ScionConnections

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Photo: Geoff Thorp, Lake Taupō Forest Management.

Assessing clonal tree performance in Māori-owned forests

The forests of Lake Taupō and Lake Rotoaira are unique. Having started as joint ventures with government, the second rotation stands, which are now approaching maturity, are all Māori-owned and governed by the Lake Taupō and Lake Rotoaira Forest Trusts (the trusts). The forests are intensely managed with innovative, science-based techniques designed to produce high-value trees. Lake Taupō Forest Management oversees the management of these forests on behalf of the trusts and they want to ensure the high-value crop comes to fruition, while growing capability within their ranks.

Partnering with Scion, Lake Taupō Forest Management has just completed a two-year study supported by MBIE's Te Pūnaha Hihiko Vision Mātauranga Capability Fund, which saw iwi researcher Ben Aves join Scion on secondment. Working together with Jonathan Dash of Scion's Forest Informatics team, the duo designed an experiment across two forests comparing improved trees with unimproved trees using a new laser scanning dataset recently acquired by the trusts.

A careful comparison

One of the key investments the trusts have made is in planting genetically improved, clonally propagated trees. Over the past 10 years, wherever they planted a new section of clonally propogated trees, they also planted a block of non-clonally propagated trees nearby in very similar growing conditions. This created a valuable comparison for Ben's experiment, which was aided by a recently acquired LiDAR dataset for the two forests.

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Right tree, right place, right purpose

A couple of months ago the Scion Strategy to 2030 was published. Titled *Right Tree, Right Place, Right Purpose* our new strategy starts by looking out to 2050. We are ambitious with our aspirations for New Zealand and bold in claiming that forests are the resource that will get us there. It's all about how we value and use forests, directly or indirectly, to enrich our country, our communities and ourselves.

In the 2050 future we envisage, forests are prized as a sustainable renewable resource that is pivotal to New Zealand's economic, environmental and social well-being.

Achieving the targets we set in our strategy would mean our children and their children are enjoying living standards far superior to today. Can we do this in three decades?

We believe New Zealand can if (and it's a big if) we as a country care enough to embrace the opportunity in front of us that has arisen from global and local drivers.

The world is changing at a much faster pace than the impact of the industrial revolution 200 years ago. With the rising global urban population comes changing patterns for consumption of food, energy, water, land use and management of environmental impacts. Existing models of food production, material consumption and waste disposal are being challenged. Smart cities require new and different infrastructure and building technologies to reduce greenhouse gas emissions and environmental impacts and improve citizens' quality of life. Technological change and new business models are threatening businesses and countries that do not adapt. Rising greenhouse gas emissions are driving action. Concern about access to clean water is worldwide, and current unsustainable land use practices are no longer acceptable.

In response to these challenges, both OECD and emerging nations are adopting the 'bioeconomy' approach. This approach uses renewable resources from the land and sea, as well as waste, as inputs to feed, food, industrial products and energy production. And, the circular economy concept is intrinsically linked to the bioeconomy as the waste from one process becomes the feedstock for another.

A successful bioeconomy is an innovative, low-emissions economy, created through the merging of sectors and industries to ensure a sustainable supply of food and other products, while maintaining biodiversity and environmental protection.

Forestry is recognised globally as a key part of a low-carbon, biobased economy. Herein is the opportunity for New Zealand and all those who are part of the forestry value chain.

Forestry is recognised globally as a key part of a low-carbon, biobased economy. Herein is the opportunity for New Zealand and all those who are part of the forestry value chain.

It's very exciting for me that New Zealand is well positioned globally with existing forestry capability and resources in pulp, paper and wood manufactured products, a clean, green image and rising opportunities in our regions.

The Scion Board, leadership team and staff are embracing this timely opportunity to put forestry, and all that can be made from trees, firmly at the heart of a new bioeconomy for New Zealand.

In *Right Tree, Right Place, Right Purpose* we set out three research impact areas for Scion's focus to 2030 as we journey to 2050. Our work, however, is not limited to planning timeframes. It encompasses multiple timeframes ranging from 100+ years for forests planted for land protection to as little as five years for short-rotation forest crops.

We will be making short, medium and long-term impact in three research areas:

Forests and landscapes

Development of healthy, resilient forests that are planted primarily for their standing-forest benefits.

High-value timber manufacturing and products

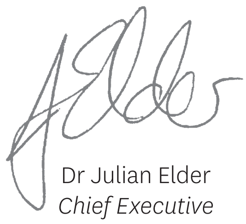
Development of products, manufacturing, high-value trees and healthy, resilient forests that capture an increasing share of the global high-end market for timber.

Biobased manufacturing and products

Development of products, processes, manufacturing, trees, other biomaterials and healthy, resilient forests to replace petrochemicals and non-sustainable materials.

Right now, we are developing the action plan and will be working with key stakeholders to refine and bring our ambitious strategy to life.

I invite you to take a closer look at our strategy and welcome any thoughts you may have on this and any other topics covered in this issue of *Scion Connections*.



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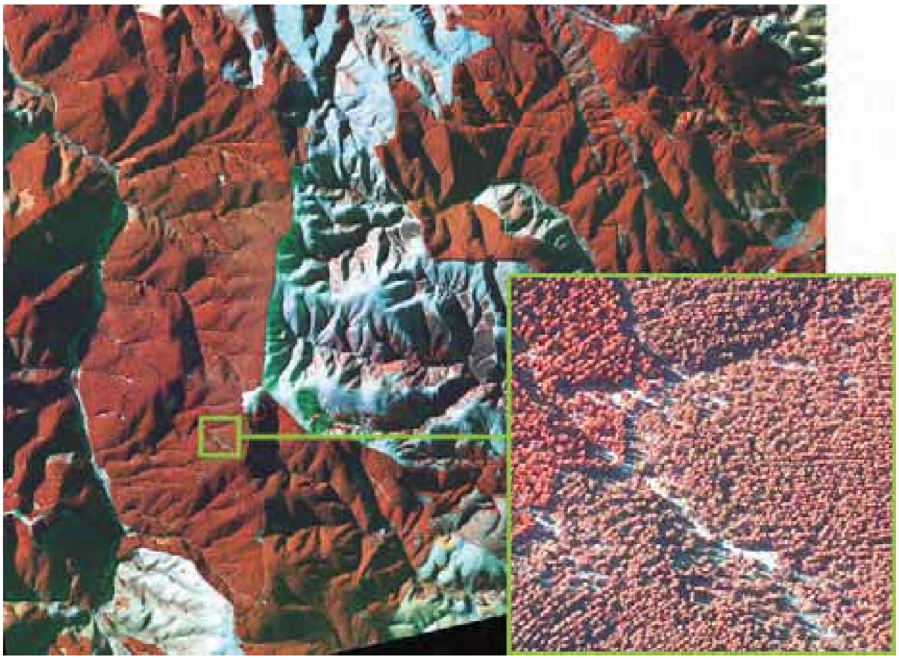

Using satellite photogrammetry for forest inventory

Forest management has undergone a transformation in recent decades. Management regimes have shifted from treatments that were applied to entire forests, to precise programmes, that can be tailored to single tree and are based on detailed data attained by remote sensing. Of the remote sensing technologies available to forest managers, satellite-based photogrammetry (the use of multiple images to extract measurements such as height) is a relatively unexplored area with huge potential.

Scion is exploring the use of photogrammetry applied to stereo-pair imagery from the Pléiades satellite constellation. Combined with an algorithm called semi-global matching, it has been used to model forest inventory attributes with a level of accuracy comparable to LiDAR.

Putting photogrammetry to the test

Scion's Dr Grant Pearse put photogrammetry to the test on a forest in the South Island of New Zealand. Not shying away from a challenge, he and the team selected a forest with rugged terrain and acquired their imagery in winter when shadows are longer and capturing high-quality satellite imagery is more difficult.

Grant explains how it was done. "Newer, agile satellite constellations such as Pléiades allow us to take multiple images of the forest from different viewing angles in quick succession."

> The high resolution imagery also allows for applications like updating forest boundaries and the spectral information (most suitable satellites include a near-infrared band) can be used to monitor forest health by detecting changes that could be caused by pathogens.

The extra images and accurate positioning information enable 3D data to be extracted from 2D images. He says, "For our study, we collected a pair of images, so if there was a steep hill limiting the satellite's view of the forest, images from the second position would capture it again from a different angle".

Using the semi-global matching algorithm and a digital terrain model (DTM) for the site, the team was able to digitally reconstruct the surface of the forest canopy. This 'synthetic' point cloud describes the upper canopy with a very similar level of detail and accuracy to traditional LiDAR data.

In a novel twist, Grant and the team focused on describing the 'texture' of the canopy surface as characterised by the synthetic point cloud. They then used this process to smooth out some dark areas created by regions of heavy shadow or where the semi-global matching performed poorly with the satellite data.

The results were very accurate and in many cases were remarkably similar to LiDAR, despite the rugged terrain and wintery conditions. The textural attributes of the canopy surface were important in closing the gap between the data sources when predicting the indicators that are used to evaluate a forest's productivity.

Implications for forestry management

Larger and larger areas of New Zealand are covered by at least one LiDAR capture – providing an accurate, reusable DTM. Scion's analysis has shown that once this DTM is available, alternative approaches such as satellite photogrammetry provide forest managers with another good option for gathering accurate, remotely-sensed data.

With this new approach comes a number of advantages. The high resolution (50 cm) imagery also allows for applications like updating forest boundaries and the spectral information (most suitable satellites include a near-infrared band) can be used to monitor forest health by detecting changes that could be caused by pathogens.

Grant goes on, "LiDAR is expensive, and the data takes a long time to be turned around, but this technique costs much less and produces results quickly".

The next step, says Grant, is for forest managers to start using the technique for applications such as mid-rotation inventory. "Photogrammetry is advancing rapidly and the same general principles can be applied to other data sources. The next step for us is to test what adjustments would be needed to apply these methods to data such as aerial imagery, which is already widely captured by the industry."

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Meet our new myrtle rust researchers

Since myrtle rust arrived in New Zealand in 2017 researchers from around the country have been focused on learning everything they can about myrtle rust to understand how it might affect New Zealand's plants, industries and ecosystems. Among our most valuable sources of knowledge are countries that have been living with the effects of different myrtle rust strains for some time. We have recruited four new researchers, each with different backgrounds that will be useful in our fight against myrtle rust.

Dr Julia Soewarto

Myrtle rust was the subject of Julia's PhD. She developed a strategy for controlling myrtle rust spread and impacts in New Caledonia - the second most affected country after Australia. Myrtle rust has infected at least 67 endemic Myrtaceae species representing 27 per cent of the known Myrtaceae in New Caledonia.

> "Within the first year of the myrtle rust incursion in New Caledonia, the main nurseries cultivating Myrtaceae reported a large loss of juvenile plants due to the disease."

Julia's work included assessing where myrtle rust may spread, and mapping the Myrtaceae host range. She carried out surveillance of the myrtle rust population genetics and tested the susceptibility levels of cultivated Myrtaceae species. Julia also used an RNA-sequencing method to identify genes that could be linked to myrtle rust resistance that may be used in a future marker-assisted selection process.

In New Caledonia, at least six types of native ecosystems were hosting myrtle rust including sclerophyllous forest, one of the most endangered tropical forest types in the world. The rapid effect of the pathogen was shocking. Julia says, "Within the first year of the myrtle rust incursion in New Caledonia, the main nurseries cultivating Myrtaceae reported a large loss of juvenile plants due to the disease. Myrtle rust regular reinfection and cost of chemical management in the nurseries resulted in the decline or abandonment of cultivated Myrtaceae species."

These experiences will inform Julia's work in New Zealand. This includes linking remotely-sensed data to visual ground-based inspections of myrtle rust on indicator species. She will also begin testing native and exotic host species' susceptibility against *Austropuccinia psidii* (the pandemic strain occurring in New Zealand) and different overseas strains from South Africa and Uruguay. Other projects will include the monitoring of natural myrtle rust infections on some key native Myrtaceae species over time and in different locations to understand environmental influences and the lifecycle of myrtle rust under New Zealand

conditions. Finally, she will also be trying to improve disease management through the development of biological control tools.

Dr Jules Freeman

Jules began working with myrtle rust in 2012, soon after the Australian incursion. His research focussed on various aspects of host resistance in *Eucalyptus* and *Corymbia* species. This included studying genetic variation in resistance within and between Tasmania's eucalypt species. He explored the molecular basis of variation in host resistance, and compared resistance to myrtle rust and native pathogens in economically important species.

"Similar to Australia, early disease surveys reveal species differ markedly in the frequency and severity of disease symptoms. It will be important to understand the nature and distribution of genetic variation in susceptibility within and between New Zealand species."

At Scion, Jules' main focus so far has been investigating the potential to breed for enhanced resistance to myrtle rust in New Zealand Myrtaceae species. By exploring overseas responses, he has the context to identify priorities and recommendations for conservation and breeding in New Zealand. The next step in this work involves simulations to determine strategies for sampling and breeding for myrtle rust resistance and will look at molecular markers indicating variation in resistance to myrtle rust.

Jules says, "Similar to Australia, early disease surveys reveal species differ markedly in the frequency and severity of disease symptoms. It will be important to understand the nature and distribution of genetic variation in susceptibility within and between New Zealand species."

Dr Kwasi Adusei-Fosu

Kwasi has been working on other rust pathogens (wheat rust) in the UK and Canada and is applying that knowledge to myrtle rust.

During his PhD, Kwasi was involved in researching and quantifying plant pathogens. Kwasi's role at Scion is to research the use of targeted fungicides and biocides on selected high priority and iconic New Zealand tree species. He says, "There is an urgent need to find innovative, practical technical solutions and design limitations of current aerial and ground-based pesticide application systems. My role is to lead, design, implement and carry out experimental control field trials."

Simon Wegner most recently worked for the Ministry for the Environment in the Freshwater Directorate on policy implementation and behaviour change. In practice, that meant being part the outward engagement efforts trying to improve the quality of freshwater planning and get tangible action among stakeholders. He was also a member of the cross-government Behavioural Insights Group, which promoted the use of behavioural sciences and related social sciences to inform government policy decisions.

Simon Wegner

Simon is involved in the social licence and social impacts work on myrtle rust. And with his experience working on behaviour change issues, he says, "People are people regardless of the context, so there will always be similarities. Each of the themes I have worked on involves understanding how people respond to some form of threat - whether the threat of fire to their homes or of plant pathogens to the forests they use and care about. What I'm fascinated by is why people respond so differently to the same threat and how the different social and psychological contexts shape those responses."

Haere mai

Our new researchers will be working on joint projects with Te Tira Whakamātaki, Manaaki Whenua, AgResearch, Plant and Food Research, AsureQuality, Will Allen Associates, Biosecurity Research Ltd, Massey University, as supported by MPI and MBIE.

Scion welcomes these fresh new faces who join a very collaborative multi-agency team in what promises to be a hard-fought battle for New Zealand's beloved Myrtaceae plants.

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Getting to the heart of coast redwood durability

Coast redwood (*Sequoia sempervirens*) has the potential to be a high-value timber crop. Its timber is attractive and its high stability and natural durability make it ideal for outdoor uses. There is strong local and international market for naturally durable timber that does not require chemical preservation or paint for outdoor use. Most of this is supplied from redwood stands grown in the USA, which has a reputation for heartwood resistance to decay.

Coast redwoods grow well in New Zealand, and we are well positioned to fill the demand for redwood products in the USA. However, there is a perception that New Zealand-grown redwood is less durable than USA-grown timber.

The *"Getting to the Heart of Coast Redwood Durability"* Sustainable Farming Fund project was set up in 2015 to quantify the natural durability and variability of redwood heartwood throughout New Zealand.

The current natural durability rating for New Zealand redwood is Class 3 – moderately durable with ground contact and a probable life expectancy of 5-15 years. One of the reasons for this rating is the high variability of durability between wood samples used for this rating. Understanding the sources of durability variation will help growers to remove or mitigate these sources, by, for example, choosing durable seedlots/clones.

Seeing red

The Scion research team believed that near-infrared (NIR) technology had the potential to be the basis of a rapid and cost-effective method to assess coast redwood heartwood's resistance to fungal decay. NIR uses light energy from the near-infrared region of the electromagnetic spectrum to measure the heartwood chemicals present to detect differences. Rather than using expensive and time-consuming laboratory tests, NIR can rapidly identify heartwood samples that are more, and less, resistant to fungal decay.

Durability testing

Coast redwood samples were taken from around the country. In all, 121 trees from eight sites were felled and over 10,000 individual heartwood samples were collected, representing trees across a range of genetics, sites and ages. Californian second-growth forest coast redwood (60-100 years) and radiata pine sapwood samples were used as controls. Each sample was tested with brown rots *Coniophora puteana* and *Gloeophyllum trabeum*, and white rot *Trametes versicolor.*

The samples were infected with the fungal culture and incubated for 16 weeks. After incubation, samples were weighed to establish how much mass they had lost. NIR spectra were then collected from the samples.

Results

The results from the NIR tests show that New Zealand-grown coast redwood is as durable as redwoods from USA second-forests. Heartwood from New Zealand-grown trees aged 46 to 90 years old had similar durability characteristics to heartwood from Californian-grown trees aged between 80 to 100 years old. The NIR results also showed that the genetics of coast redwoods have a strong influence on heartwood durability. Seedlings from the same genetic material, no matter where they are planted, will likely have similar heartwood durability characteristics at harvest. The New Zealand redwood sector now has a test method to quickly screen coast redwood heartwood for durability.

The next steps are to understand what research is needed to refine the durability ratings obtained with NIR with more samples, and to provide New Zealand Standards with a statistical link between the durability measured using this method and the traditional environmental exposure durability tests.

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New Chief Operating Officer for Scion

Dr Bart Challis

Dr Bart Challis is the newest member of Scion's Executive Management Team. As the newly appointed Chief Operating Officer, Bart will be responsible for overseeing research infrastructure and operational requirements. He will also lead our strategic science delivery, aligning it with Scion's Statement of Core Purpose and Strategy to 2030.

Dr Challis grew up in Rotorua and went on to complete a genetics-related PhD at the University of Otago before spending 16 years working internationally in Western Europe, North America and Asia. During this time, Bart worked in the biotechnology/life sciences industry performing various management and executive roles for multi-nationals including QBioGene, Invitrogen Inc and Active Motif Inc. Since returning to New Zealand, Dr Challis has worked as an executive at Hill Laboratories, initially managing the Agricultural Division, and more recently managing all commercial aspects of the Hills' organisation.

As an experienced executive with 20 years' technology-related industry experience, Dr Challis has established a proven track record in international technology commercialisation, research, development and operational management. He has also undertaken strategic partnering, creating and implementing strategic vision, leadership and successful multi-party negotiations.

The Scion team is excited to have Dr Challis on-board and we look forward to realising Scion's vision of growing New Zealand's prosperity through trees.

Assessing clonal tree performance in Māori-owned forests

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The LiDAR dataset provided Ben with the information needed to optimise the sampling design for the experiment. This reduced the total number of sites that needed to be measured in the field, and increased the efficiency of estimates of growth performance across the forests. He was able to identify pairs of both clonal and non-clonal plantings of the same or similar age and not less than three years of age. Each pair was within 200 m of each other, and had similar soil, elevation and climate. This resulted in 144 plots (72 clonal, 72 non-clonal) for Ben to measure for tree growth metrics, straightness and other wood properties.

Data analytics

Examining the data collected on the ground, and linking it to the LiDAR data, showed Ben where patterns could be established. Ground measurements were linked to metrics calculated from the LiDAR point cloud. Using these relationships between the ground data and the LiDAR point cloud, models were developed to upscale information from Ben's field measurements to the entire experiment.

Separate models were created for the clonal and non-clonal trees, each including variables that affect value recovery – tree size, uniformity and branching patterns. Site information including slope, aspect and elevation was extracted from the LiDAR data and accounted for in the analysis.

The results of the experiment were very promising. The three key findings showed that for a given age, the clonally propagated seedlings were larger, straighter and grew more uniformly than the non-clonal seedlings. These findings indicate that the trusts' investment in science and precision management was worthwhile.

Leaving a legacy

The two trusts administer around 50,000 ha of land, with approximately 16,000 Māori landowners, and many more whānau who have a connection to the land. The last of the joint venture stands in Lake Taupō Forest will be harvested in 2021, after which the trust will commence harvesting its fully-owned stands. The same will happen in Lake Rotoaira Forest from 2026. Ownership and management of the second rotation crop has required that the trusts assume responsibility for all management decisions, so capability building projects like this are multipurpose.

Geoff Thorp, General Manager for Lake Taupō Forest Management agreed: "For over 10 years we have invested heavily in clonal planting stock – which costs around twice that of non-clonal material. Now we have clonal stands of sufficient age, we have been able to ascertain how that investment is performing – and the results are very reassuring. We will continue to build on Ben and Jonathan's work, and are developing further research to identify more detail such as which individual clones perform best and whether performance varies across different sites. We are also finding that the LiDAR data is assisting in many other aspects of our forest management – including some we had not expected."

Scion and the Lake Taupō and Lake Rotoaira Forest Trusts are looking forward to developing a new project together.

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How will climate change affect plantation forestry in New Zealand?

New Zealand-grown *Pinus radiata* will be taller and slimmer in the future according to a new paper[1]. While sequestering greater amounts of carbon, the trees will be more exposed to risks from extreme winds and wildfire.

Researchers from Crown research institutes Scion and Manaaki Whenua Landcare Research have considered how climate change and future biosecurity threats might affect New Zealand's plantation forests.

Considering the effects of increasing levels of carbon dioxide on photosynthesis, the productivity of radiata pine could increase on average by 10 per cent by 2040, and double that by 2090.

Lead author, Scion's Dr Michael Watt explains: "Increasing concentrations of carbon dioxide in our atmosphere will increase the rate at which trees grow. An increased growth rate will result in trees becoming taller and more slender."

This study indicates that the greatest threat to New Zealand's plantation forests is likely to come from increased wind damage as increasingly slender and taller trees will be more susceptible to damage by future wind storms. The risks of breaking or uprooting can be reduced somewhat by modified forestry practices such as timely thinning and earlier harvesting, according to co-author Dr John Moore.

Very high and extreme fire risk days are also predicted to increase, with the length of the average fire season increasing by about 70 per cent by 2040 and 80 per cent by 2090. Fire scientist Grant Pearce found the most fire prone regions (Gisborne, Marlborough and Canterbury) will remain the most at risk, but that the relative increase in risk is highest in Wellington and coastal Otago, where it could double and triple to 30 days and 20 days per season, respectively.

New Zealand is currently free of any significant damaging insects, but population levels and damage may increase in the future as warmer temperatures may provide an environment for foreign species and accelerate insect development. Weeds are likely to expand their range under climate change and compete more strongly with plantations.

"A decade's worth of research into multiple climate change effects on New Zealand's plantation forests has been summarised here," says Michael Watt. "Determining the magnitude of climate change effects is crucial for informing national economic strategies, forest management and offsetting increasing carbon emissions as the country progresses toward a net carbon zero economy."

FOR FURTHER INFORMATION on this study contact Dr Michael Watt at michael.watt@scionresearch.com

[1] Paper: https://doi.org/10.1093/forestry/cpy024

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