ScionConnections

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*Andrea Stocchero (Scion) and Hinerangi Goodman (Chair Matekuare Whānau Trust) featured on TV1 news, talking about their work and the trust's aspirations to live sustainably on their whenua.*

# Sustainable papakāinga

The village of Te Whaiti lies some 80 kilometres south east of Rotorua. Situated among the imposing Ikawhenua and Huiarau Ranges of Te Urewera, this isolated land is home to the Matekuare whānau, a community striving to improve their housing conditions.

The Matekuare Whānau Trust (a hapū of Ngāti Whare) has a long-held vision of building a papakāinga (whānau housing) on their land. And not just any houses, houses that support healthy people and connection to the land. Their papakāinga would fill the needs of their community, with tikanga Māori, affordability, sustainability, and hauora (health and wellbeing) at its heart.

Designing such a home is the task of a holistic and collaborative research project led by Toi Ohomai Institute of Technology, with assistance from Unitec Institute of Technology, Tallwood (an Auckland-based design and prefabricated-construction company) and Scion. Together, the research partners have worked to assemble the above concepts into a house design that meets the needs of the community, and then to test the designs to show they can serve the people's needs.

### Holistic study

Healthy homes come from a combination of performance, design and construction and the best management of indoor moisture and temperature. Buildings can be designed and built to ensure healthy indoor living conditions are achieved and maintained in an energy-efficient, affordable way. Such high-performing buildings are healthier, cheaper to run and have a lower impact on the natural environment.

This project focussed on two areas of research to ensure that home designs

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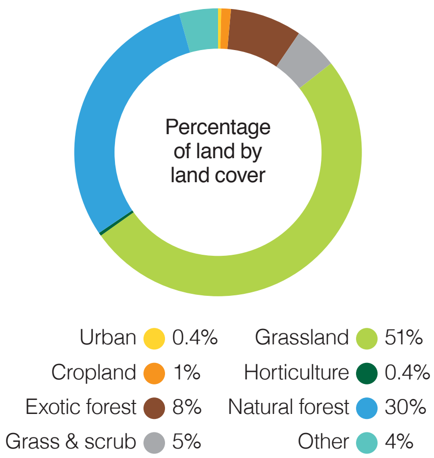
# We need forests, but what type?

Our strategy "Right tree, right place, right purpose" is all about making sound decisions. One person's right tree in the right place for the right purpose is not necessarily everyone's so we must consider society's different perceptions when working out where best to plant trees and change a land use. Our rural landscapes are familiar scenes, and fears about these landscapes changing from pasture to plantation forestry are understandable.

Yet land use facts should help allay those concerns. Planted forestry's share is small – only 8 per cent – compared with land used for pasture, crops and horticulture[1].




"... it is hard to see what all the fuss is about when land use is already so heavily skewed to pastoral farming," said Pattrick Smellie in the *NZ Herald* recently. I agree.

However, there is more to New Zealand forests than simply seeing exotic plantations for timber and fibre production versus indigenous forests managed for conservation values. There was an excellent reason for this dichotomy - exotic forests were planted to take pressure off our rapidly shrinking natural forests. It's time we moved from this blanket view.

All our forests are affected by human activity. Increased atmospheric $CO_2$ levels and expected increasing storm impacts will not spare any of our forests, and we must think more broadly in the conversation about the future of our forests.

Forests are a highly multi-functional land use fulfilling a primary purpose while giving many secondary benefits. They provide many products, like timber, fibre, energy, chemicals, food, medicines plus services such as carbon storage, erosion control, clean water, recreation, human wellbeing, biodiversity conservation, climate regulation and aesthetics.

A key challenge confronting us now is climate change. New Zealand committed to Paris Climate Agreement targets to reduce our greenhouse gas emissions by 30 per cent below 2005 levels by 2030. Planting forests to store carbon from the atmosphere is part of the solution. The One Billion Trees Programme will contribute to this target over the next decade and is being promoted strongly, with payments to landowners to encourage planting.

The question is what type of forest? From a purely carbon perspective, fast growing exotic plantations are often the best and most effective approach. However, other perspectives and concerns, and other benefits sought from trees, must be considered when deciding on the 'right tree'.

If we want to increase the carbon stored in trees there are many ways to do this across various forest types from untouched primary natural forest to trees outside forests.

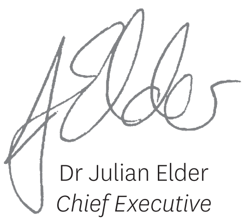
For instance, if primary forests are affected by animal browsing, pest control could enhance tree growth and hence the amount of stored carbon; recovering natural forests could be fertilised to accelerate growth rates; and agricultural lands offer many options. A recent study[2] on sheep and beef farms has identified large areas of natural forests that could be actively managed to enhance carbon stocks.

If we look at new planting on agricultural land there are options that may not have too much effect on farm production. For example, we calculated the carbon stocks for running a 20 metre strip of radiata pine trees up both sides of all waterways in all farmland and came up with ~100,000 hectares and 100 million cubic metres of new forest at age 30, which equates to ~50 million tonnes of carbon sequestered, while only decreasing agricultural land area by ~1.0 to 1.3 per cent. New shelterbelts, spaced trees planted on less intensively farmed pockets are all additional places where carbon may be captured without too much impact on farm production.

Recent work[3] has shown that existing plantation forests are not growing as fast as they could, so another approach to increasing carbon stocks is to intensify management across the existing 1.8 million hectares of planted forests. Current thinking is that it may be possible to double productivity, and hence carbon stored, through a combination of high performing genotypes, and tree crop and soil management.

These are just a handful of options but can help to expand our thinking. Discussion and communication of perceptions and understanding what we want from our forests and trees is important to good decision making by landowners, supported by a sound and commonly used scientific evidence base.

We need to plant new right trees in the right place for the right purpose, but we also need to make the most of the opportunities presented by our existing forests to integrate all forests into our national thinking and create new integrated landscapes for future generations to enjoy and use.



Dr Julian Elder
*Chief Executive*

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[1] https://www.mpi.govt.nz/dmsdocument/23056-analysis-of-drivers-and-barriers-to-land-use-change
[2] https://beeflambnz.com/sites/default/files/FINAL%20Norton%20Vegetation%20occurence%20sheep%20beef%20farms.pdf
[3] Moore and Clinton 2015. Enhancing the productivity of radiata pine forestry within environmental limits, NZJF. 60:3 pp35-41

*An example of East Coast land showing mixed forest growing on a hillside beside a section of highly erodible land.*

# Combatting erosion with strategic afforestation

Strategic afforestation is a precise undertaking. The factors that influence where, why and what kind of forest is planted involve detailed information on environmental conditions, forest genetics and economics. Scion, in collaboration with PF Olsen, is working with the Hawke's Bay Regional Council to identify where forests could fit into the regional landscape.

This project is a 'real life' application of Scion's strategy 'Right tree, right place, right purpose' promoting an approach that would see landowners consider a range of factors before planting. This project aims to help landowners make informed decisions about planting, including which tree species is best for which purpose (e.g. planting for erosion, timber, carbon or products such as mānuka honey), the environmental site conditions (e.g. slope, rainfall, temperature) and social considerations for nearby landowners and the wider catchment.

## Why plant a forest?

The Hawke's Bay Regional Council wants to know how forestry can help to reduce erosion in the region. With this clear purpose in mind, the project team has produced a map of the most erodible land across the region, identifying sites that lose more than 1,000 tonnes per km² of surface material annually. These sites are perfect to plant woody vegetation to reduce erosion, but each site has unique environmental conditions to take into consideration.

The biophysical considerations include rainfall, altitude, slope angle, aspect, soil type, erodibility, fertility and sediment loss. These factors, along with genetics and silviculture, will largely determine which species will perform best on the site (which will vary according to the purpose or desired outcome from planting). However, the species most likely to thrive might not necessarily serve the purpose for planting. For example, native species may be preferred for permanent forests and erosion control, or fast-growing exotic species might be favoured for carbon.

After identifying sites for potential afforestation across erodible landscapes of the Hawke's Bay for commercial plantations and permanent forests, the next step was spatial mapping of tree species site suitability – for radiata pine, coastal redwoods, *Cupressus lusitanica*, *Eucalyptus* species, tōtara and mānuka (for honey production).

## Incorporating the economics

Forestry is a long-term investment and landowners need as much information as possible to de-risk their investment decisions.

Scion's Forest Investment Framework (FIF) model takes a wide range of factors into account to provide landowners with more information. FIF combines information on forest productivity, infrastructure networks, planting and harvesting costs, the economic values of ecosystem services such as timber, carbon capture, erosion reduction, leaching reduction and habitats for native species. This, and other sources of information, are integrated in FIF to calculate outputs for the areas of interest.

The next step is to apply a social analysis to risk matrix. This will include interviewing farm foresters on their experiences with forestry and learning more about the financial drivers for farm foresters.

## Conclusion

The project will help reduce the need for landowners to do extensive research on their own and aid them to make informed decisions with long-term environmental and social consequences in mind.

Projects like this could go on to help inform Te Uru Rākau policies on afforestation around New Zealand, ensuring, as always, that the right tree is planted in the right place for the right purpose.

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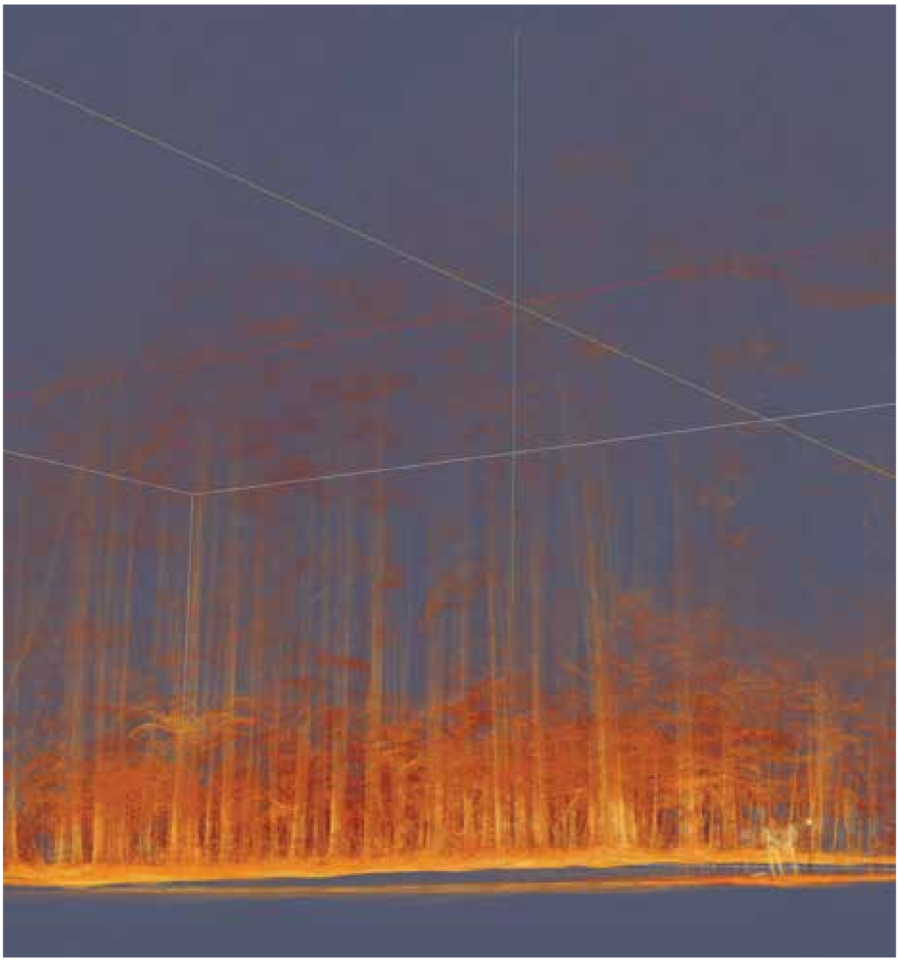
FOR FURTHER INFORMATION on this project contact Professor Tim Payn at tim.payn@scionresearch.com



# Closing the gap on forest productivity

Genetics, environment and forest management, or silviculture, all affect forest productivity and wood quality. Understanding the effect and interactions of these will help us close the gap between actual and potential productivity to create highly productive and profitable future forests.

The research programme Growing Confidence in Forestry's Future (GCFF) is wrapping up this year after six years of research activity. One of the goals in this programme was to understand what drives forest productivity to meet New Zealand forest growers' vision to double the production of planted forests.

### Is there a productivity gap?

The main factors that affect forest productivity are climate, soil, genetics and silviculture. Identifying the current limiting factor allows forest managers to take steps to close the gap between actual and potential productivity. The first step is to work out what is going on in your forest through forest inventory and monitoring.

### Remote sensing provides new insights into forest structure and condition

Scion's Forest Informatics Team has developed lidar scanning techniques for forest inventory. While lidar is very precise, the cost has often been off-putting for small-to-medium forest owners. However, costs are decreasing all the time and the technology is, therefore, becoming more widely accessible.

Use of satellite data for forest inventory has several advantages. Using stereo-pair images taken of the forest canopy, researchers could calculate canopy height and total recoverable volume of wood, accurately predicting forestry inventory attributes for radiata pine forests on rugged terrain. However, at least one lidar capture to create a digital terrain model is still required to generate canopy height models using satellite data. Many regions will have this terrain information freely available when Land Information New Zealand coordinates several upcoming regional scanning campaigns.

Satellite data is also less expensive than aerial lidar data and includes additional information such as spectral data. The information in this spectral data can be used to identify and map harvested areas, or monitor stress caused by disease, drought or soil deficiencies.

Overall, researchers have found that the level of detail possible with lidar means it can be an effective tool for carrying out inventories at a wide range of scales. Satellite data is likely to be most useful for forested areas where it is not cost-effective to capture lidar, such as when the resource is in an isolated region or occurs in scattered forests over a large area.

### Climate as a limiting factor

Altering the climate is not an option for increasing productivity but choosing the right genetic stock for your conditions could make a difference. Work in the Kaingaroa Forest combining remote sensing, seedlot and climate found that the seedlot and spring and summer temperatures were the most important factors determining productivity, showing the importance of matching seedlot to site.

This can be taken further by identifying individual trees with desirable characteristics growing in specific microclimates such as south-facing slopes. From these trees, it is possible to identify the genes responsible for favourable characteristics and to breed new material to capture these traits.

### Improving soil fertility

Optimising nutrition over a rotation by ensuring adequate nitrogen, phosphorus, carbon and other essential nutrients will enable trees to grow to their full potential on a particular site. Tools such as the Nutrient Balance Model (NuBalM) developed by Scion can calculate these demands and show when fertiliser addition could be used to increase productivity.

Fertiliser addition affects more than just

tree growth, it also affects the microbes present in the environment and the way these interact with the trees. Nitrogen fertiliser has been shown to have a long-lasting effect on the make-up of the soil microbial community. Altering the microbial community can also have positive impacts such as enhancing a tree's tolerance to drought.

Many forests in New Zealand are now into to their fourth rotation. As a result, maintaining nutrients between rotations, especially on low nutrient sites is becoming more important. Research has demonstrated the forest floor contains most of the nutrients.

To protect the soil, it is better to use harvesting practices that disturb the forest floor as little as possible and leave as much slash as possible on site to help maintain soil fertility for the next rotation.

### Genetic improvement delivers

Selective breeding is a very powerful tool for improving growth rate, form, wood quality etc. of radiata pine. The results from five decades of large-scale trials spanning New Zealand make it possible to predict the magnitude of gain for key traits when genetically improved trees are used.

Relative to unimproved tree stocks, the moderate levels of genetic improvement across the national radiata pine forest estate are estimated to have increased its present value by $3.5 billion, or $2,000 per hectare. If the current estate comprised highly improved material, the total increase in present value over unimproved material is estimated to be of the order of $8.5 billion, or just under $5,000 per hectare.

Improving the genetics of radiata pine will continue to be a powerful lever to lift productivity in the long-term as other factors that affect productivity, such as stand density and nutrition, are optimised.

### Maximising the potential of a site through good silviculture

Fully occupying a site with trees is perhaps the simplest way to improve productivity. However, forest growers need to find the right balance between understocking a site and overstocking it.

Scion researchers have combined information from growth and yield models with the spatial variation in site productivity to predict the optimum post-thinning stand density (stocking) for a given regime on a given site. For example, the average optimum stocking level for growing S30 structural saw logs was predicted to be around 615 stems/hectare. This result is confirmed by end-of-rotation assessments from long-term research trials containing a wide range of stocking levels. Given that the current average stand density for unpruned sawlog regimes is around 500 stems/hectare, there is definite scope to increase forest productivity and future log supply through changes in thinning practice.

### A productive future

The GCFF programme has focused on how we can increase forest productivity, produce a consistent supply of quality wood and remain a sustainable industry.

Over the next five to ten years the New Zealand forestry industry can look forward to greater productivity, increased planting and increasing investment in processing. Productive forests, with the right genotypes, on the right site, growing for the right purpose will benefit regional economies, the country and contribute the raw materials to build a sustainable future.

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*New research leader Dr Gancho Slavov is a great addition to Dr Heidi Dungey's Forest Genetics Team.*

# Forest genetics and tissue culture programmes accelerate change

There is a huge potential for improvements in radiata pine genetics and breeding technologies to create benefits for the entire forestry industry.

Our vision is to enable high-quality plants to be delivered to the forest faster. This will mean achieving the best genetic gains possible in the forest and disrupting the standard process of growing trees from seed to significantly increase forest productivity.

With these aims in mind, our forest genetics and tissue culture scientists have formed a new partnership with the Radiata Pine Breeding Company (RPBC) and embarked on a new research programme with Forest Growers Research. Scion has also appointed a new research leader to help bring about this transformational change.

### Tree improvement moves into a new phase

Scion and RPBC have forged a new relationship to work together to deliver improved tree genetics for radiata pine growers. Optimisation and integration of genomics technologies into the breeding programme will be the key focus of this stronger relationship.

Genomics involves understanding the ancestral relationships, or family relationships among trees, likened to ancestry.com for trees. It also involves understanding the relationship between a large number of DNA markers and tree characteristics. By learning more about these marker relationships, we can predict the best trees to accelerate breeding, prevent the negative consequences of inbreeding, and inform forest conservation programmes. Genomics is also expected to cut the breeding cycle time by up to 50 per cent, substantially reducing or perhaps even eliminating field testing.

RPBC supplies genetic material to the majority of forest growers in New Zealand, as well as up to 30 per cent of Australia's radiata pine-growing industry. By working in partnership with the RPBC, the effects of increased tree quality and decreased breeding time will be realised quickly and on a wide scale.

### Introducing Gancho Slavov

Dr Gancho Slavov will be one of the scientists helping to make this research happen. Gancho joined Scion in May 2019 as a Research Leader for Quantitative and Molecular Genetics.

His experience is in population and quantitative genetics and genomics of species including mugo pine, Douglas-fir, poplar, willow and miscanthus. Gancho's key interests are in developing predictive genomic models from phenotyping data, and in accelerating and improving breeding/conservation programmes to mitigate climate change.

This role brings together and applies all of Gancho's expertise. He says, "Radiata pine is a fascinating species, and there is potential for genomics to make big improvements in the forestry industry. The genomic prediction approaches that I'll be working on could also be applied to accelerate breeding and conservation programmes for other exotic, and hopefully some indigenous, tree species".

### Tissue culture plant propagation

When it comes to introducing genetic improvements into forestry stock, tissue culture could be a speedier option.

Tissue culture is the growing of plants in a nutritious medium in the laboratory. Tissue culture has many advantages such as producing multiple plants from a single, immature seed. This process could be improved to increase the quality and multiplication of individual varieties of tree.

Scion is working closely with Forest Growers Research on their new tissue culture propagation partnership 'Tissue Culture for the 21st Century'. The seven-year programme supported by the Forest Growers Levy Trust and MBIE, aims to produce a reliable and cost-effective tissue culture process by using bioreactors to quickly produce small rooted plantlets. Their work will make dramatic improvements in the delivery of genetic gain and future biotechnology developments into tree stock.

### Transformative change

Scion's Science Leader for Forest Genetics, Dr Heidi Dungey, says her team's overall strategy is to be able to identify and breed trees with any desired trait. For example, tools can be developed and used for selecting trees that accentuate carbon sequestration to aid the mitigation of climate change and to establish a more sustainable biobased economy. Once selected, we need to be able to mass produce them as required and deploy into the forest as fast as possible Heidi says. "We want to create resilient forests that become a 'supermarket' for an array of different biobased products."

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FOR FURTHER INFORMATION on our Forest Genetics programme contact Dr Heidi Dungey at heidi.dungey@scionresearch.com

*Progress is quick on Scion's Innovation Hub. Photo taken on 21 August.*

# Scion's new innovation hub is taking shape

The new three-storey building under construction on our Rotorua campus has been described as an ambitiously designed structure. It showcases the latest in engineered timber products and manufacturing techniques within its unique and challenging structural form, while using products that meet our preferences for sustainability and environmental performance. The predominant feature is the timber components constructed with painstaking precision and assembled into diagonal grids.

Diagonal grids (diagrids) are an efficient way to provide strength and stiffness and require less material than traditional structures.

Diagrid components arrived on site ready to assemble in July 2019 and were erected by a specialist team. This process is further sped up because most of the building happens offsite, making onsite construction quicker and quieter compared to many other construction styles.

Scion's diagrid is unusual as it is nearly entirely made of timber. The diagrid wall frames and floor/roof beams have been manufactured by TimberLab from precision-cut laminated veneer lumber (LVL). The diamond and triangle diagrid sections were prefabricated and delivered complete with fittings to the site.

To make sure the diagrid was up to the job, the strength of the components was tested at Scion. An apex portion was subjected to 45 tonnes of downward pressure then pulled upward by a 31.5 tonne force. A node section, where diagrid components are integrated with a horizontal member, was subjected to 20 tonnes of compression in an attempt to twist the horizontal component.

Doug Gaunt, Science Leader for Wood and Fibre at Scion, says all the pieces tested passed with flying colours. "Both the elements tested comfortably performed even at the maximum design loads the engineers had calculated."

The 2,000 m² facility consists of diagrid LVL wall frames, LVL floor/roof beams, cross laminated timber (CLT) floor and lift shaft panels, Glulam (glued laminated timber) and CLT entry canopies as well as structural steel to support the glazing systems integrated throughout the engineered timber.

Irving Smith Architects, RTA Studio and Dunning Thornton Consultants have collaborated in the design of the building, which features a three-storey timber diagrid with central atrium and wrap-around diagonal curtainwall cladding. The ground floor will be open to the public and showcase not only the innovative structure, but also Scion's research across the forest and biomass value chains.

Construction is expected to be completed by mid 2020.

FOR FURTHER INFORMATION on our new Innovation Hub contact Rob Trass at rob.trass@scionresearch.com

# Sustainable papakāinga

*(Continued from page 1)*

address the health and wellbeing of whānau members and their environmental (living) conditions (work undertaken by Toi Ohomai and Unitec); and the design of optimised prefabricated, modular housing (undertaken by Tallwood, Toi Ohomai and Scion).

### Modelling heat and moisture flows

Scion's research modelled the heat and moisture flows on the wall, floor and ceiling structure options for a design created by Tallwood. This hygrothermal modelling simulates the movement of heat and moisture within a building to look at how temperature, and moisture (humidity) can vary under different designs.

The modelling results supported developing a design that improves thermal performance and moisture management within the structure. This design includes using an additional mineral wool rigid insulation in the exterior of the structure and more insulation in the cavity. It also includes a weathertight and moisture control membrane and an interior airtight membrane with vapour control. The simulations also assessed risk for mould growth on indoor surfaces and within the structure.

The results fed into designs that were tested for buildability by Toi Ohomai to overcome construction challenges and create solutions for the final design.

### Results

An efficient thermal envelope helps create a healthy and comfortable home and reduces costs over a building's lifetime.

This research project presents a housing model that emphasises the use of sustainable materials, energy efficiency, low maintenance, simple construction and small size. The project has delivered a model for houses that are healthy and affordable over their lifetime. These houses will deliver healthy and comfortable living environments and lower environmental impact.

While this study was undertaken for a specific Māori community housing project, the results provide valuable insights for any housing project in New Zealand.

This project was funded by the Building Better Homes, Towns and Cities National Science Challenge.

FOR FURTHER INFORMATION about Scion's role in this project contact Andrea Stocchero at andrea.stocchero@scionresearch.com

*Ecklonia radiata.*

# Seaweed science

Seaweeds have an impressively wide range of uses. Different species are used as key ingredients for food, cosmetics and fertilisers, to name a few. Seaweeds have unique properties, and Scion is one year into a new project to investigate if cellulose from seaweed could make your smartphone battery perform better, for example.

### Wide and long cellulose

Cellulose is a structural component in the primary and secondary cell walls of plants and algae. Seaweed cellulose is unique, it forms long and wide cellulose chains. Land-based plants have a chain width up to five nanometres. In contrast, the cellulose chains in seaweeds can be 20 nanometres or more across (the exact number of chains and their width varies between species).

The width of cellulose chains is known to affect heat transfer. Scion scientist Dr Stefan Hill is leading a project to learn more about this relationship.

The project is looking to extract cellulose from seaweed, physically characterise it, and test its thermal conductivity. The seaweed cellulose will then be incorporated into paper and plastic composites to evaluate their thermal properties.

### Making headway

As the first year of a three-year project draws to a close, a lot of progress has been made.

Selected species for testing included *Undaria*, *Ecklonia*, and one other. The third seaweed will be one of 20 samples harvested by project partner AgriSea and will be selected based on its properties and availability to harvest sustainably.

With samples in hand, Scion staff mechanically pulped the seaweed with equipment traditionally used in wood fibre processing. With seaweed reduced to fibres, a chemical treatment was then used to extract seaweed cellulose nanocrystals.

Stefan and the team from Scion, along with Ashleigh Browne from AgriSea, then took the samples to the Australian Synchrotron for x-ray diffraction tests. The synchrotron generates high energy electron beams that are shot at the sample. By looking at the way the beams are scattered when they hit the sample, it is possible to work out its structure and crystal size.

Initial results are still undergoing analysis but have revealed some interesting trends to explore further.

### Far reaching impact

Stefan and his team hypothesize that seaweed cellulose crystals have a heat transfer rate that is at least twice as fast as currently reported celluloses. If they are proven right, seaweed cellulose could have a variety of uses in electronic applications in technology like smart phones where fast and effective heat transfer is essential for passively cooling batteries to extend their life (and stop them catching fire).

The project received funding from the Ministry of Business, Innovation and Employment's Endeavour Fund, as a Smart Idea.

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