduates, and to obtain thoughts or suggestions for improving the quality of the degree and learning experience at the SoF.

While there existed much variation in comments given the various perspectives, interests and professional environments of the employers and graduates, there were several suggestions that were commonly voiced. These fell into two general categories and are offered for consideration by the SoF and forestry community:

Student engagement in the profession and awareness of keys to success

- Increase marketing initiatives and more fully reveal the breadth of forestry employment opportunities to recruit to the SoF individuals in greater number and with a wider variety of interests
- Beginning early in the degree, and continuously throughout, endeavour to increase students' engagement in the forestry profession and elevate their appreciation of keys to professional success
- Alert incoming students to the skills, abilities and important characteristics identified by employers and recent graduates, perhaps using some of the 2017 survey results to emphasise the message

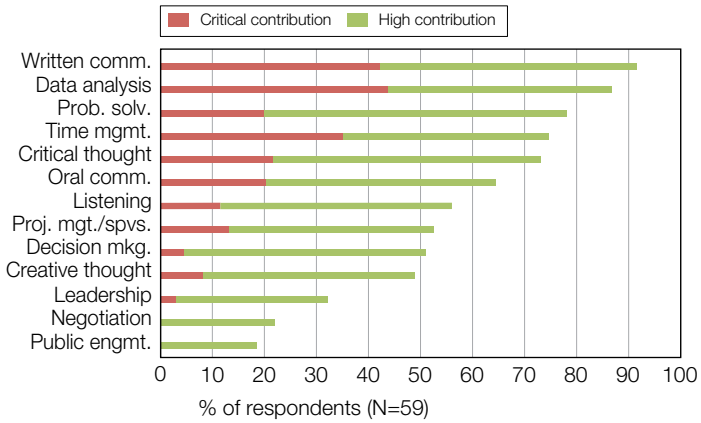

Figure 13: Graduate: degree contribution rating – professional abilities

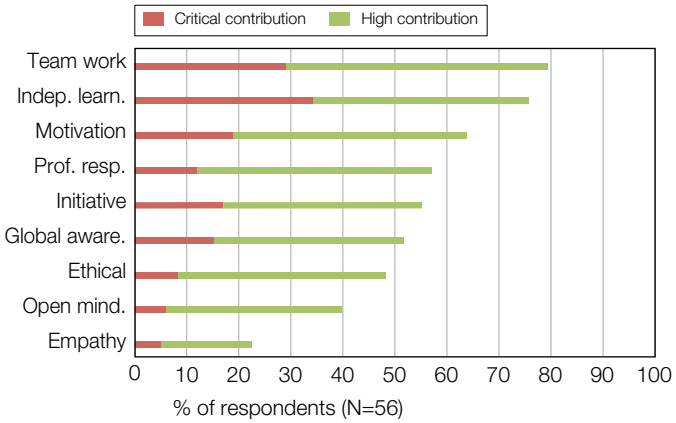

Figure 14: Graduate: degree contribution rating – personal traits

- Regularly hold formal and informal sessions where recent graduates and employers engage with students, especially in the early years, and discuss:
  - what is important for success in the profession
  - what they found valuable to derive maximum benefit from their time enrolled at the SoF
  - the breath of employment opportunities and the importance of gaining forestry work experience while a student.
- Increase the 90 day requirement for practical work experience and actively engage with industry to increase students' pre-graduation employment opportunities and participation.

Curriculum content

- Either through the formal curriculum, or extra-curricular initiatives, explore means by which to increase student exposure to and working knowledge of:
  - health and safety legislation and protocols
  - environmental law and regulation as they affect forest practice
  - Māori values and interests in relation to forestry
  - effective team work, conflict resolution, negotiation and other aspects of human dynamics in the working environment
- Incorporate in curriculum papers across all years greater use of problem-based exercises purposefully designed to require application of forestry knowledge, independent thinking and analytical tools
- Incorporate communication, problem-solving and time management more fully in courses across the curriculum
- Use the current pedagogical approach to written communication as the model and apply it to strengthen other professional skills, including oral communication, data analysis (with Excel and other analytical tools) and team work
- Evaluate alternative designs of the year one curriculum with objectives to:
  - increase the value of papers, particularly science foundation papers
  - engage students in more hands-on, problem-based forestry exercises with learning outcomes for both technical skills and professional abilities (e.g. writing, team work).

Final points

Several overarching messages come out of the 2017 survey responses. First, the relatively high response rate signifies the forestry community's deep interest in, and support of, the SoF BForSc degree and its importance to the sector and the profession.

Second, the SoF graduate profile provides a general educational direction deemed appropriate for contemporary forestry by both employers and recent BForSc graduates working in the profession.

Third, the importance of helping students develop professional abilities cannot be over-emphasised, and these abilities warrant explicit inclusion and purposeful treatment in the SoF educational objectives alongside those that are forestry-specific in nature.

Fourth, encouraging and supporting student engagement in practical work experience and direct interaction with professionals during their undergraduate years is important to help connect them to the profession and to better prepare them for employment on graduation.

Finally, graduates and employers are strongly supportive of the SoF and its educational mission. Their collective responses provide every reason for the SoF to feel confident that it offers a very high quality degree. The thoughtful input from both parties also revealed opportunities for the SoF to make this highly regarded degree even more valuable to both its graduates and the New Zealand forestry sector.

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Forestry in Indonesia

George Kuru and Tony Wood

Abstract

Indonesia has been undergoing a significant change in the last 20 years. From an industry dominated by natural forest harvesting for solid wood products, 55% of production is now for industrial wood for pulp and paper production. FAO statistics for 2016 show that pulpwood made up 40.9 million m³ from a total of 74.7 million m³ produced for the wood industry.

Pulpwood plantations make up almost 2.5 million ha and 85% of this area is either owned, or controlled, by the three major pulp and paper companies. Three species – *Acacia mangium, Acacia crassicarpa* and *Eucalyptus pellita* – combine for over 98% of the planted area. Due to disease and monkey damage, the industry has been moving away from acacia to eucalyptus for mineral soil conditions. Crassicarpa remains the only feasible choice on peatland soils.

Pulpwood plantations are managed on government-owned land that is leased on a concession basis to private companies for a 30-year period. Due to production demand, rotation lengths are typically five years with a mean annual increment (MAI) of between 23–25 m³/ha/year. This means that over 300,000 ha are harvested and replanted every year.

Plantation owners incur significant challenges in managing their concessions. On top of pests and diseases, they face considerable pressure from fire, encroachment and land claims. All concessions have people either living within or immediately adjacent to them. Despite the government owning the land, local communities have access rights, meaning that compensation must be paid in order to be able to plant. By law, 20% of a concession area must be set aside for livelihood crops for communities, which places further financial pressure on management.

Overview of Indonesia

Country overview

The Republic of Indonesia is a unitary, transcontinental sovereign state located mainly in Southeast Asia, with some territories in Oceania. Situated between the Indian and Pacific oceans, it is the world's largest island nation.

At 1,904,569 sq m, Indonesia is the world's 14th largest country in terms of land area and the seventh largest in terms of combined sea and land area. With over 261 million people, it is the world's fourth most populous country as well as the most populous Austronesian and Muslim-majority country. Java, the world's most populous island, contains more than half of the country's population.

Indonesia's republican form of government includes an elected parliament and president. Indonesia has 34 provinces, five of which have special status. Its capital is Jakarta, which is the second most populous urban area in the world. The country shares land borders with Papua New Guinea, East Timor and the eastern part of Malaysia. Despite its large population and densely populated regions, Indonesia has vast areas of wilderness that support a high level of biodiversity. The country has abundant natural resources such as oil and natural gas, tin, copper and gold. Agriculture mainly produces rice, palm oil, tea, coffee, cacao, medicinal plants, spices and rubber (Workman, 2017).

Indonesia consists of hundreds of distinct native ethnic and linguistic groups, with the largest ethnic group being the Javanese. A shared identity has developed, defined by a national language, ethnic diversity, religious pluralism within a Muslim-majority population, and a history of colonialism and rebellion against it.

Administration of forestry in Indonesia

Indonesia land administration is classified into two principal categories – forest land and non-forest land. Forest land is administered by the Ministry of Environment and Forestry (MEF).

The MEF administers 128 million ha of land, which accounts for nearly 70% of the land area of Indonesia. It is estimated that approximately 80% of forest land is 'forested', mainly by natural vegetation ranging from scrubland to full virgin jungle. Most of Indonesia's forest is owned by the state (86.9%) and the remainder is so-called 'titled forest', meaning that the land title is registered by private organisations or individuals. The vast majority of the production forests are owned by the state, but directly managed by private corporations and institutions based on forest concessions.

Companies and/or individuals wishing to establish plantations forests may apply for the concession rights on government land. These concessions can vary in size from 5,000 to 100,000 ha gross area, and can be managed for 30 years until they either have to be extended for a further period or returned to the government.

Indonesian forestry

Summary of forest areas

In 2015, Indonesia had around 91 million ha of forested land, which constitutes 53% of the total land area. Around 86.1 million ha is primary or otherwise naturally regenerated forest, and around 4.9 million ha planted forest (FAO, 2015).

Of the 4.9 million ha, approximately 2.5 million ha is in acacia and eucalyptus plantations managed for the pulp and paper industry on five to seven-year rotations. The remainder is spread over rubber, teak and plantations for the veneer and solid wood industries. The plantation industry has come under intense scrutiny from NGOs in the last 10 years due to the conversion of natural forest, to the point that most conversion has now stopped, with only a few small companies continuing to do so. Pulp mills will no longer accept natural forest wood for production.

The largest single plantation owner within Indonesia is the Asian Pulp & Paper (APP) Group, which holds the rights to almost 2.5 million ha of concession-based land and has over one million ha of plantation, almost half of which is on peat swamps. To put this into scale, by managing on a five-year rotation, they are harvesting and replanting over 200,000 ha of land every year.

Production summary

There are two distinct forms of forest resource management in Indonesia. These are the plantation industry, which up until recently was dominated by teak plantations in Java, and the selective forestry in natural forests, located mostly on outer islands. Over the past two decades, plantation forestry for the pulp and paper industry has become a significant component of Indonesia's forest industry. Pulpwood plantations are dominated by the acacia and eucalyptus species, which grow quickly in Indonesia's tropical climate and can be managed on short rotations of five to seven years.

According to FAO (2017), the Indonesian industry produced about 75 million m^3 of roundwood, which is almost entirely used within the country.

The balance between total roundwood production and subtotals in Table 1 is mostly used for fuelwood, which remains a key source of fuel for cooking and water heating. Logs cannot be exported in roundwood form so all exports are in processed or semi-processed products.

With the exception of pulp and paper, timber industries have been on a decline since the late 1990s. Pulp and paper demand now makes up 50% of the log production in Indonesia and all of this production now comes from plantations. No natural forest wood is used for the production of pulp and paper since 2015.

Indonesia is a net exporter of timber and timber products, and although exports are going worldwide, the Far East contributes to most of the timber exports. Key exports include processed goods, namely, plywood, pulp and paper, mouldings and joinery, furniture, sawn timber and veneer. Pulp and paper products account for over 50% of Indonesia's wood-based exports, which demonstrates the particular relevance of this industry for the Indonesian forest sector.

Pulp and paper industry

There are currently eight Kraft pulpwood mills in Indonesia, six of which remain operational, with the other two having been mothballed (see Figure 1). These are mostly located on the island of Sumatra, with the remainder being in Kalimantan.

The total mill capacity is estimated to be 9.2 million bone dry metric tonnes (BDMT) of bleached hardwood Kraft pulp (BHKP), which would require 32.5 million m^3 of roundwood (this estimate is lower than the official estimate published in FAO statistics). Due to mothballing and wood supply issues, the actual mill production is estimated to be 6.6 million BDMT.

APP is a fully integrated pulp and paper group with 14 paper factories located in Sumatra and Java (see Table 2). APRIL produces printer paper at its Kerinci mill site and this company commissioned a viscous fibre plant at Kerinci in 2016. APRIL has historically produced large quantities of market pulp (BHKP), but it appears to be committing to increasing the quantities of downstream pulp and paper products.

Table 1: Indonesia 2015 wood production figures

Category	Production quantity m^3	Imports quantity m^3	Domestic consumption m^3	Exports quantity m^3
Logs (roundwood)	75,040,000	560,000	75,541,000	59,000
Sawn wood	4,169,000	226,000	3,930,000	465,000
Veneer	761,000	16,000	742,000	35,000
Plywood	3,800,000	62,000	1,082,000	2,780,000
Pulpwood (logs)	40,860,000	0	40,860,000	0

Note: Pulpwood logs are used directly by pulp mills or exported as chip

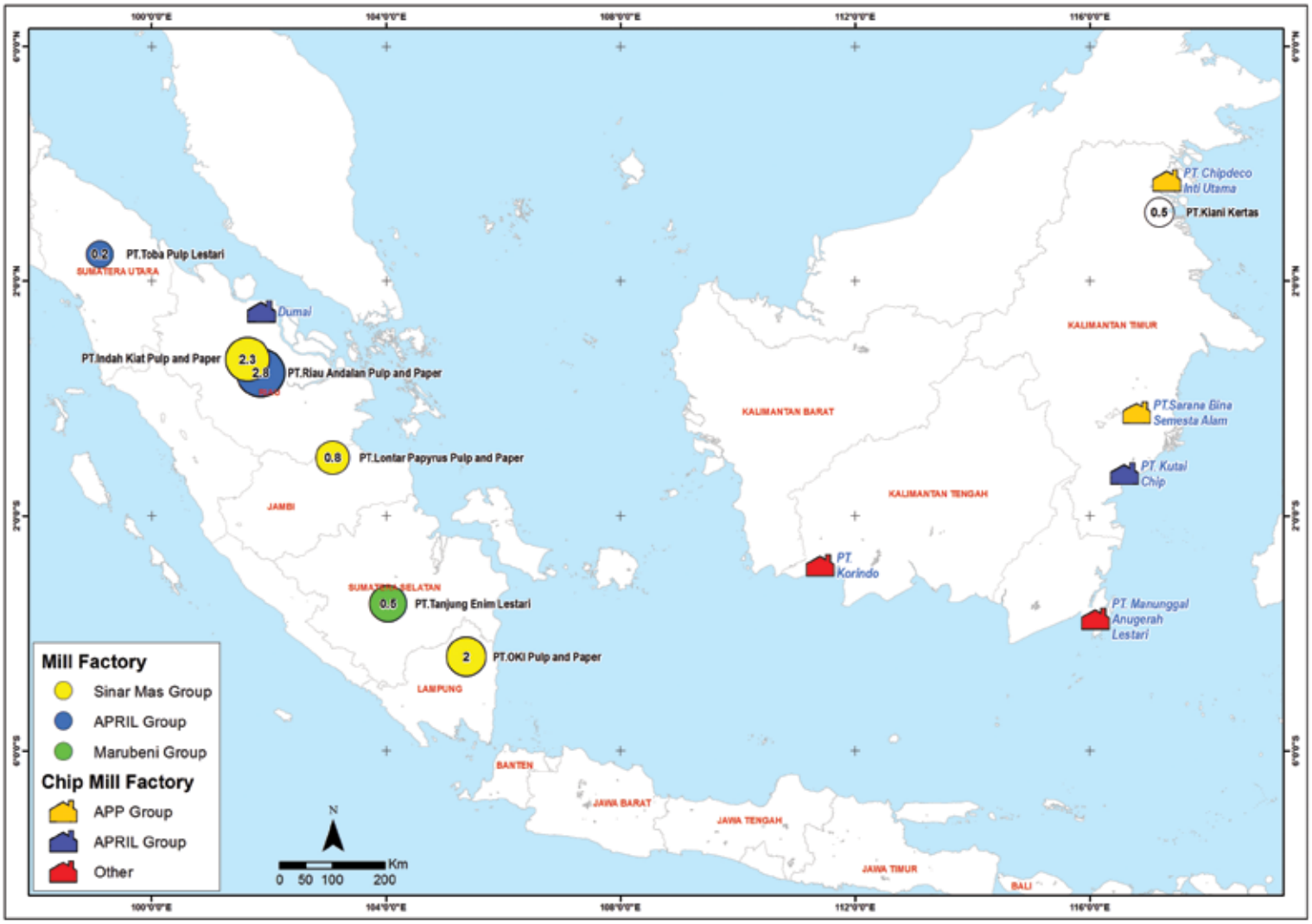

Figure 1: Location of pulpwood processing facilities

Pulpwood plantations

Indonesia has a significant pulpwood plantation resource. Pulpwood plantations were first established in the 1970s on the island of Sumatra. Since the 2000s, pulpwood plantation development has spread to the island of Kalimantan. The total area of pulpwood plantation is estimated at approximately 2.5 million ha as at 2018. It is expected that further plantation development will be located in Kalimantan and maybe some in Papua New Guinea.

Almost 84% of plantations are controlled, either directly or indirectly, by 'the big three' pulp and paper companies of APP, APRIL and PT TEL. Most of their concessions were obtained during the New Order regime under President Suharto in the late 1980s and 1990s, or during the transitional political era that followed until around 2005. Since that time, concessions on good quality land that are well located logistically have become scarce. This would suggest that there is little scope for the expansion of pulpwood expansion in the future.

Growth rates within the acacia plantations averaged between 25–27 MAI in the first rotation, with a general decline in subsequent rotations on mineral soil sites, mainly due to pest and disease impact but also general site degradation through poor harvesting practices. The problems in *A. mangium*, which was the staple crop for the first 20 years, have become so bad that a major change to eucalyptus species has occurred in the last 10 years.

All of the big three companies are struggling to fulfil supply commitments to their pulp mills and the issues for this are complex. There are the pest and disease issues as mentioned above, declining site productivity, but also fire and encroachment by local communities.

In addition, the pulp and paper companies are being forced by the government to rehabilitate peatlands, further compounding the wood supply constraints. Rehabilitation options require 're-wetting' of drained peatlands, needing either changes in commercial species and silvicultural practices or the restoration of natural forest ecosystems. Alternative sources of land are supposed to be provided by the government as compensation, but where these will be located remains unclear and almost certainly they would be more expensive in terms of management and logistics.

Table 2: Pulp mill capacity by location

Mill	Group	Capacity	Estimated production 2017	Potential pulp log consumption (capacity)
		Tonnes of pulp/year (BDMT)		m^3/yr
PT Indah Kiat Pulp and Paper	Asia Pulp and Paper (APP)	2,300,000	2,100,000	10,350,000
PT Lontar Papyrus Pulp and Paper		800,000	750,000	3,600,000
PT OKI Pulp and Paper Mills		1,900,000	1,000,000	4,500,000
PT Riau Andalan Pulp and Paper	Asia Pacific Resources International Holdings Limited (APRIL)	2,800,000	2,200,000	12,600,000
PT Toba Pulp Lestari		200,000	200,000	900,000
PT Tanjung Enim Lestari	Marubeni	500,000	350,000	2,250,000
PT Kiani Kertas	Nusantara Group	500,000	0	2,250,000
PT Kertas Kraft		135,000	0	610,000
Total		**9,135,000**	**6,600,000**	**37,060,000**

Pulpwood plantation silviculture

Historically, pulpwood plantations were developed in two main species – *A. mangium* and *A. crassicarpa*. *A. mangium* was a hardy species that thrived on the low fertility heavy clays, which are the prevalent type of mineral soil in Indonesia. *A. crassicarpa* is the only known pulpwood species that grows well on tropical peatland soils. Other species were tried, including various eucalyptus, and until recently all these generally failed. The exception is North Sumatra where *E. urophylla, E. grandis* and other species have successfully established on volcanic soils at high altitude.

In recent years, *A. mangium* has been beset by rapid increase in attacks from pests and diseases. The three principal problems are:

1. **Root rot** – This has become the most economically damaging disease of *A. mangium* with high tree mortality rates observed during second and third rotations. Two main types of root rots have been found in *A. mangium*, viz brown root rot and red root disease caused by *Phellinus spp*. and *Ganoderma spp*., respectively (Eyles, 2008).
2. **Stem canker and wilt** – *Ceratocystis acaciivora* is a fungus that infects wounds on *A. mangium* causing stem damage that quickly leads to death. It is rarely seen in the first rotation stands but can cause in excess of 60% mortality by the third rotation (Brawner et al., 2015).
3. **Monkey damage** – A behavioural change in macaques has led to increased browsing of young *A. mangium* shoots. Monkey damage causes a high level of damage through stem breakage, especially to young trees. The browsing and associated stem damage also makes the plantations highly susceptible to other pests and diseases, especially *Ceratocystis*. Damage levels are usually very high but localised. However, damage has escalated due to rapid population increases of the macaques.

Ganoderma root rot

In the 2000s, *E. pellita* was identified as a species that grew well on heavy clay soils at low altitude. The plantation companies have implemented a breeding programme to improve the growth and fibre characteristics of *E. pellita*, and this has been so successful that it is now the preferred pulpwood species for mineral soils. Because of the declining productivity, *A. mangium* has had to replaced, especially on third and subsequent rotations. It has largely been replaced by *E. pellita*.

The rapid transition from *A. mangium* to *E. pellita* over more than 500,000 ha in a very short time is almost unprecedented in plantation forestry history. The two species are very different in their management, with *A. mangium* being a low input/low maintenance crop that is propagated largely from seed compared to *E. pellita,* which is propagated using clones and requires intensive silvicultural maintenance and high inputs of fertiliser.

Stem wilt from *Ceratocystis*

Sumatran macaque

Small barge used for transporting logs from the harvesting site to a log yard

One benefit has been that the move to eucalyptus species opens the door to much higher productivity in the future through continued improvements in genetics and tree maintenance.

Companies are now adopting Brazilian approaches to plantation management, with a view to attaining MAI in the high 30s in the next generation of plantations.

Peatland plantations

A distinctive feature of Indonesian pulpwood plantations is that approximately 45% of them are located on peatland soils, which are 100% organic matter and naturally saturated. In order to establish plantations, these areas were cleared of their natural forest cover, then drained and converted to forest plantations. To date, only *A. crassicarpa* has been found to be commercially viable on peatland soils.

These plantations are accessed and managed through a network of canals, which allow control of the water table to facilitate planting of the tree crops. The canals are used for access as well as for barging of wood during harvesting. Specialist ground-based systems for harvesting have to be developed because of the water-logged nature of the soil and weak soil structure and New Zealanders played a key role in this process.

Management of drained peatland soils is very contentious and two issues have been particularly troublesome:

- Indonesia is the world's fifth largest producer of greenhouse gases (GHGs) and the largest contributor of forest-based emissions world-wide from land use, land use change, and forestry (LULUCF). The largest source of LULUCF emissions in Indonesia is from oxidation and the burning of drained peatlands
- Forest fires, which are particularly prevalent in drained peatlands, emit huge quantities of smoke and haze. This has nearly catastrophic impacts on public health and aviation, not only in Indonesia, but also in neighbouring countries as well.

In 2015, huge fires destroyed significant tracts of peatland forest, both natural and planted, which prompted a huge international and national response. This brought the public to the full awareness of the environmental impact created through draining and developing peatlands.

This in turn has led the government to create a special task force for the restoration of up to four million ha of peatlands. A significant portion of the area is currently utilised by the two largest pulp and paper companies, meaning that the retirement and restoration of this peatland will have a significant impact upon their raw material supply unless viable alternative sources can be found. This is an ongoing development and the full extent of the new laws and their impact upon plantation production is not yet known.

Typical peatland plantation with canals

Social impact on plantation forestry

The Indonesian situation is significantly different to New Zealand plantation forestry in terms of community interaction and impact. In the pre-2000 New Order era, concessions were issued with little consideration to indigenous people's rights. In a country with a population as large and diverse as Indonesia, this inevitably led to conflict, which was mostly resolved by the authorities, often using force.

Following the establishment of democracy, people started to move back into the concession land, reclaiming and/or demanding recognition of their land rights. The authorities could no longer resort to force, and companies suddenly found themselves with encroachment, arson and sometimes violent conflict. Offices and equipment were burnt or ceased, staff were threatened, and existing plantations cut down and planted back into other crops. Because of the sheer volume of claims involved, many of these remain unsettled despite years of endeavour.

In reality, all plantation forestry in Indonesia is community-based to a greater or lesser extent. All companies have paid compensation to local communities for the area planted, even though the land is government-owned. All companies must work with local communities for the continued management, protection and development of the concessions.

By law, 20% of land within any given concession must be designated for community projects. This is known as 'Tanaman Kehidupan', or literally 'Livelihood Plantations'. This is an increase from the traditional 10% used pre-2017. These 'Livelihood Plantations' can take many forms and below are just a few examples of the more common formats seen:

- Rubber plantations where the local community either takes a share of the rubber production or of the profit
- Pulpwood plantations where the local community receive an initial payment at planting, get paid for all labour-related work during planting and tending, and then receive a bonus based on production
- Pulpwood plantations where the local community receives an annual rental per hectare and a bonus based on harvesting production
- Alternative livelihood crops such as fruits, nuts or honey
- Intensive agriculture on a smaller portion of the land close to the village that is supported by the company and plantation forestry on the larger portion.

Every plantation company has a special department for the handling of community relations. These teams communicate with communities, negotiate on claims and on compensation for any new planting (and even re-planting after harvesting in some cases), manage community development schemes, and ensure that donations for cultural events are effectively utilised in the correct way.

The definition of communities who have the right to negotiate with the company can be any of the following:

- Communities located within the concession boundaries
- Communities outside the concession boundary, but obtaining economic benefit from within the concession area
- Communities with registered traditional rights to the land.

Recent immigrants into the area are not usually considered for compensation and/or programmes.

Large ocean-going barge for inter-island log transport

These payments impact on company profit levels and therefore need to be carefully managed. Pure plantation companies with no vertical integration have traditionally been marginal, or even loss-making, enterprises. Large levels of compensation or profit sharing cannot be sustained and this is reflected between industry levels of payment. Mining pays the highest, followed by palm oil, rubber, agriculture, and then forestry at the bottom of the list. For this reason, communities prefer almost any other crop to forestry as they receive more payment.

An important aspect to understand is that communities in and surrounding forest concessions are poor, with low levels of savings. They live mostly hand-to-mouth and require constant income just to survive. Any system that ties up land for long periods with no cash flow will not be well received unless alternative sources of income can be developed.

Any new projects (whether for pulp and paper), or higher value products, need to follow the Free and Prior Informed Consent (FPIC) protocols. These are relatively new to Indonesia so their application is not yet widespread or understood.

Future of the Indonesian forestry sector

Transformation in compliance

International and domestic NGOs have been successful in bringing considerable pressure onto the pulp and paper industry to ensure compliance to international sustainability standards. This had forced companies into looking beyond the legally required certification within Indonesia and pursue internationally recognised voluntary standards such as the FSC, PEFC and IFC performance standards.

It was quickly discovered that no matter how well plantations were managed, they would be unable to obtain FSC due to the 1994 forest conversion cut off limit. Most forests were converted after this date. PEFC has been adapted to an Indonesian equivalent, known as IFCC, and around 600,000 ha is now certified as forest converted pre-2010. While there has been much talk about utilising the IFC performance standards, the forest conversion clauses have thus far precluded any successful application.

In 2003, Indonesia started to develop an operator-based timber control system for all its timber exports, building on a mandatory third-party certification approach for legality and sustainability. The system, called SVLK, became the basis for the timber legality assurance system under Indonesia's Voluntary Partnership Agreement (VPA) with the EU.

The VPA covers all exports, and its coverage will expand to include the domestic market on a stepwise basis. On 15 November 2016, Indonesia began issuing Forest Law Enforcement, Governance and Trade (FLEGT) licences to verified legal timber products exported to the EU. In the following 12 months, Indonesia issued more than 39,000 licences for shipments exported to all 28 EU member states, with a total value of more than one billion Euros (see www.euflegt.efi.int/indonesia).

Sustainability in the pulp and paper industry

Historically, the pulp and paper sector has relied on wood harvested from clear-felling of natural forests. Initially, the natural wood fibre was sourced from concessions allocated for conversion to forest plantations. In the 1990s and 2000s, large quantities of natural wood fibre was sourced from lands being converted to palm oil plantations.

After substantial pressure from international markets and civil society campaigns, the Indonesian pulp and paper sector has completed a transition from natural wood fibre to plantation wood fibre. In 2013, the APP Group commenced its Forest Conservation Program (FCP) based on no deforestation of natural forest and the 100% use of plantation-grown wood fibre. The APRIL Group committed to its own Sustainable Forest Management Policy in 2015.

Recently, the government has announced it will regulate the development of plantations on peatlands. These peatlands emit very high quantities of GHGs and Indonesia has been under tremendous international and domestic pressure to reduce the area of forest and agri-business plantation. The actual implementation requirements are still being developed, but essentially forestry companies will be retired to release large areas of peatlands in the future, re-wet these lands and rehabilitate the natural forest. In return, the government has committed to swapping the peatlands for drylands, which can be developed as forest plantations.

Future for the pulp and paper sector

Going forward, the pulp and paper sector faces considerable challenges in terms of both supply and sustainability. All of the big three pulp and paper companies are currently purchasing wood from external sources while they battle the internal issues of fire, pests, diseases, encroachment and the impact of the peatland regulations.

Operationally, the impact of harvesting every five years must be faced with greater focus. While regular harvesting is a benefit in peat soils (these soils actually improve with some compaction), poor harvesting practices are having a significant impact on the performance of plantations on mineral soils. Low impact harvesting and the introduction of cable systems are critical to the long-term future, and there exists an opportunity for international-level harvesting contractors to come in and obtain large-scale contracts for this.

There is no doubt that Indonesian plantation owners have significantly improved their management according to international-level certification standards, but there is still significant room for further improvement and the challenge remains about how to verify this. With FSC and IFC being largely unattainable, and IFCC being only partially recognised, how do plantation owners verify that they are meeting the required standards for environmental and social management? ISO only covers some aspects and other local Indonesian standards are not yet acceptable in the international markets.

It is highly unlikely that there will be further significant expansion of pulp and paper processing capacity within Indonesia. Companies must first secure a sustainable level of logs and find a way to demonstrate that plantations are sustainably managed environmentally and socially.

Finally, the transition from *A. mangium* to eucalyptus has had a significant and potentially long-lasting impact on plantation management in Indonesia. Acacia is an easy care and low input species, and companies only needed to implement relatively basic management capabilities to support the species. Companies have had to significantly improve their capabilities in tree breeding and impose greater management control to successfully implement the transition to eucalyptus. In addition to developing the technological approaches and systems, this has required a significant cultural change within the companies.

The first generation of eucalyptus has only really achieved similar yields to acacia. However, if the improvements in tree breeding and silviculture continue, significant gains in plantation productivity are possible, more in line with those achieved in Brazil under similar climatic conditions.

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Looking back and forward

Peter Wilks

Well, the 2018 NZIF conference has been and gone in Nelson and it was a pleasure to be on the organising committee and be part of what was agreed to be a pretty good event. Actually, truth be told is that Angus Malcolm and outgoing Administrator Jay Mathes collectively did most of the donkey work so much of the kudos should go to them.

The last Nelson conference I was involved in as an organiser was back in 1994 and that was very different with no 'head office' to call on for support. Back then the theme was 'sustainability', and I guess that is what still concerns all foresters today with recent weather-related events such as at Tolaga Bay threatening our licence to operate as the current buzz word goes.

Of course, back in the mid-1990s we were in the middle of a planting boom and now we are harvesting those same trees with all the attendant growing pains that has produced – debris, safety, worker shortages etc. Ironically, we are also potentially witnessing another planting boom, this time government incentivised, whereas in the 1990s it was the private sector that led the way.

So I guess the question is just how far have we come since then, and is the current government's planting initiative of the 'one billion trees' and the reincarnation of a mini Forest Service the sign of things to come? Certainly this government has taken a more hands-on approach to encourage forestry, but how much new planting can be encouraged without 'distorting the market' is debatable.

My own view is that price signals around log prices and land prices, combined with a stable political environment, are what drive good decisions around forest investment. The proposed NZIF Forest National Forest Policy, if picked up by the government, will be helpful in giving investors the confidence to own forests in New Zealand.

While thinking historically, I realised that the School of Forestry is close to 50 years old with it opening at the University of Canterbury in 1970 under the direction of Professor Peter McKelvey. I am sure there will be some celebrations organised around that milestone in 2020.

One of my Forestry School colleagues (we graduated in 1981) wrote 'The last word' in the February 2017 edition of the Journal and it was a pleasure to catch up with Geoff Thorpe in Nelson at the conference. His article 'Forestry Secret Services' was on the subject of ecosystem services, and it was a reminder that we had our own issue here in Nelson about a year back when the local council put the Rabbit Island Management Plan up for review. This forest has about 1000 ha of plantation forests and is intensively used by the public for recreation. The value of mountain biking in Whakarewarewa Forest to the Rotorua economy that Geoff referred to was provided as a case study to successfully argue in support of proposals to open up the island to more public access. Expect more demand to use our forests for recreation in the future.

One trend that I constantly get reminded about around our house is the need to reduce plastic. It seems this is a worldwide movement that is gaining a lot of momentum and not before time. Anyone who has been to the Pacific Islands, or for that matter just about any developing country in the world, is shocked by plastic littering beaches and anywhere off the tourist trails.

It might seem too good to be true but biodegradable plastic could be a reality after scientists at the University of Warwick in the UK found that the lignin, which holds cellulose wood fibres together, is a 'natural glue' that can be turned into a strong, mouldable and biodegradable plastic. The remarkable properties of wood are still being discovered.

As a young forester in the 1980s I would have never dreamed that 30 years on so many new uses for wood were yet to be discovered. Who could have foreseen back then that the iconic '4 by 2' would be challenged by reconstituted wood in the form of laminated veneer (LVL)? We saw LVL being produced at Nelson Pine

Table 1: Production statistics – Chile versus NZ

2016 FAO data	Annual harvest m^3	Logs exported m^3	Sawn export m^3	Pulp export tonnes	Total value of forestry exports $US billion
Chile	33 million	34,000 (!)	3,170,000	9,300,000	7.51
NZ	30 million	17 million	1,730,000	1,400,000	4.04

Solid radiata 100*50 mm at $6.45/m

LVL 100*50 mm at $6.20/m

Industries during the conference field trip. I was in the local Mitre 10 recently and took these two photos. If you were a builder what would you choose?

Despite the increasing use of wood for niche engineering uses, one issue that we often hear about is the lack of 'added value', with the public perception that we should be processing more logs domestically. If there is one thing I would like to see in the future is that we get to where Chile is in this regard. Take a look at the figures in Table 1 and make up your own mind about whether we could do more.

And finally on the theme of looking at the value of history, there is a Māori saying that I think is very apt for us as foresters:

Ka mua
Ka muri
(Walk backwards into the future).

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