FOREST GROWERS RESEARCH

Science Report 2024

supported by forestgrowers commodity levy

PAGE

KEY to ICONS

Programme(s)

Collaborators

Funding

FOREST GROWERS RESEARCH

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Foreword

My working career has covered three economy-wide boom bust cycles and many more independent primary sector cycles.

As this foreword is written, however, primary producers world-wide seem to be suffering simultaneously. What looks like coordinated loss will reinforce pessimism. Misery loves company so we compete in a commercial version of the victimhood stakes. That can spiral further than necessary before the bounce.

Funding for research will be affected. This annual Science Report should remind forest growers that in depressing times we should be putting more into industry good investment, not cutting back. They need to see that they get more from the levy than they would spending the money themselves.

The levy commenced in November 2013. This Report is a celebration of the resulting 10 years of research investment. Today, approximately 60% of the levy - on average over $5M per annum - drives industry-good research. For every $1 invested, Forest Growers Research have secured an extra $2.50.

Later this year there will be a referendum to renew the levy for another six years.

In tough times we all have to get more tough on ourselves. We must be as determined to get value for money as our levy payers are in their businesses. It must show in everything we do.

We need to lose tolerance for self-deluding jargon. We need to filter out meaningless reassurances. Most of those paying can sniff out ritual nice-sounding fluff. They've been forced to see and hear a lot of it as organisations in prosperous times have padded out their professional propaganda.

So I look through the annual review with eyes freshly sharpened. I'm glad to see cases that should give those paying confidence about value for them. They will be more sceptical than a year ago. They'll want comfort that research grants are not rewards for seeming nice or well-intentioned.

In the new climate they'll respond better to people and organisations that plainly run a hard ruler over their activities and tell it like it is, internally and externally. Organisations that have the confidence to speak plainly inspire more trust.

Over the past two years we have been insisting that grant applicants specify how outcomes can be measured. That needs more than spinning a story of objectives and benefits

Stressed industries should increase their attention to cost containment. Collaboration and sharing of costs of research and other common good expenditure should reduce waste. Growers may have more to lose from bad regulation and other public/political threats. So as you review the record of research bear in mind the competition for funding and celebrate what has been achieved.

Stephen Franks
Chair
Forest Growers Levy Trust

Introduction

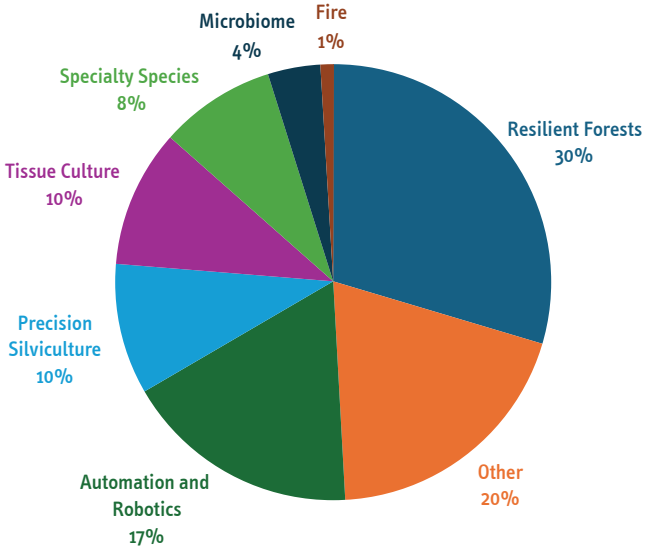
Welcome to the 2024 Science Report, where we take a look at some recent research activities and review some of the successes and challenges of our research model.

2024 is turning out to be a busy year. As well as managing and supporting a research portfolio worth almost $20million, spanning the whole industry value chain, we have been talking with you, the industry, as we prepare for the Forest Growers Levy vote later in the year.

This year marks a decade since the levy was introduced, and some very real benefits of levy-funded and Forest Growers Research (FGR) -managed research are now becoming apparent. This year, forestry research will receive $4.748 million from the levy - funding that drives significant leverage from other sources, underpins our long-term programmes, and contributes to short-term research and development. It goes without saying that levy funding is essential to continuing forestry research at or near the current level.

Our over-arching goal, through our research programmes, is to improve forest values, resilience, safety and environmental performance, and keep abreast of innovations both in New Zealand and internationally. We are guided by the industry's Forest Growing Science and Innovation Strategy 2020-2035, produced by the Forest Owners Association and Farm Forestry Association. FGR's role is to facilitate research and manage resources optimally to maintain research momentum, as well as balance the portfolio across the diverse needs of the industry. In this report we profile our programme managers and support staff who are the ones responsible for ensuring programmes are kept on-track and outcomes are delivered.

The pie-chart shows how levy funding has been allocated to the various programmes in FGR's research portfolio over the past four years (2020-2023). Around 76% of funding is allocated to multi-year programmes; (Automation and Robotics, Precision Silviculture, Tissue Culture, Resilient Forests and Specialty Species) the remainder to a wide range of shorter-term projects focused on the industry's immediate and varied needs.

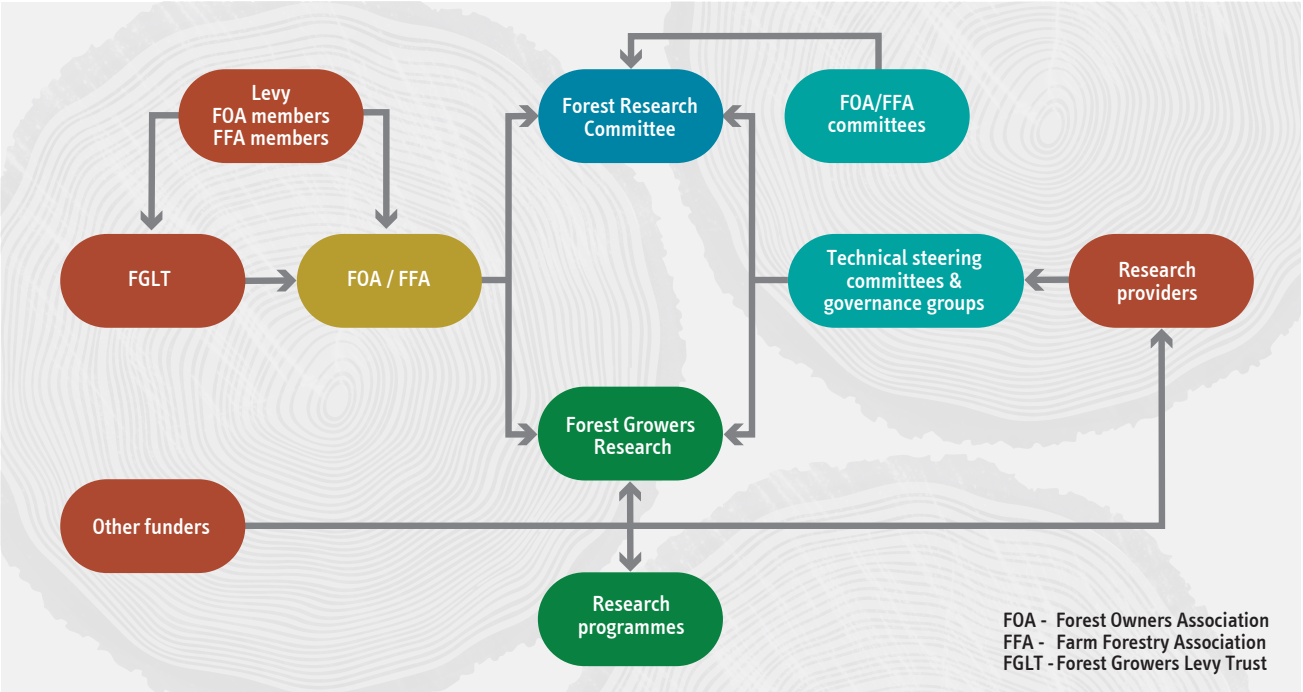


^ *Allocation of levy funding between research programmes (2020-2023)*

We are excited at the prospect of developing new research programmes in 2025 to support diversification of the future forest estate (more details in the Future Research section). Like all primary industry sectors, we face challenges – some of which are good problems to have, all of which are relevant to core elements of what we do:

- balancing long- and short-term investment in research and development
- balancing the needs of both small and large growers
- balancing radiata pine against other species
- navigating shifting government priorities
- managing research funds that are increasingly over-subscribed.

The operating framework or 'ecosystem' which we are part of is unique in its industry representation and diversity. We have a strong industry input to programmes through governance groups and technical steering teams, which is invaluable in ensuring we maintain forward impetus, have a pathway to adoption of research outcomes, and overcome challenges. We are grateful to all those who contribute time, expertise and other resources as part of this ecosystem. This includes the Forest Owners Association, the Farm Forestry Association, the Forest Growers Levy Trust and other funders; also our research providers. New Zealand has a



world-class forest research sector, and thanks are due to all the scientists and support staff who work hard to deliver results for industry benefit. Both long- and short-term research programmes continue to generate exciting outcomes: the selection of research updates from throughout the value chain presented in the second part of this report represents just a small proportion of the work that is happening.

Forest Growers Research is owned, governed, managed and directed by the forest industry, and regular two-way communication is essential if we are to understand each other's capabilities and constraints in a fast-moving world. We recognise that the industry wants evidence that research is delivering value for money. To this end, we engage regularly with our technical steering teams who provide a direct link with industry. We also work hard with our research providers to deliver regular updates in various ways, including technical reports, journal publications and popular articles, conferences, workshops and field days, and increasingly, webinars and videos. Later this year FGR will launch a new website, greatly improving our ability to deliver regular research updates to you. We welcome feedback.

Recent research programmes: some highlights

$19m total research investment (2023-2024)

40+ industry partners and research partners

40+ industry workshops, webinars and field days

100+ publications in science journals

25+ PhD students supported by FGR programmes

Paul Adams
Chief Executive Officer,
Research and Development Director
Forest Growers Research

Ian Hinton
Chair
Forest Research Committee

Milestones

Important milestones in New Zealand forest research

DATE	EVENT	RESEARCH ACTIVITY
1970s – 1980s	New Zealand Forest Service oversees forest research (since 1919)	State managed and funded research activities through NZ Forest Research Institute.
1987	NZ Forest Service abolished. Assets corporatised.	
1988-2007	Research managed by numerous industry-led co-operatives; work mostly undertaken by the NZ Forest Research Institute (a Crown Research Institute established in 1992).	User-pays research determined by industry-led co-ops.
2003	Radiata Pine Breeders Co-op becomes the Radiata Pine Breeding Company.	
2005	NZ Forest Research Institute becomes Scion – a Crown Research Institute (CRI).	
2007	**Future Forest Research Ltd (FFR)** formed when remaining co-ops merge. FFR is an industry-owned company; new research structure and activities ensue.	FFR manages research under four themes: (i) **Radiata Management** (ii) **Diversified Species** (iii) **Environment and Social** (iv) **Harvesting and Logistics.**
2010	FFR strengthens industry-led research governance and research programmes. Research providers broadened to include other CRIs; Lincoln University; University of Canterbury; Marlborough Research Centre; NZ Farm Forestry Association.	**Steepland Harvesting** programme begins (2010-2017) – the first multi-year industry/ government funded-programme managed by FFR.
2013	Forest owners vote to introduce a levy on harvested timber.	**Growing Confidence in Forestry's Future** and **Healthy Trees, Healthy Future** programmes begin (2013-2019)
2014	**Levy introduced** Forest Growers Levy Trust established to manage levy funds and make decisions on fund allocation. NZ Forest Owners Association provides secretariat and organises the committees that oversee research fund allocation.	

DATE	EVENT	RESEARCH ACTIVITY
2015		**Specialty Wood Products Research Partnership** (SWP) begins (2015-2022).
2016	Future Forests Research becomes **Forest Growers Research Ltd (FGR)** to better align with its purpose and the levy trust funding. Shareholding transferred and held in trust for the broader industry.	**Extreme Wildfire 1** programme begins (2016-2021)
2017	**Forest Growers Research Ltd** takes over management of industry funded research on July 1st 2017.	A strong science and innovation sector is recognised as critical for future-proofing the industry and its ongoing success.
2018		
2019	Forest owners vote for the levy to continue for a second term. Forest Research Committee (FRC) develops the **Forest Growing Science and Innovation Strategy 2020-2035.** Three key research themes identified: 1: increasing the profitability of our main species – radiata pine and Douglas-fir 2: ensuring the long-term sustainability of commercial forestry through realising value from emerging species and developing new models for forestry 3: future-proofing commercial forest-growing in New Zealand.	**21st Century Tissue Culture Partnership** begins (2019-2026). **Automation and Robotics** - Forestry Work in the Modern Age – Te Mahi Ngahere i te Ao Hurihuri - begins (2019-2026).
2020		**Resilient Forests** programme begins (2020-2026) **Tree Root Microbiome Project** begins (2020-2025)
2021		**Extreme Wildfire 2** programme begins (2021-2026)
2022		**Precision Silviculture Partnership** begins (2022-2029) Series of **Diversified Forestry** short research projects funded by Te Uru Rākau's Forestry and Wood Processing Industry Transformation Plan (ITP) (2022-2023)
2023	FGR consults widely to identify research and development priorities for a more diverse future forest estate.	
2024	Forest owners have the opportunity to vote for a third six-year levy period, to begin at the end of 2025.	
2025	Second levy period ends.	

Research: Delivering Value

Recently we asked people in the forest industry to identify recent research outcomes of most operational value. The list of research outcomes identified covers a broad spectrum and highlights the breadth and depth of research which continues to be driven by the New Zealand forest industry. A selection of the responses is presented here.

- **Genetic improvement and deployment of radiata pine and Douglas-fir** has benefitted the whole forest industry; FGR's Tissue Culture Partnership will mean the best germplasm is available to all growers more quickly at a competitive price.

- **Genetic improvement of several specialty species** - including durable and non-durable eucalypts, cypresses and redwoods. Growers have access to improved germplasm, and more confidence in planting these species.

- **Forest nutrition** including nutrient monitoring and mapping, has provided new understanding of how soil nutrients affect forest growth and the importance of micro-nutrients. Precise, cost-effective fertiliser regimes are now possible.

- **Biuret** low-nitrogen fertiliser is proven to produce faster-growing, more robust seedlings in nurseries; in-forest trials are also yielding positive results. Scion is working with Ballance Agri-Nutrients in the very lengthy process towards commercialising biuret.

- **Final crop stocking** – spatial models have shown conclusively that higher stocking rates than were previously 'the norm' in structural radiata pine regimes significantly increase productivity and profitability.

"Better understanding of site occupancy and increasing final crop stocking to achieve greater yields ... is quite a step change for the industry."

- **Understanding red needle cast** and the potential for copper sprays will be of major benefit to growers in regions where the disease is proving such a threat. Advanced remote sensing technologies for detecting and monitoring red needle cast are also of significant future value to the industry.

- **Remote sensing** – 'eyes in the sky' technologies including satellite imagery, drones and LiDAR, when combined with AI and deep learning technologies, are one of the most powerful developments in forest research.

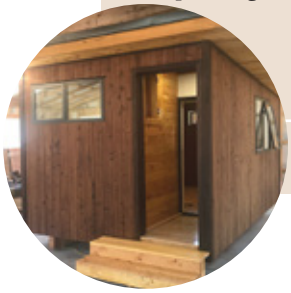
- **Fire operational tools** – for example fire activity triggers which guide operations management in the forest, and fire and smoke models which are regularly deployed during fire outbreaks - are having tangible benefits in reducing the risk of fires accidentally being started and improving fire management operations on the ground.

- **Winch-assist and associated technology** and **hauler camera systems** – developments in both these areas of mechanised harvesting have been major contributors to realising the vision of 'no hand on the chainsaw, no boots on the ground'.

"Winch assist was the main game changer; ancillary research that went alongside the programme was gold – things like studies on tensions in the tether ropes etc."

- **Slash management** – a significant research input means we now have a better understanding of the volumes, potential values, and ways to handle slash. New tools, such as slash grapples, are enabling improved slash management.

- **Alternative exotic species/specialty wood products research** has highlighted the properties, potential and versatility of alternative species timbers, giving growers confidence to diversify new plantings as an alternative to radiata pine.



"The information now available to landowners and advisors is giving them the confidence to plant alternatives to radiata pine. We have overseen a 70% increase in alternative exotics planting over the last 3 years compared to the 3 years prior."

- **Workshops** – the University of Canterbury Forest Engineering team has delivered over 50 workshops on a range of engineering topics in the past ten years to several hundred participants in total. Many of the workshops use results from FGR research programmes.

- **Student scholarships** - FGR research programmes have supported numerous post-doctorate, PhD, Masters and undergraduate students.

"Financing scholarships ensures we are transferring knowledge to the next generation. It also means we are training people in research skills – critical to innovation and development in the forest industry."

People & Portfolios

Our people and research portfolio

Forest Growers Research (FGR) is an industry-owned company which manages and facilitates research and development for the benefit of the New Zealand forest sector. We do this in two main ways:

- research is managed within the Forest Growers Levy Trust (FGLT) research investment portfolio. This money comes directly from forest growers in the form of a levy on harvested timber
- many forestry research programmes also receive funding and support leveraged by the forest levy, including major government and industry funding, for example from:
    - government/industry partnerships – we partner with the Ministry of Business, Innovation and Employment (MBIE) and the Ministry for Primary Industries (MPI)
    - forest companies and other industry partners who contribute to forestry research both directly and often indirectly through in-kind contributions.

FGR currently manages three multi-year, multi-million dollar government/industry partnerships directly, as well as overseeing programmes managed by Scion – one of FGR's key research providers.

Programmes managed by Forest Growers Research


Automation and Robotics – Keith Raymond

Forestry Work in the Modern Age – Te Mahi Ngahere i te Ao Hurihuri – is the third multi-year government/industry partnership managed by FGR's Keith Raymond to focus on mechanising and modernising forest harvesting. This seven-year (2019-2026), $29.36 million primary growth partnership (PGP) involves nine forestry companies and ten machinery manufacturing partners.


21st Century Tissue Culture Partnership – Alison Slade

The 21st Century Tissue Culture Partnership is a seven-year (2019-2026), $8.4m programme to speed up, and scale up, the deployment of the best radiata pine genetics available. Managed by FGR's Alison Slade, project partners are the Ministry for Business Innovation and Employment, seven forestry and aligned companies, the Forest Growers Levy Trust, and Scion.


Precision Silviculture Partnership – Claire Stewart

The Precision Silviculture Partnership is a partnership between the Ministry for Primary Industries via its Sustainable Food and Fibre Futures Fund, the Forest Growers Levy Trust, 12 forest companies and several nurseries and manufacturers. This seven year (2022-2029) $25.5m programme is managed by FGR's Claire Stewart.


Specialty Species – Marco Lausberg

Recent research into specialty species has included the Specialty Wood Products Research Partnership (2015-2022), and a series of short projects funded by Te Uru Rākau's Forest and Wood Industry Transformation Plan (2022-2023). FGR's Marco Lausberg, who managed this research, is currently undertaking a broad consultation to determine future research priorities for specialty species. The consultation is funded by MPI's Sustainable Food and Fibre Futures Fund.

Programmes managed by Scion

Resilient Forests – Dr Peter Clinton
The Resilient Forests research programme encompasses (i) forest productivity/wood quality (ii) enhancing resilience/pest and disease management, and (iii) managing for risk and uncertainty. The six-year (2020-2026) programme is managed by Scion's Dr Peter Clinton and is funded by Scion's Strategic Science Investment Fund and the Forest Growers Levy Trust.

Extreme Wildfire – Dr Shana Gross
Scion's current $13.5m five-year (2021-2026) Extreme Wildfire Programme aims to increase understanding of wildfire behaviour and spread, as well as enhancing planning for, and prevention of wildfires. Programme manager is Scion's Dr Shana Gross. Funding is from MBIE's Endeavour Fund, Scion's Strategic Science Investment Fund, and the Forest Growers Levy Trust.

Tree Root Microbiome Project – Dr Steve A Wakelin
The Tree Root Microbiome Project is a five-year (2020-2025) $15m research project, managed by Scion's Dr Steve A. Wakelin. The project has global reach and global partners, and aims to establish radiata pine as a model tree-root-soil platform for global research. Funding is from MBIE's Endeavour Fund and the Forest Growers Levy Trust.

Project support

Amanda Brake, Forest Growers Research (Rotorua): Office Manager, Rotorua.

Debbie Harrod, Forest Growers Research (Rotorua): Administration and Marketing Support

Alison Wilson, Scion (Christchurch): Project Delivery Manager for the Resilient Forests, Extreme Wildfire and Tree Root Microbiome Projects

Dagmar Cheeseman, Scion (Rotorua): Project Manager

Research Providers

Scion is New Zealand's Crown Research Institute for forestry, wood and wood-derived materials. Scion staff play key roles at many levels in FGR research, including leading and administering several multi-year programmes. Scion scientists also contribute to FGR programme governance and technical steering teams.

Academic and technical staff at the University of Canterbury College of Engineering and School of Forestry are integral to many FGR research programmes, including those which feature forest engineering, wood technology and remote sensing.

Many under-graduate and post-graduate students from the School of Forestry benefit from FGR scholarships and go on to careers in the forest industry or in forest research.

NZ Farm Forestry Association Special Interest Groups, including those for cypress, redwoods and eucalypts, are involved in FGR research. The NZFFA has a representative on the Forest Research Committee, and on several FGR project governance and steering teams.

The Marlborough Research Centre, through its partnership with New Zealand Dryland Forests Innovation, has been a major participant in durable eucalypt research: the biggest component of FGR's Specialty Wood Products Research Partnership.

Scientists from Lincoln University contribute specialist skills to FGR research programmes. Recent projects include work on forest bio-protection (developing Trichoderma strains and testing their benefits to tree growth and health), wilding control, and the Tree Root Microbiome Project.

Other Crown Research Institutes contribute to forestry research in specialist areas. Examples include Manaaki Whenua-Landcare Research leading the 'Winning with Wildings' project; NIWA's climate scientists and climate data resources are integral to forest growth model development.

Tree Improvement

Radiata pine large block trials deliver first results

Investing in tree breeding demands quantifying genetic gain, along with regularly updating growth and yield models. Between 2010 and 2016 the Radiata Pine Breeding Company and Forest Growers Research collaborated to design a series of genetic gain trials (the 'GG1' trials). The aim was to quantify gains in growth and wood properties by comparing control-pollinated (CP), selected open-pollinated (OP), and open-pollinated control seedlots.

Four large block trials were established in 2010-2011, and a further twelve from 2012-2016, on a range of site types across the New Zealand radiata pine estate. The later trials had a slightly different suite of genetic treatments and included clones derived from somatic embryogenesis (i.e. tissue culture).

A full independent analysis of GG1 trial data is underway, following recent measurement by Buck Forestry. Initial findings from the 2010-2011 series include a significant improvement in diameter at breast height (DBH) for the 'CP Control' and 'OP Good Growth & Form' seedlots compared with the other treatments including the OP control seedlots. Also, seedlots selected for wood properties – i.e., 'CP High Density ' and 'OP High Density' - are demonstrating higher basic wood densities.

Buck Forestry; forestry companies who host the trials

RPBC shareholders, RPBC royalties, Forest Growers Levy Trust

2010-2011 Large Block GG1 Trials - entries which do not share a letter are significantly different.

Genetic Treatment	No.Trees	DBH (mm)		Density (kg/m3)		Predicted Modulus of Elasticity (GPa)	
CP Control	1106	220	b	391	b	6.76	ab
CP High Density	1131	208	a	394	bc	6.84	ab
OP Control	1383	210	a	391	b	7.02	b
OP Ext Internode	1130	209	a	393	b	7.07	b
OP Good Growth & Form	1076	219	b	385	a	6.67	a
OP High Density	1084	207	a	399	c	7.00	b

CP (control-pollinated) Control; Modified WD (wood density); OP (open-pollinated) control; OP (open-pollinated) Ext (extended) Internode; OP (open-pollinated) Good Growth and Form; OP (open-pollinated) High Density.

Similarly, results from the 2012-16 trials show that selecting high stiffness and high-density clones give significant improvements in these traits. There is a trade-off with growth, however, as the diameters of both CP and OP seedlots were significantly greater than clonal varietals chosen for their wood properties.

The trials will continue to be managed as a source of data for updating growth and yield models.

^ *Paul Thompson of Buck Forestry using an IML Resistograph to test basic corewood density*

Increasing the supply of quality coast redwood

Coast redwood (*Sequoia sempervirens*) is increasingly being planted but there is no formal redwood breeding programme in New Zealand. The Farm Forestry Association's Sequoia Action Group has been working to increase the supply of quality planting stock with proven timber properties.

In 2023 the Action Group identified superior redwood stands of known provenance and wood properties, and a seed collection programme ensued. The Group's Rob Webster reports that seed yields, while reasonable, were lower than hoped for. "We learnt that the age of cone production can vary considerably, not all stands produce cones, and not all trees within cone-producing stands produce cones. Also wet weather during pollen-shed can severely affect cross-pollination and result in low seed yields."

A second strategy considered in the quest to increase longer-term planting-stock supply is to collect budwood from the tops of superior trees using either a drone or arborists and graft this onto root stock as a precursor to developing a seed orchard. Individual trees with superior growth and form were identified, and cores taken to assess basic wood density and heartwood durability. Some 36 trees have so far met the Group's very high selection criteria – this is an expensive approach so only the best trees will do. The Group plans to proceed with collecting budwood and propagation initiatives if funds become available.

Te Uru Rākau Forest and Wood Industry Transformation Project, FGLT, NZFFA Sequoia Action Group.

^ *An arborist scales a 1930 redwood at Te Puia, Tairawhiti, in the hunt for cones.*

Propagation and Nursery

Tissue culture for the 21st Century

The 21st Century Tissue Culture Partnership (TCP) is an industry/government partnership which aims to speed up and scale up the production of the best radiata pine genetics, increasing their availability to all growers at a competitive price.

The TCP science team, based at Scion, continues to make good progress in developing techniques to select and nurture embryos from top radiata cell lines. The project is based around somatic embryogenesis – a micropropagation technique that starts by cultivating immature embryos extracted from green cones, or from cell lines stored in cryo-storage. New developments include incorporating robotics and AI into processes.

An independent mid-term review of the programme in 2023 was very positive but identified a gap between the research and industry. In response, the TCP team held an open day for industry, and then began providing plantlets to the project's industry partners, allowing them to begin their own trials.

Three large radiata pine nurseries – Arborgen, Timberlands (plus independent partner Nga Rakau Nurseries), and PF Olsen, each received 200-400 plants to trial in whatever way they wanted. Each company has different facilities and ideas about how they want to test the planting stock, but the common thread is use of the Vivi tray system - the method of adapting the plantlets from tissue culture to the nursery developed by the TCP team in collaboration with their Finnish partners.

"We are developing a tissue culture pipeline from our top families so we can deliver the best genetics to industry at scale. High-merit clones need to be produced and tested across different environments before large scale deployment, and working together with the Tissue Culture Partnership will achieve this."

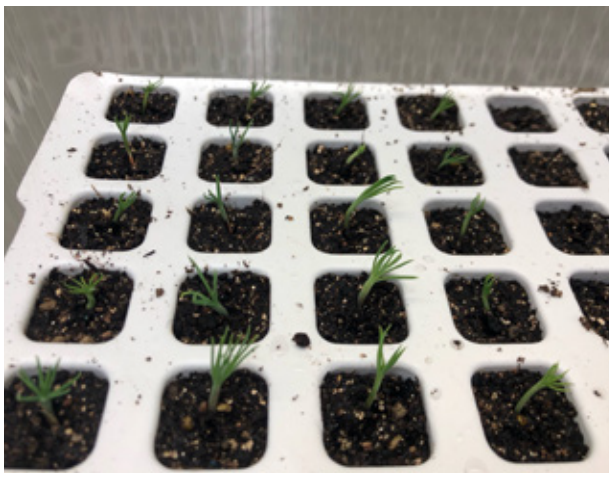
Mark Paget, *Radiata Pine Breeding Company.*

Scion's Cathie Reeves is delighted with this new phase of the project. "It's really exciting to have reached this point, after all the lab work. And strengthening our links with industry is rewarding too. Our industry partners are all very keen to try different things with these plantlets. They are monitoring them well and keeping us informed about how things are progressing."

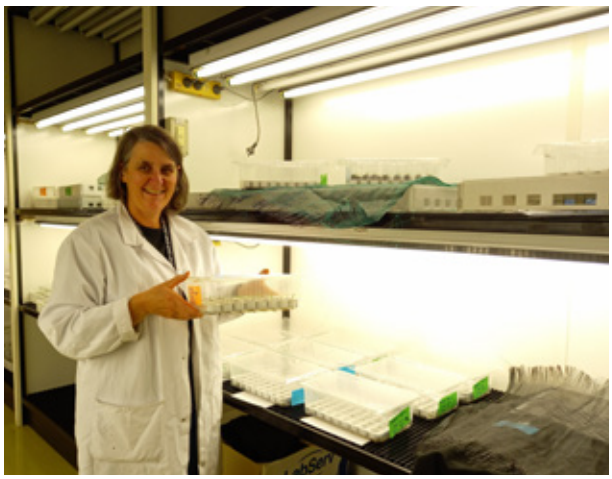
Cathie reports that a second series of trials is planned, with partners using their own protocols for producing plantlets but using the TCP's Vivi protocols for hardening the baby trees. The TCP team has also set up a mini field trial on Scion's Rotorua campus.

21st Century Tissue Culture Partnership

Natural Resource Institute, Finland; ArborGen Inc; Timberlands Ltd; Proseed NZ; Radiata Pine Breeding Company; Manulife Investment Management (NZ); PF Olsen Ltd; Rayonier-Matariki Forests



^ *Vivi trays of somatic embryos ready to be despatched to industry partners.*



^ *Cathie Reeves prepares Vivi trays in the lab.*

Autonomous nursery stock monitoring

Monitoring growing stock in tree nurseries is an essential but time-consuming operation, involving regularly walking the rows to assess tree numbers, growth and health. Autonomous monitoring has obvious appeal.

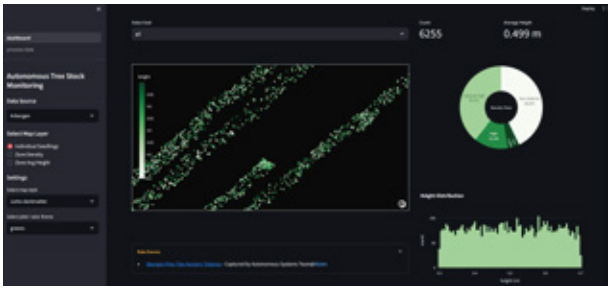
The Precision Silviculture Partnership is supporting the development of two autonomous data-capture options: (i) UAV (drone)-based capture, and (ii) ground-based capture. The aim is to deliver easy-to-interpret information via a dashboard interface to nursery staff, both in the form of a website and as data that can be integrated into a geographic information system.

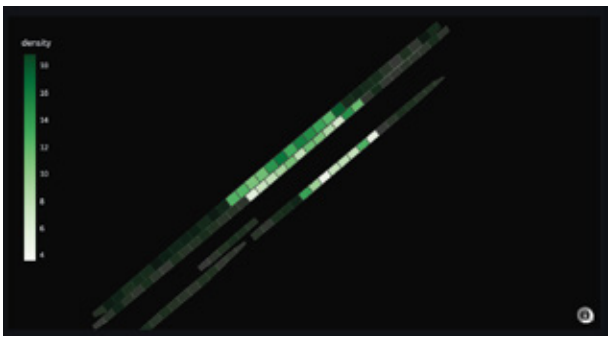
The technology platform, currently at prototype stage, aims to deliver a combined data 'pipeline' so regardless of whether data is captured by UAV or a ground-based machine it goes through the same processing and travels to the dashboard. The data-capture technology can count trees in nursery beds, do a basic colour score to indicate health, and generate a tree height score to estimate growth.

Autonomous ground-based machines are relatively novel in forest nurseries. A prototype GOVOR® autonomous mini-tractor which runs up and down between nursery beds was trialled at three different nurseries. The unit is multi-use so has the ability not only to monitor but also to spray and mow. It was evident in testing that for monitoring and in some cases, spraying, it would be ideal if the machine spanned the bed rather than moving alongside it. The next phase of the project will be to explore how to adapt the mini-tractor to give it higher clearance so it can travel above the beds.

Precision Silviculture Partnership

Scion, Tui Technologies; Argovor Ltd, Arborgen Australasia's Te Teko and Tokoroa Nurseries, Rotorua Forest Nursery





^ *Prototype dashboard providing information for nursery managers.*

"We firmly believe that autonomous monitoring will become an essential tool for all nurseries. Currently, manual inventory counts and plant health assessments are time-consuming and costly. Accurate scanning of seedling crops with a focus on plant health will provide a snapshot of crop conditions, allowing nurseries to promptly address any issues with the necessary fertilizer or chemicals. Rapid access to real-time high-precision data will significantly enhance decision making for the modern nurseryman."

Sean de Haas, *NZ Nurseries Manager, Arborgen Australasia*

^ *Tui Technology's Jacob Kelley tests the GOVOR autonomous tractor prototype with nursery manager Konrad Buchler at Arborgen's Te Teko nursery. (Data-capture technology has not yet been fitted to the tractor.) Monitoring irregular height and density of seedlings in nursery beds are challenges the system will be designed to deal with.*


Small beginnings
yielding
big results


2023 Conference


and

field visits

Microbiome & Site Factors

The Tree-Root Microbiome Project: future-proofing forests

Scion's Tree-Root Microbiome Project reached a major milestone this year, with completion of its global sampling programme. Over 1000 samples have been collected from 16 different countries, coordinated by a Scion team and enabled by cell-phone app. Sampling took place across the world's major radiata pine growing regions, as well as from native populations in California, and Guadelupe and the Cedros Islands off the coast of Mexico – home to the world's most isolated and endangered remnant 'Monterey pine' populations.

"This is a data-rich project," says Scion's Sarah Addison, who has coordinated much of the specialist international sampling. "Each sample will produce thousands of data points - biological, genetic, physiochemical and environmental. My challenge is to tease out the links between environmental factors and the microbiome. The focus is very much on climate change, and the role the microbiome can play in ensuring pine's long-term resilience."

A second research theme is focusing on host drivers, with geneticists hoping to isolate the importance of the tree's genetic make-up in influencing its microbiome. If strong links can be identified, this then provides an opportunity for future tree breeders to build microbiome factors into breeding, in the same way that breeding can target, for example, disease resistance.

Understanding the longevity of the tree-root microbiome, and investigating whether microbiome-friendly nursery practices can be developed, is a further element of the research.

^ *Tree-Root Microbiome Project sampling locations around the world.*

"The radiata pine genome is made up of some 25 billion base pairs of DNA – this compares with a human's eight billion pairs," says project leader Dr Steve A Wakelin. "But trees also have many thousands of micro-organisms which comprise their holobiome - all the life that lives in and on them. These micro-organisms add to the pine genome, becoming a massive total genetic resource with multitudes of ancillary metabolic pathways. It is the role of these organisms in the critical functions of radiata pine that is under scrutiny.

"We now know that around five to ten percent of the root microbiome found around young trees stays with the tree for life. We want to establish whether these long-lasting species are keystone species – that is, essential to the tree's well-being. In time, nurseries may be able to supply trees with both elite microbiome-rich genetics, and elite microbiome-rich roots and soil, which could confer resilience to, for example, the hotter, drier conditions we are likely to experience in some parts of New Zealand in years to come."

Lincoln University; Victoria University of Wellington; Australian Plant Phenomics Facility; Hawkesbury Institute for the Environment (at University of Western Sydney); Woodwell Climate Research Center, Massachusetts; Wright State University, Ohio

^ *Project team members Madeline Greene and Mariah Slaughter with a massive Monterey pine (>5 metres diameter), Shore Acre State Park, Oregon.*

Trichoderma: wide-ranging benefits in plantations

After five years of trials in nurseries and in the forest, the advantages of inoculating radiata pine with Trichoderma have been convincingly proven by Dr Helen Whelan at Lincoln University.

Trichoderma are beneficial fungi which enter plant roots and do a similar job to mycorrhizal fungi. They are applied most effectively as a seed coat dressing or liquid inoculant in the nursery.

Helen tested two Trichoderma mixtures in a total of 13 trials established in 2018 and 2021. The mixtures were applied as a seed coating or to cuttings as a soil drench in the nursery, and trials planted across New Zealand's main forestry regions.

"Both inoculations significantly enhanced young tree growth in a wide range of growing conditions," says Helen. "Trichoderma increased stand volume by a mean of 13.2% in the eight 2018 trials, and tree height by a mean of 9.1% in the five 2021 trials, compared to untreated controls."

Trial results also confirmed that Trichoderma increased the size uniformity of tree stems by 9.6% and suppressed the incidence of red needle cast and dothistroma by 28% and 17% respectively in 2023 – a bad year for needle disease.

The business case for one strain is now being developed with an industry survey to be sent out later this year.

Forest Growers Levy Trust

Appletons Tree Nursery; ArborGen Ltd; City Forests; Ernslaw One Ltd; Juken NZ Ltd; Leithfield; Manulife Investment Management (NZ); OneFortyOne; PF Olsen NZ; Port Blakely Ltd; Proseed New Zealand Ltd; Rangiora Nursery; Rayonier-Matariki Forests; Southern Cypresses Nursery; Timberlands Ltd; Wenita Forest Products Ltd.

^ *Dr Helen Whelan measures trees in a four-year-old trial in OneFortyOne's Kings Ridge Forest, Nelson.*

Salvaging information after cyclone damage

One of Scion's network of Accelerator trials, at Rangipo near Turangi, was badly damaged by February 2023's Cyclone Gabrielle, which laid waste to several thousand hectares of trees in the area.

"Before the cyclone, the trial, planted in 2016, was performing outstandingly well," says Dr Simeon Smaill, "but Gabrielle's winds wreaked havoc on some areas of the trial."

Around 31% of the 7000 trees were bent beyond 45°, snapped or toppled, but the project team realised that the devastation presented a unique opportunity to salvage a huge amount of data describing wind damage in a trial setting. A big data collection campaign was undertaken, using airborne LiDAR for rapid analysis of the damage, and ground-based measurement of almost all the damaged trees. Wood properties were determined from samples collected from damaged and undamaged trees.

Early conclusions included that damage level was closely associated with tree genotype, and stocking rate also had an effect. Analysis of wood properties showed that trees with higher wood density sustained less damage.

"We have all the data to describe what happened," says Simeon, "and from this we may be able to learn which factors influence the chance of wind damage. We now have the opportunity to build the first cut of a prediction model which describes where in a forest wind-risk will be highest and how it could be managed."

Resilient Forests

Lake Taupo Forest Trust; NZ Forest Managers Ltd.

^ *Cyclone Gabrielle damage at the Rangipo Accelerator trial.*

Establishment

New technologies for precision planting

The Planting and Establishment workstream of the Precision Silviculture Partnership (PSP) aims to increase forest value by identifying opportunities offered by new digital, automated and mechanised technologies to increase operational precision at planting and enhance planting success and early growth dynamics.

Evaluating planting machines

Two very different planting machines have been imported into New Zealand – the M-Planter and the PlantMax. The Precision Silviculture Partnership (PSP) is evaluating these machines in partnership with the forest companies and contractors who own and operate them.

- **The M-Planter**

The M-Planter is a Finnish machine, first imported into New Zealand by Timberlands Ltd in 2018, and since trialled by others. The machine comprises a planting head attached to a hydraulic boom mounted on a 25-tonne excavator base machine. Seedlings are loaded into a cassette which sits on the planting head. The machine operator plants individual seedlings into each spot with the option to spot-cultivate the planting spot prior to planting.

A Scion review of the M-Planter after five planting seasons found that, while manual planting is still substantially cheaper, if land preparation costs are included, then comparative costs become closer. The machine's ability to undertake multiple operations simultaneously is a key strength, including spot-mounding, ripping and applying fertilizer or hydrogels at the time of planting. Balancing planting speed with quality is a challenge: a planting rate of 1500 trees/day is needed for direct financial feasibility but planting quality has been found to diminish above around 1100 trees per day. A trial of the M-Planter is underway in the northern South Island led by Aspect Forestry to assess machine performance and productivity across a variety of soils and terrain types, including on steeper terrain.

^ *The M-Planter working in cut-over.*

^ *Trees planted in spot-mounds by the M-Planter.*

> **"Our aim is to combine research and industry skills to evaluate new technologies and assist with their development and adoption. There are many parts to the precision planting and establishment matrix."**
>
> **Claire Stewart**, *Manager, Precision Silviculture Partnership*

- **The PlantMax**

The PlantMax is a Swedish machine which can plant up to 2,800 seedlings per hour. A forwarder tows a second wheeled planting machine: crewed by two operators, the combination has a scarifier on the front and two planting arms at the back, capable of planting a tree every three seconds. Hawke's Bay company Pan Pac Forest Products Ltd imported a PlantMax in 2023 and tested it on both cut-over and ex-pastoral sites.

A partnership between Pan Pac, the PSP and various industry and research providers is evaluating the machine's productivity and performance of stock planted by the PlantMax .

In the 2023 planting season, over a trial period of 35 days, the PlantMax achieved an average planting rate of 1,800 seedlings per hour (>14,000 plants per day), with up to 2,100 seedlings per hour on the ex-pastoral site and 1,500 seedlings per hour on the cut-over. On the cut-over, the scarifiers eliminated the need for an additional land preparation operation, significantly reducing total planting cost. Restricted machine manoeuvrability on hilly terrain meant sizeable gaps were left in steeper or trickier areas, which required manual planting. Adapting the planting unit to a new base machine to improve performance in New Zealand terrain is now being evaluated.

^ *The PlantMax operating in cut-over.*

^ *One of two PlantMax planting arms.*

Timberlands Ltd; Manulife Forest Investment (NZ); Rayonier-Matariki Forests; HA Fear Ltd, Pan Pac Forest Products Ltd; Scion; Forme Consulting Group; Aspect Forestry; PF Olsen Ltd; Tasman Pine Forests; M&R Forest Management.

Adding hydrogels to extend the planting season

For planting machines to be economically feasible, the planting season must be extended beyond its normal winter window. Research into hydrogels – compounds which retain moisture around tree roots – is on-going at Scion because of their potentially key role in enabling planting to continue in dry spring/summer conditions.

A lab-based trial compared a biological hydrogel (nanocellulose), a synthetic hydrogel, and water, in terms of their ability to mitigate water stress in newly planted seedlings and support early root growth. Results indicated that, in dry soils, any intervention – whether hydrogels or just water - improved seedling establishment and mitigated plant stress. The nanocellulose hydrogel produced similar outcomes to just water, while the synthetic hydrogel gave overall best results.

^ *Examples of seedlings planted into dry soil with no additions (left) or planted with a hydrogel or water.*

Precision Silviculture Partnership

The next phase of this research will explore hydrogels' utility to extend the planting season in different soil types as well as under more extreme conditions. The intention is also to explore the potential of hydrogels as a carrier for fertilisers or growth hormones applied either in the nursery or at the time of planting.

Testing GPS-enabled spades

Manual planters are still going to be needed for the foreseeable future for the majority of New Zealand's forests, including to plant steep or awkward areas inaccessible to machines. Regardless of how trees are planted, precise tracking of individual planted tree location is desirable, both for quality assurance and for future precision-based operations.

Several GPS-enabled spades, which record the location of each tree planted, are under development globally (including two in New Zealand). Only one, the Australian TeraLabs STALogger, is ready for testing. As part of the PSP, Brian Russell (Contempo Lab) and Scion's Carol Rolando put the spade through its paces, evaluating its set-up and use, data download and analysis, and the GPS accuracy and precision.

The team concluded that the STALogger's GPS technology was not yet accurate enough to enable individual tree identification, so at this stage the technology needs further refinement. Other spades will be tested as they become available, likely to be in 2025.

"We have had great co-operation from industry collaborators," says Carol Rolando. "They have all been very helpful in sharing their development plans."

Optix USA; TeraLabs Australia; Caroll NZ; HA Fear NZ; Weyerhaeuser USA; Braitonas Lithuania; Stream Forest NZ.

Managing for Risk and Uncertainty

Embracing uncertainty in forest planning

Planning for the future in a fast-changing, uncertain and complex global landscape is one of the biggest challenges facing forest managers.

"'Watch and wait' is no longer a viable strategy," says Dr Grace Villamor, who leads work on risk and uncertainty at Scion. "But changes bring opportunities as well as downsides, so the best thing is to be well-informed and prepared."

Grace is championing research into innovative 'foresight' planning, which involves disciplined, detailed analysis of alternative futures. This includes scanning the horizon for policy or other trends, and imagining the different ways these could play out for the forest industry.

"Foresight planning helps managers by encouraging them to systematically consider different future scenarios and outcomes," says Grace. "It is a highly participatory approach."

Examples Grace and colleagues have been assessing with forest owners include the need for corporate social reporting to access markets, and the implications of climate change on forestry; also identifying new regulations being developed by New Zealand's trading partners, such as the imminent European Union Deforestation Regulation (EUDR). This imposes rigorous new traceability and border compliance requirements on various imports including wood and wood products and has important implications for the New Zealand forest industry.

"There is no single future to plan for," says Grace, "but with new tools such as foresight planning, forest growers can embrace uncertainty and complexity, and have strategies in place to make the most of opportunities."

"We have recognised the need to take a fresh approach to managing our forests – it's no longer business as usual. So we are embracing all the innovative tools at our disposal to protect unstable landscapes while ensuring long-term viability of our forests and the communities we operate in. Scion's portfolio diversification work - particularly using state of the art dynamic growth modelling for alternative species, and modelling for the impact of climate change, is a component of this."

Andrew Clarke, *Forest Investment Services, Ernslaw One*

Resilient Forests | Forest Growers Research, Scion

Diversifying forestry under different climate change scenarios

How best to diversify the forest estate to reduce the risks associated with various climate change scenarios is a conundrum being addressed by Dr Grace Villamor and colleagues at Scion.

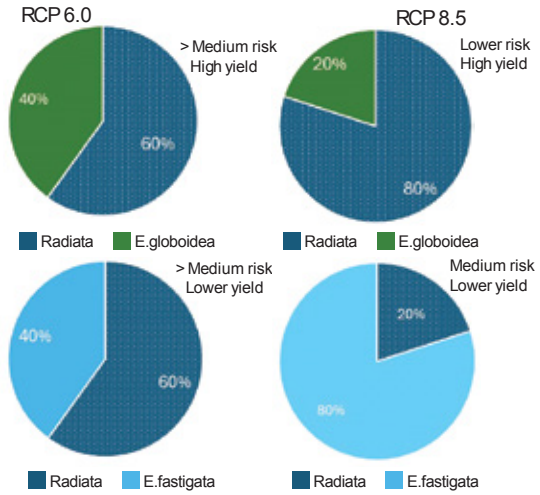
Using a portfolio modelling approach, the team has asked: *"What combination of tree species is best to reduce climate change risk while simultaneously producing the highest return or yield?"*

The species considered were coast redwood, Douglas-fir, *Eucalyptus globoidea, Eucalyptus fastigata*, and tōtara.

Tree productivity was modelled under four different climate change scenarios using a '3-PG' model, which simulates tree physiological processes based on biotic and abiotic factors, including climate. Productivity and risk of each species were then combined in another model to produce a ranking of the best combinations of alternatives.

"Based on our results, (and while market values are excluded for now) *Eucalyptus fastigata* and *E. globoidea* appear the best species to diversify with overall," says Grace. "The eucalypts performed well under all climate change scenarios compared to other tree species. The simulation also showed that a 100% radiata pine forest is subject to large risks in all climate scenarios."

The team are using portfolio modelling to explore various other diversification options – not just alternative species – for large and small-scale forest owners as they grapple with future uncertainties.



^ *Model outputs showing optimal species combinations with different levels of productivity and risk under two climate change and four risk/yield scenarios. (RCPs – Representative Concentration Pathways).*

Managing a Growing Crop

SILVICULTURE

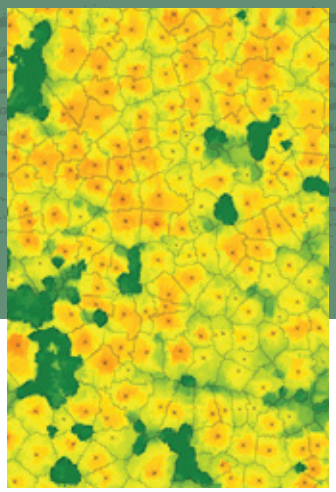
TreeTools: improving pre- and post-thinning assessments

A team at Interpine Innovation is developing a 'TreeTools' system to help forest managers with thinning assessments. LiDAR with cloud-based web-processing will assist both pre- and post-thinning assessments, while aerial (RGB) camera images with real-time analysis will support post-thinning analysis.

Interpine's Susana Gonzalez, who is managing the project, says "Our aim is to empower forest managers to efficiently plan and monitor thinning operations by making data-driven decisions."

TreeTools has two components:

1. **Web portal:** LiDAR data is used to analyse forest stands – for example before a thinning operation. A web-based interface will provide easy-to-interpret information on tree height, location and stocking density. Forest managers can plan thinning operations with detailed information on stand metrics and variability. Less ground-based inventory will be needed, and thinning prescription accuracy increased.
2. **Tree-counting platform:** during or after thinning operations, a tree-counting platform will utilize drone imagery to count trees, analyse stocking, and provide real-time feedback. A forest manager visiting a thinning operation can fly a drone over a stand and undertake quality assurance on the spot. This has numerous benefits – for example, allowing under- or over-thinning to be corrected immediately, so avoiding having to recall a crew long after they have left the block. The system will also provide precise stand record data for future management.



^ *Image from the web-based portal, with information on tree height and location.*

^ *An example of RGB tree-counting imagery.*

Interpine has developed TreeTools to prototype stage: the next step involves more training of the AI component with data supplied by industry partners to ensure the model is robust. Processing speed will also be increased before the product is delivered to the forest industry at the end of June 2025.

Precision Silviculture Partnership

Interpine Innovation

Training silviculture workers in virtual reality

A new virtual reality (VR) tool is providing a smart way to prepare silvicultural workers for thinning operations. Thinning is one of the highest-value decisions made in the forest, but often decisions around which crop trees to select are made under time pressure and with a whole host of other variables to consider.

Scion data engineer Grant Evans has adapted gaming technology to generate highly realistic forest environments.

The VR headset allows trainees to move through the forest, assessing trees from all sides. The forest environment can be adjusted – for example, by varying tree size and shape, stocking, slope, even weather conditions – so trainees can experience typical forest conditions. As the trainee moves through the forest, the trainer can watch on another screen, pointing out tree characteristics and guiding selection.

"I'm hugely impressed," says Rayonier-Matariki Forest's Quality Manager Fraser Field, who is part of the development testing team. "For entry-level workers, this tool is excellent. We will improve our training practices now to incorporate VR, including training for NZQA unit standards. I have lots of ideas about how to extend the use of VR in training."

"Virtual reality supplements training in the forest," says Claire Stewart, Precision Silviculture Partnership (PSP) manager. "The tool fits with the PSP's aims of digitising, mechanising and automating forestry tasks to make them more efficient and safer."

> **"I immediately fell into training mode when I tested the tool."**
>
> **Fraser Field,**
> ***Quality Manager, Rayonier-Matariki Forests***

Above right: Grant Evans and Claire Stewart with the on-screen VR simulated forest and headset.

Precision Silviculture Partnership

Rayonier-Matariki Forests

Red needle cast: a continuing challenge

Red needle cast continues to challenge scientists and forest managers, thanks to its unlimited variability in timing, severity and location. Climatic drivers of the disease, including moisture and temperature limits, are now well understood, but how the disease persists in hot, dry summers when it is latent, and how previous disease levels affect future disease risk, are still a puzzle. Summer weather is proving to be a good predictor of disease risk in the following autumn and winter.

"We know that hot, dry summer conditions stop the disease in it tracks," says Scion's Dr Emily McLay. "After a normal summer, inoculum build-up has to start from scratch as the weather gets cooler and wetter in autumn. Then disease build-up can be exponential in the right conditions. But if we have a wet summer, like 2023, then build-up never really stops, and we risk much earlier and more severe disease expression."

"Understanding the disease processes has allowed us to build a prototype infection-risk model which we hope will become a decision-support tool for forest managers. Risk prediction could ultimately be based on detailed summer climate data in a particular location - if we can predict the likelihood of a severe localised outbreak, decisions around whether to apply copper or some other treatment before symptoms appear in autumn will be easier."

^ *An East Coast radiata pine stand severely affected by red needle cast, September 2023.*

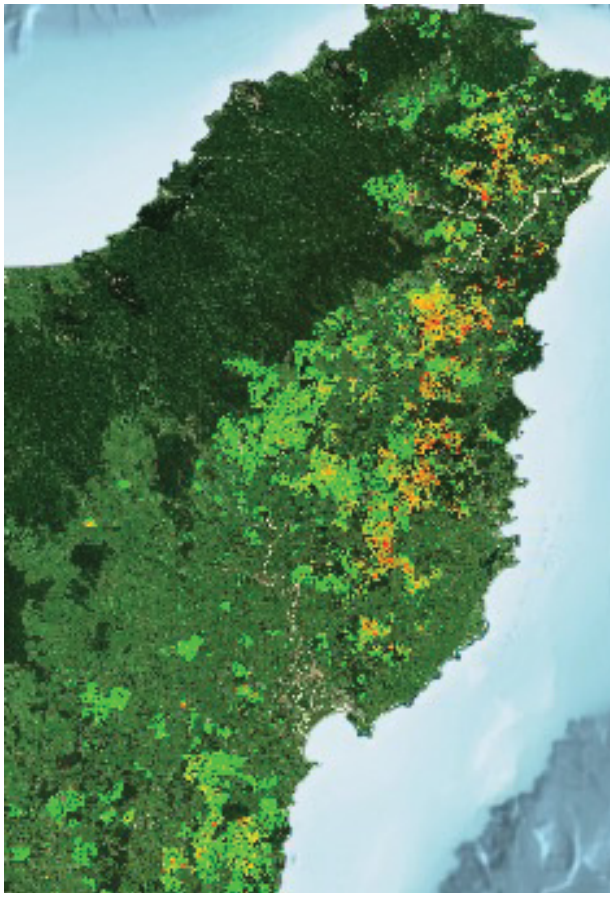
Calculating the impact of red needle cast on growth

Calculating radiata pine growth losses caused by red needle cast is a complex problem, partly because there are many variables, including climate and site factors, which can affect growth.

Scion's David Lane and Joane Elleouet have analysed radial growth data obtained from coring infected trees. The cores were taken at two sites – one on the East Coast with severe, repeated red needle cast infection, the other a less badly affected site in the central North Island. Using statistical techniques, they have isolated the disease's impacts.

The analyses have quantified not only the growth losses caused by red needle cast on an annual basis, but also trees' recovery period following a disease outbreak.

"In a worst-case scenario, we calculated a 31% growth loss due to red needle cast in the year after a disease event," says Joane, "and a total 24% loss over four years after a single event. After four consecutive disease-free years, a tree will recover and grow normally again."



^ *East Coast regional depiction of red needle cast severity for 2023 from Sentinel-2 imagery at 10m resolution (green = no disease, yellow/orange/red = low/medium/high disease severity). (Image: Dr Nicolò Camarretta).*

The North Island East Coast site had individual tree growth data available from 2005 (when red needle cast was first observed in New Zealand) through to 2021. A hypothetical worst-case scenario generated using these data showed a 24% growth loss over the 15-year period. Extrapolating this out to a full rotation, an overall 14% growth loss could be anticipated.

Resilient Forests

Peter Beresford, Plant and Food Research, Juken New Zealand Ltd.

EXTREME FIRE

Slash sensor reduces wildfire risk

Slash or debris piles left in the forest after harvesting are a potential source of forest fires. Under certain conditions, the heat produced during slash decomposition causes piles to self-combust.

Scion's Dr Richard Parker and Taylor Welsh have produced an updated version of a previous sensor prototype which monitors temperature within slash piles, and streams data at 10-minute intervals to the mobile phones of forestry staff. Staff can monitor temperature changes without having to visit the forest, and act before dangerously high temperatures (over 80°C) are reached.

^ *The data logger, modem, battery and solar panel, which are placed in the forest, near the slash pile.*

The sensors comprise a two-metre-long probe, plus attached data logger, modem, battery and solar panel. Several prototypes have been deployed in commercial forests over the past couple of years, and with the help of forest staff, a lot of problems have been ironed out.

"Some key forest staff have been fantastic in helping us to ensure the sensors can withstand the forest environment and advise on prototype development," says Richard. "There have been a lot of 'back-end' challenges too - things like how to handle data storage and finding the best communications network, which has proved to be the cellular network."

^ *Wenita Forest Products Ltd's Mark Pearson inserts the probe plus sensor into a slash pile.*

The next step will be to investigate how best to commercialise the sensor. "Forestry companies are really keen on the concept," says Richard, "but working out how best to deliver it to the market is a whole new challenge!".

Extreme Wildfire

Wenita Forest Products Ltd and other forestry companies

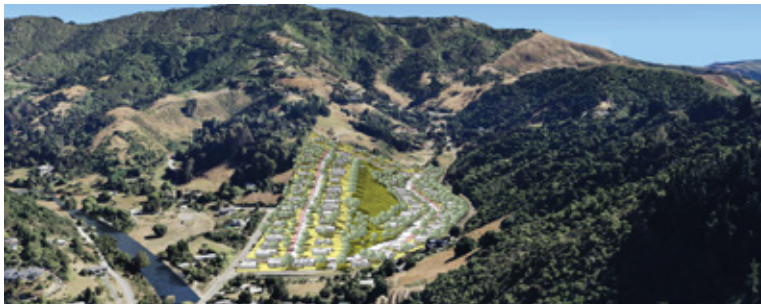
Building wildfire risk into residential planning decisions

Improving understanding of wildfire spread and extreme fire behaviour, and helping New Zealanders learn to live with wildfire, is an important theme of Scion's Extreme Wildfire research. Work with communities in the Queenstown Lakes District over the past few years highlighted that housing developments are often planned and designed with little thought given to wildfire risk.

To learn why uptake of wildfire-smart planning and design in New Zealand is low, Scion social scientists and collaborators ran a series of five workshops for professionals involved at each stage of residential development: local government and consultant planners, climate change/risk advisors, transport and Geotech engineers, architects and landscape architects.

The workshops were billed as focusing on 'natural hazards scenario planning', with no specific mention of wildfire risk. The facilitators were then able to observe the extent to which wildfire risk came into the professionals' thought processes when considering different urban-fringe housing development scenarios.

< *Workshop participants discuss planning for natural hazards in new housing developments.*



^ *A medium-density residential planning scenario*

The workshops also provided an opportunity to explore different training techniques for professionals, with the aim of designing future training initiatives to be more effective. This area of research will continue with follow-up evaluation to gauge how well information is retained over time using different training techniques.

"The workshops were very successful, and we are analysing the findings now," says Scion's Lisa Langer, who leads the work. "If we find evidence that wildfire is not being considered by planning professionals, one of the next steps will be to talk to their professional bodies and make recommendations on ways to fill this gap."

Extreme Wildfire

GNS Science, University of Canterbury, Massey University, Royal Melbourne Institute of Technology.

Harvesting & Transport

Load securing and tensioning system in service

An automated log-load securing system has reached commercialisation. The system is designed to eliminate long-term injuries to drivers from both throwing chains and manual tensioning of chains, and to improve load safety.

The system comprises three components:

- **Chain thrower** – which eliminates manual chain throwing
- **Auto-tensioning winch** – tensions load-securing chains and maintains tension while the load is travelling
- **Load-monitoring system** – measures the tension on each load restraint and transmits the tensions via Bluetooth to the driver's cab, alerting him/her to any loss of tension.

The three products can stand alone or operate together, and feedback from logging truck drivers is very positive. Industry is already recognising that the chain thrower will decrease injuries and extend drivers' careers as well as opening up logging truck driving to new groups including women, who may not have the physical strength needed to throw chains.

FGR partnered with two Nelson-based manufacturing partners – Trinder Engineers Ltd and Waimea Engineering Ltd – throughout the system's development. Following feedback from early adopters, the capabilities of the chain thrower have been expanded, increasing the range of logging trucks it can be fitted to. Trinder Engineers is also working on integrating the tensioner into the bolster base. This is to simplify the purchasing process for customers so they can simply buy a bolster with a tensioner, thrower, and load monitoring system all built in.

There are already 26 chain throwers and 25 tensioners in service, fitted across eight and four units respectively. The load-monitoring system is undergoing refinement and field trials, and should be commercially available in the next few months.

Forestry Work in the Modern Age – Te Mahi Ngahere I te Ao Hurihuri

Manufacturing partners: Trinder Engineers Ltd and Waimea Engineering Ltd (Nelson).

> **"2023 and 2024 to date have been challenging times for the forest industry – nonetheless, we have been receiving interest from across the country and internationally for our chain throwers, largely from forest haulage companies but also from others including ports, general and heavy haulage."**
>
> **Jared Sylvester**, *Trinder Engineers*

^ *Building the tensioner into the bolster base at Trinder Engineers.*

^ *Female truck driver using the chain thrower.*

Automatic quick coupler ready for the industry

An automatic quick coupler which enables harvesting machine operators to rapidly change machine attachments, such as a processor head or a log-loading grapple, without leaving the cab, is now commercially available from Auckland company Aptella (previously Synergy Equipment Ltd).

The coupler has been developed as part of the FGR Automation and Robotics Programme. Quick couplers have been operating in Europe for some time, but until recently, none appeared big enough for the larger grapple processors commonly used in New Zealand harvesting operations. Aptella were importing Swedish 'Steelwrist' quick couplers for industrial use and believed the largest had good potential to be adapted for forest harvesting.

^ *Picking up a processing head with the quick coupler.*

A project was formed between FGR and four industry partners. After development work, a demonstration machine was set up for harvesting operators to trial. Industry partners supplied the quick coupler, a base machine, a processing head plus supporting cradle, grapple and loader bucket, and provided backup technical support. FGR funded the purchase of the coupler and the costs of installation and commissioning.

In March 2024, a field demonstration was held in Kinleith Forest, South Waikato, at the harvesting operation of contractor Loggabull Ltd. The quick coupler was successfully put through its paces in front of a large audience.

"This set up has an important place especially in lower-volume harvesting operations," says programme manager FGR's Keith Raymond. "One base machine can do the job of two machines, saving money, easing congestion on the skid, and meaning a smaller landing space is needed. It's great news that the coupler is now commercially available."

^ *(L-R) Jason Stamp from Aptella New Zealand, Phil McKenzie from AB Equipment Ltd and Andy Bedford from Total Hydraulic Solutions Ltd.) introduce their products at the FGR quick coupler field demonstration.*

Forestry Work in the Modern Age – Te Mahi Ngahere I te Ao Hurihuri

Manufacturing partners: Aptella, AB Equipment Ltd, Total Hydraulic Solutions Ltd.

Manulife Investment Management Ltd, Loggabull Ltd.

Capturing data from harvesting operations

University of Canterbury PhD student Patrick Humphrey is working at the high-tech end of harvesting data collection – aiming to develop a communications system in which all machines on a harvesting site are generating data which can be processed to become a management tool.

Data describing machine operations (CANbus data) is already collected in some machines. Pat's novel system transfers the data via Wi-Fi to the cloud, where it is processed to provide near-real-time information on machine-use parameters. As a proof-of-concept, Patrick collaborated with Canterbury's Brand Logging to introduce the system data on their John Deere 959 MH felling machine operating in two different Canterbury forests, collecting 86 different machine variables. He built an interactive dashboard to illustrate the processed data and show differences in machine performance in the two forests – for example in daily and weekly operating efficiencies, fuel consumption, and many other parameters.

The more ambitious aim of the research is to now develop a proof-of-concept system through which all machines in a harvesting operation can be interlinked, and to utilise machine learning to predict and optimise operations, presenting the results in the dashboard.

"Eventually, harvesting contractors will be able to get data-based information about the utilisation of any or all of their machines in different harvesting scenarios," says Pat. "Also we could do things like introduce predictive maintenance protocols, or measure CO_2 emissions from different harvesting combinations."

"Ultimately data collection will happen at every point in the harvesting supply chain. Making better use of this data can improve logging contractors' business and their ability to scope work and work processes. It will also form a key tool for learning and feedback for operators working on their machines."

^ *Pat Humphrey demonstrates his dashboard to Shane Hubbard from Brand Logging in Balmoral Forest. Shane and his forwarder are part of the second phase of Pat's research, predicting the operational status of forest machinery.*

Forestry Work in the Modern Age – Te Mahi Ngahere I te Ao Hurihuri

Brand Logging

Wood Properties / Product Development

Assessing the impact of wind damage on wood properties

Cyclone Gabrielle caused severe wind damage to Scion's Rangipo Accelerator trial in the central North Island. Scion's wood scientists took the opportunity to study the impact of this damage, especially tree-bending, on wood properties across a range of radiata pine genotypes.

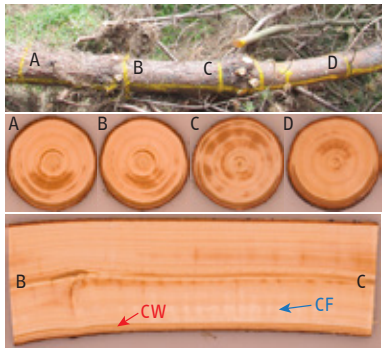
Standard tests were used to assess wood stiffness and wood density in a selection of standing but damaged trees. Destructive sampling was then carried out on a small sub-set of bent trees to examine internal stem characteristics.

Results confirmed that genotypes with higher wood density sustained less damage overall. Analysis of the internal properties of bent stems revealed there was some compression failure, where cell walls had been crushed, and the bent trees had formed severe compression wood as a response.

"These findings are potentially worrying," says Scion's Dr Jono Harrington. "If the less bent trees are allowed to grow on and recover enough to grow into acceptable final crop trees, these unwanted internal defects may not be obvious until the trees are milled."

How the wood properties in the damaged zones develop will only be known if monitoring continues over time.

"While establishing trees with higher wood density might mitigate some of the damage associated with wind events, forest managers need to trade this off against other factors," says Jono. "For example, higher density trees may be more prone to toppling in weak soils or may grow more slowly, lengthening rotations and increasing exposure to risk."



(i) Stem section from tree W2. (ii) Discs cut from the stem section while still green. (iii) A longitudinal slice between positions B and C. Compression wood (CW) and white zones assumed to be regions of compression failure (CF) are visible.

Resilient Forests

Lake Taupo Forest Trust; NZ Forest Managers Ltd.

Showcasing alternative timbers

Wood and wood products from New Zealand-grown alternative species are showcased in a strong, sustainable, two-roomed cabin, built to demonstrate the diversity of available New Zealand-grown timbers that are well-suited to small-scale construction projects. The project arose from the Specialty Woods Products Research Partnership (SWP), a Forest Growers Research-managed partnership that ran from 2015 to 2022.

"We wanted to test the durability of thermally modified cypress in a real-world environment. This grew into an opportunity to showcase other products that emerged from the SWP," says Vaughan Kearns of Ruapehu Sawmills, who designed and built the cabin. Vaughan is a strong advocate for New Zealand- grown timbers and was heavily involved in the SWP.

^ *Rosie Sargent, Scion wood technologist, and Vaughan Kearns, Ruapehu Sawmills, outside the specialty species cabin built by Vaughan.*

Thermal modification of cypress and eucalypts – a high-temperature technique to increase their stability and durability - was undertaken during the SWP by Scion wood technologist Rosie Sargent. Other work explored incorporating eucalypts into engineered products, and durability testing of various products, which will continue for some years to come.

"New Zealand timbers are often overlooked by architects and timber merchants," says Vaughan, "but this cabin demonstrates how versatile and attractive they can be."

Roof frames	Grand fir, Douglas-fir, cypress*
Roof sarking	Western red cedar
Wall frames	Cypress, *Eucalyptus fastigata* laminated veneer lumber
Cladding	Thermally modified poplar and cypress
Barge boards	Cypress
Ceiling linings	Poplar plywood
Wall linings	Cypress horizontal tongue and groove
Feature wall	Thermally modified cypress
Flooring	*Eucalyptus obliqua* with poplar/birch plywood backing
Support beams under cabin	Cypress

* *Cypress timbers used: Cupressus macrocarpa, C. lusitanica, Chamaecyparis x ovensii (Ovens Cypress) and Ch. Lawsoniana (Lawson Cypress).*

Specialty Wood Products Research Partnership, Te Uru Rākau Forestry and Wood Processing Industry Transformation Plan.

Ruapehu Sawmills

Future Research

Diversifying Forestry's Future

There is no doubt that forestry is part of New Zealand's DNA: commercial forests are here to stay.

In July 2024, Forestry Minister Todd McClay clearly stated, "Forestry's success is critical to rebuilding New Zealand's economy, boosting our GDP and providing regional jobs in a highly productive sector… It is important to ensure there is sufficient pipeline of logs to support domestic wood processing as well as encouraging the planting of new trees on suitable land to meet our international climate change commitments."

However, the coalition government's strategy is currently silent on which species "support sensible planting", what "new and innovative wood products" might augment our future export portfolio and how we stimulate confidence in an industry facing significant challenges. Radiata has served us well for a century, but geopolitical instability, policy uncertainty, price reductions, market decline and climate change mean we must make the right choices about what we plant next.

But when your industry is so highly geared to one species, how do you decide? With support from MPI's Sustainable Food and Fibre Futures Fund, we have undertaken a wide-ranging consultation process over the past nine months to determine the aspirations and research requirements for a more diverse, resilient and profitable forestry industry over the next 30-50 years. We interviewed 75 people across 60 organisations, canvassing a very broad range of views.

Not surprisingly, building resilience into the industry concerned people the most (see table). But other themes emerged:

- Don't reinvent the wheel, build on what is already known and the investment already made into other species.
- Find a contingency species for radiata that can slot seamlessly into the current supply chain.
- Find a way to shorten radiata's rotation age without compromising wood quality.
- Develop new high-value products/markets, utilising the whole tree.
- Understand the characteristics of other forestry models such as mixed species regimes.

Reslience area	Issue
Economic/profitability	There is no obvious contingency for radiata pine. Alternative species lack sufficient scale to be viable.
Ecological/climate	Species other than radiata require more specific matching of species to site.
	Radiata's long rotation age and age class distribution are exposing the industry to too much risk.
	Radiata forestry is being pushed to marginal land where it may not be best suited.
Technological	There is insufficient information to provide confidence and guide planting of other species.
	There are not enough resources (funding, people, infrastructure) to focus on more than one or two species beyond radiata.
Market	The building sector doesn't have the confidence to use other species and products.
	New species planted today are for markets 40 - 50 years from now.
Policy	Government regulations (such as rules set by the Overseas Investment Office) are limiting international investment into new plantings.
	Plantings won't occur at scale without incentives.
Cultural/social	Licence to operate and misunderstandings around radiata pine are limiting expansion.
	People want to plant species other than radiata pine but there are limited options and limited information.

Key themes emerging from the consultation process grouped under the various aspects of resilience.

We aren't the only ones grappling with these questions. The Parliamentary Commissioner for the Environment will be releasing a parallel investigation into alternative forestry species for climate mitigation and other benefits. His report is due out by the end of the year.

We are now working through our recommendations with the Forest Research Committee to prioritise a series of new research and development programmes to diversify our future forest estate. As debate continues around forestry's role in reducing our country's emissions, it has never been more important to ground what we do in science.

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