Scion Connections

THE BIOTECH REVOLUTION

SOLUTIONS TO TACKLE CLIMATE CHANGE AND DRIVE REGIONAL GROWTH

TRAILBLAZING RESEARCH

UNRAVELLING THE MYSTERIES OF FIRE TORNADOES

PROPAGATING TREES

TISSUE CULTURE AND ARTIFICIAL INTELLIGENCE BOOSTS PRODUCTIVITY

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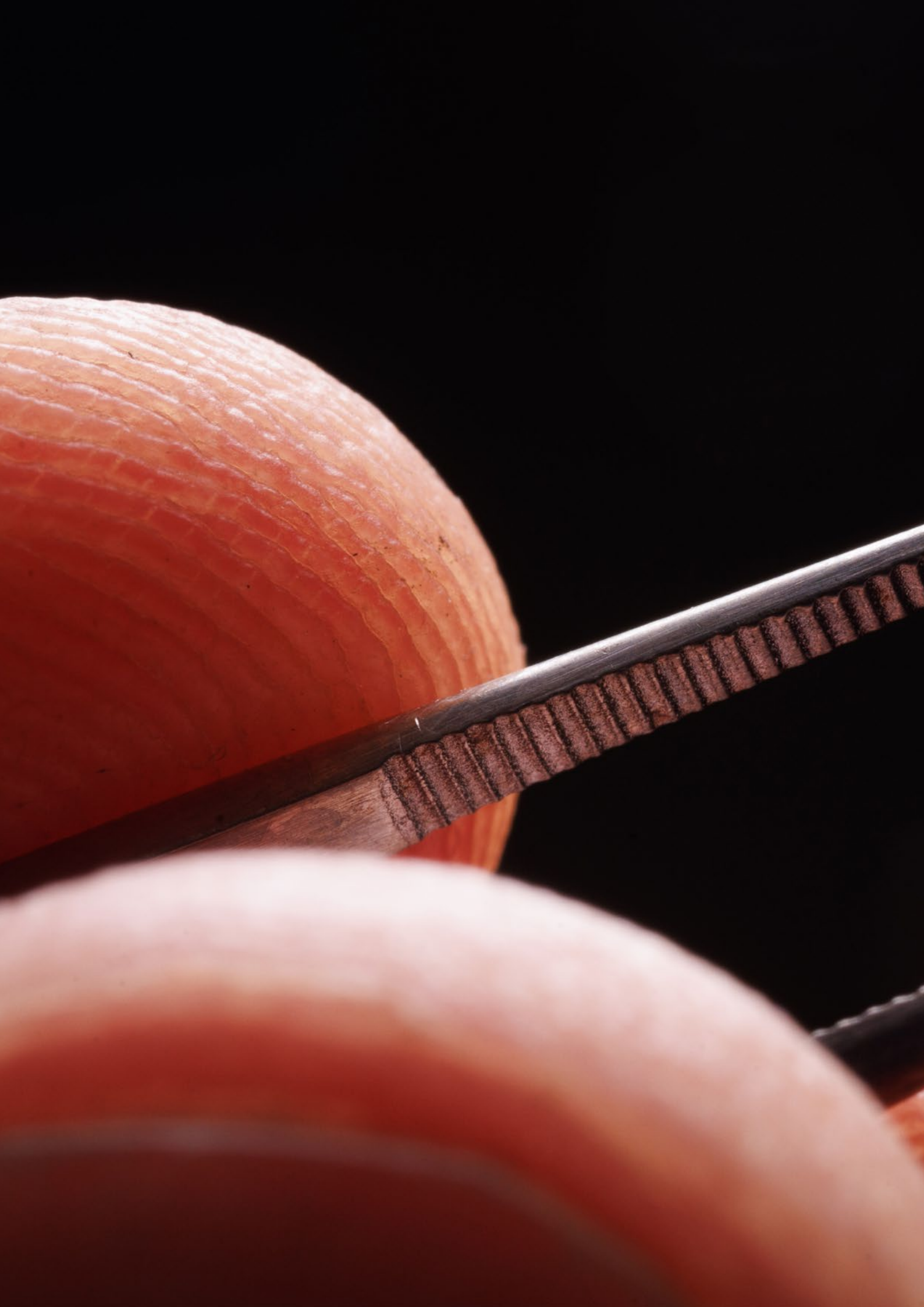

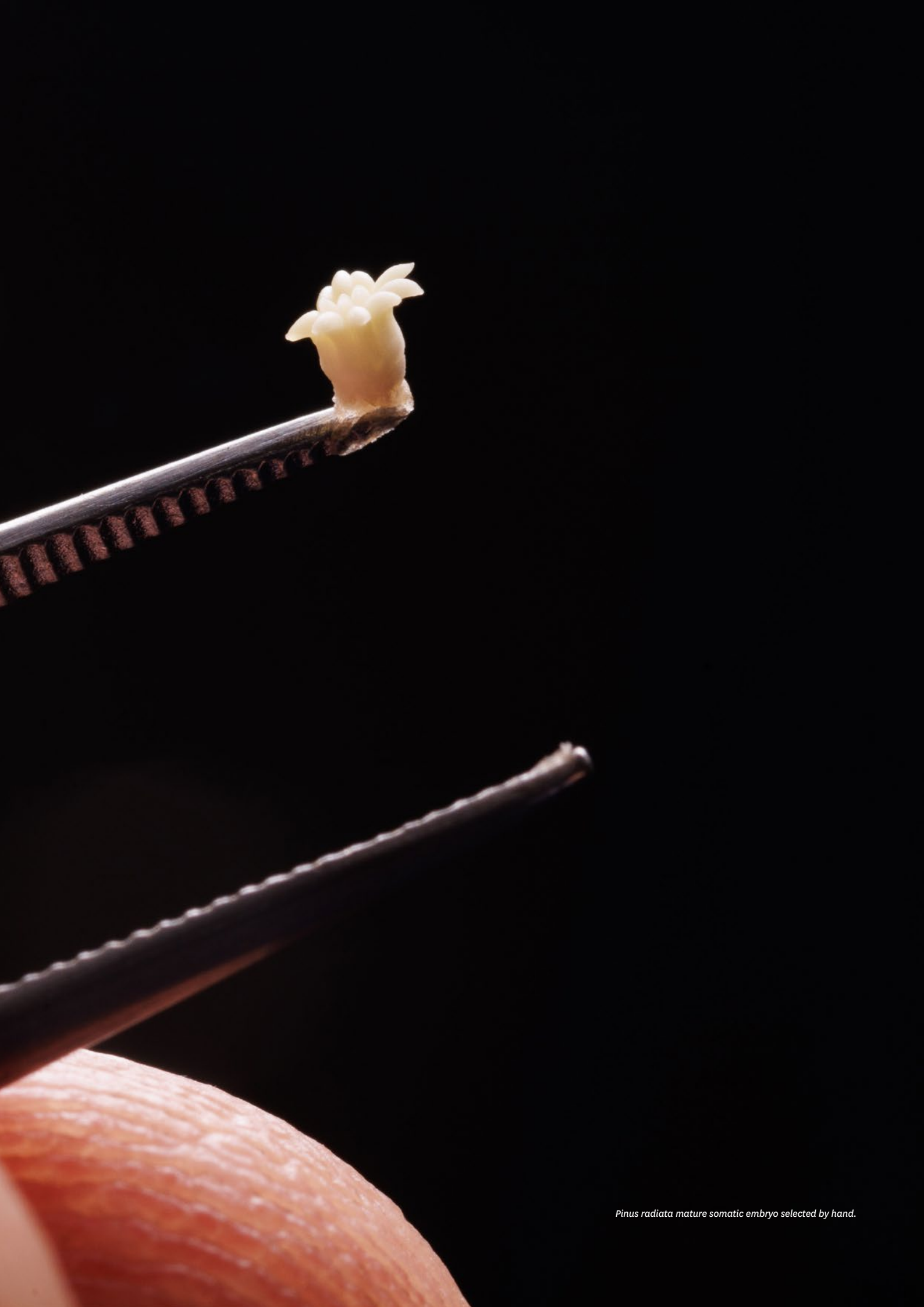

Pinus radiata mature somatic embryo selected by hand.

Kia ora,

Climate change poses an urgent challenge that affects us all, demanding an increased focus on science to combat its impacts. Our scientists are deeply passionate about this issue and are resolutely committed to discovering solutions for the climate crisis.

This crisis serves as a catalyst for significant shifts in behaviour and innovative approaches to shape New Zealand's future through a circular bioeconomy lens. Our Rotorua and Christchurch campuses are at the forefront of pioneering research and cutting-edge technology, led by our dedicated science teams.

Moreover, our emphasis on partnerships and collaborations lies at the core of our operations. Working closely with industry, iwi, government and other institutions, we are driven to deliver impactful science. We understand that more can be achieved together than working in isolation. Our stories vividly illustrate how our research paves the way for a thriving society, more resilient environments, enhanced biodiversity, and economic growth with higher paying jobs in the regions.

To stay connected with Scion, we invite you to explore our website. Engage with us on our social media channels to be part of the conversation. Together, we can work towards a brighter, more sustainable future for Aotearoa New Zealand.

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What's inside

COVER: Senior technician Jessica Harris inside Scion's fermentation technology laboratory where teams are accelerating biotechnology research and capabilities for New Zealand.

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Pioneering a sustainable bioeconomy for a greener tomorrow

New Zealand's forests play a vital role in transitioning to a circular bioeconomy, aligning with priorities for sustainability, thriving communities and climate action.

I was in Australia recently, attending the biennial Australia-New Zealand Institute of Forestry (ANZIF) conference. The overall theme of the conference was Embracing our Natural Capital: The Science, Technology and Art of Managing Forests for All Values. Presentations strengthened my views on just how much advantage New Zealand's forests give us in building tomorrow's world. Their rapid growth rates will be vital for supplying the sustainable biomass that will grow New Zealand's low-carbon economy.

As the world is responding to climate change and other environmental challenges, economies are looking to move away from the petrochemical economy to a circular bioeconomy. That move is about protecting the environment and helping meet our net-zero targets by taking more greenhouse gasses out of the atmosphere and locking them up, either in standing forests or by replacing products and materials based on fossil-fuels and petrochemicals with alternatives produced from sustainably grown biomass. A circular bioeconomy will see our forests and other sustainable biomass being made into new biomaterials including bioplastics, clothing, and the bioenergy and biofuels needed to fuel our low-carbon economy.

Scion is working to help New Zealand transition to a circular bioeconomy, right across our three impact areas and 11 research portfolios. It is an approach that aligns closely with a Te Ao Māori worldview which positions New Zealand with a globally unique value proposition. This is a huge economic opportunity for New Zealand. We can revitalise our rural communities with a mosaic of economic activity in our regions from farming, forestry and a myriad of new manufacturers creating the materials and products needed in a new circular bioeconomy. Compared to petrochemical industries these new approaches work at smaller scales that fit better with New Zealand's size and landscape.

New Zealand's future is at risk. Economically, we're already seeing this in climate-related disruptions to global supply chains. Climate change is accelerating and intensifying the impact of weather-related hazards. While climate change is a direct threat to New Zealand, if we act decisively we can turn this into a once-in-a-generation economic opportunity. Scion's science and innovation can be the game changer to help make that happen.

Scion can't do that alone, and we need a future-fit science and innovation system if Scion and others are to deliver on government expectations and serve Aotearoa to the best of our ability.

At the ANZIF conference in October, there was plenty of discussion about Australia's national research priorities. The Australian Government has proposed four of these: ensuring a net-zero future and protecting Australia's biodiversity; supporting healthy and thriving communities; enabling a productive and innovative economy; and building a stronger, more resilient nation. The priorities focus more on broad societal goals than on the mechanisms for achieving them, and one of the speakers at the ANZIF conference summarised those national priorities in the following points:

- Transforming landscapes at scale
- Incentivising bioeconomy transitions
- Delivering circular economy objectives
- Diversifying regional economies

That summary resonates strongly with me, and with the work that Scion is doing. Here in New Zealand, we need to get in with this journey or be left behind. In a constrained fiscal environment, it is even more important that the government-funded research, science and innovation system has more of its funding aligned to delivering on these great opportunities for our country and our communities. We want to set outcomes to be delivered and to be supported – and held to account – for delivering them.

DR. JULIAN ELDER.
CEO, SCION.

Fixing the aerial invader hole in our biosecurity net

> We are of the opinion that you can't do anything if you don't at least research it.
>
> ILZE PRETORIUS

Dr Ilze Pretorius will lead research into aerial pest invasions.

Scion has been funded $10.85m for a project to protect New Zealand from aerial pests.

New Zealand's trade and tourism border security is among the strictest in the world in efforts to protect the environment and primary industries from unwanted pests and diseases.

But aerial invaders (insect and pathogen pests arriving by wind) are harder to control. Recent examples of such pests include myrtle rust and fall armyworm.

Scion researchers are aiming to fix the aerial invader hole in our biosecurity net and have received investment funding of $10.85 million over five years through the Ministry of Business, Innovation and Employment (MBIE) Endeavour Fund – New Zealand's largest contestable research fund.

The research programme *Protecting Aotearoa from aerial invaders in a changing climate* will aim to develop a novel, integrated aerobiological surveillance and prediction system to manage aerial pest movement.

Scientists will look at trajectory modelling, how airbridges connecting Aotearoa to other landmasses are changing due to climate change and fill knowledge gaps on aerial invader/pest survival in extreme atmospheric conditions.

The science team estimates preventing establishment of just one serious pest would recover programme costs 10 to 100 times through avoided losses in the forestry and/or horticultural sectors, maintenance of carbon sequestration, and biodiversity conservation.

> If anyone can do something, it's probably us.
>
> ILZE PRETORIUS

The programme will also establish a baseline of aerial invader arrivals with help from the Taranaki Mounga Project, a partnership with iwi, agencies and community working on restoring Taranaki Maunga.

It will be led by atmospheric dispersion modeler Dr Ilze Pretorius, who is based in Scion's Christchurch office.

Pretorius says the project has been in formation for about five years and some preliminary research has already been done. She says reaching this point has been a huge team effort.

"No one in the world is really doing research on this, there's this assumption you can't do much about aerial pest pathways, but New Zealand is in a unique position with water borders. If anyone can do something, it's probably us," she says.

"It's a very difficult problem but we are of the opinion that you can't do anything if you don't at least research it and get to an answer. Either way, even if you can't eradicate, this research will still lead to a lot of benefit."

While the goal is detecting aerial invaders early enough for eradication, the tool could also help optimise surveillance networks.

She says she is looking forward to partnering with Taranaki Mounga Project to establish a baseline of pests that are coming in, as well as the research about how atmospheric conditions influence the ability of pests to survive in the atmosphere – work that hasn't been done before.

The team is planning to build a custom wind tunnel to test how rainfall influences the ability of migrating moths to fly to then incorporate findings in the prediction model.

"That's easier said than done. Enticing moths to fly in that experiment will be an interesting challenge because it's up to the organism and not us."

The funding bid was submitted in partnership with representatives from University of Canterbury, NIWA, AgResearch, Plant & Food, Virginia Tech in the United States, and universities in Europe and Seoul.

The successful project was funded through the Endeavour Fund Research Programme investment mechanism. This supports ideas with credible and high potential to positively transform New Zealand's future in areas of future value, growth, or critical need.

While Pretorius is on maternity leave, the project will be handled by colleagues Jess Kerr, Toni Withers, and Brian Richardson.

Scion chief executive Dr Julian Elder says the funding illustrates the value of the work Scion is doing in the research and innovation space.

He says New Zealand's 2050 greenhouse gas emissions targets could be severely compromised by new pest introductions, so the team's research is critical.

"We're delighted with the funding win and are proud to lead research that will tackle climate change and support industry transformation to shape a sustainable renewable future driven by forestry and wood products."

The funding was announced by MBIE on 15 September 2023.

The project is one of 68 nationwide to receive a slice of $246m Endeavour Fund investment.

Scion scientists will also contribute their expertise to three Smart Ideas and one Research Programme led by other organisations that secured support from the Endeavour Fund.

The successful programme was the University of Auckland led project *Waste to treasure: Using novel chemistry to valorise residual plant materials*.

The Smart Ideas include the manipulation of fungi-associated bacterial communities to combat plant disease project led by Lincoln Agritech, unlocking the potential of microbial bioactive compounds to promote forest health led by Lincoln University, and wireless chipless label sensor for seafood quality monitoring through supply chains led by Auckland University of Technology.

New directors welcomed to the board




L TO R:
Kiriwaitingi Rei-Russell, Nicole Anderson, Zara Morrison, Phil Taylor.

With a wealth of experience spanning various sectors, these directors are shaping Scion's future success and driving our mission forward.

Former Minister of Research, Science and Innovation Hon Dr Ayesha Verrall appointed Nicole Anderson, Phil Taylor and Kiriwaitingi Rei-Russell to Scion's board for a three-year term.

Board chair Dr Helen Anderson says she's delighted by the calibre of the individuals, who were welcomed to the board in July.

"Their passion for sustainability, economic development and good governance aligns perfectly with Scion's mission. Their contributions will be instrumental in shaping our organisation's future success."

As a chartered professional director, Nicole Anderson (Ngāpuhi, Te Roroa, Te Aupōuri) has a proven track record in governance across a range of sectors, bringing experience in strategic analysis, business planning and commercial development to Scion's board. She is currently a director at Kāinga Ora – Homes and Communities, Far North Holdings, Top Energy and is the chair at Northland Inc, Northland's Regional Economic Development Agency. After three years' service she has also recently become board chair at International Accreditation New Zealand (IANZ), the national authority for the accreditation of testing and calibration laboratories, inspection bodies and radiology services.

> "Their passion for sustainability, economic development and good governance aligns perfectly with Scion's mission."
>
> DR HELEN ANDERSON, BOARD CHAIR

Phil Taylor brings more than four decades of experience in commercial forestry to his new director role at Scion. He has served on numerous boards and directorships, primarily focusing on research and development and community service organisations. He has gained international experience in forestry and governance and has held chief executive roles in forestry since 1999. Currently, Taylor is the managing director at Port Blakely in Canterbury. In this role, he oversees all of NZ Forestry's holdings. He also serves on the board of both the New Zealand Forest Owners Association and the Forest Growers Levy Trust.

Kiriwaitingi Rei-Russell (Te Arawa – Ngāti Whakaue, Tūhourangi Ngāti Wāhiao, and Ngāti Awa – Te Pahipoto) was born and raised in Rotorua. She has a legal and governance background with a strong focus on primary industries. An advocate for Māori economic and commercial development, she was the chief executive at Māori Investments for 10 years and is now the head of Māori Alliances at Zespri based in Mount Maunganui. While being heavily involved in the kiwifruit industry, Rei-Russell currently holds directorships on Ngāti Awa Group Holdings Ltd, Waiu Dairy LP and Putauaki Trust. She is also the deputy chair of the Māori Kiwifruit Growers Inc and was the first woman appointed to the Bay of Plenty Rugby Union. She was also a future director to the Board of Auckland lnternational Airport from 2016 to 2018.

The trio join existing Scion directors Helen Anderson, Greg Mann, Stana Pezic, Dr Jon Ryder, and Brendon Green (Ngāti Hikairo, Ngāpuhi). Their first meeting together in July was also the first for future director Zara Morrison (Ngāti Whakaue, Ngāti Tūwharetoa). Morrison was nominated for the 12-month role by the trustees of Ngā Hapū e Toru – Ngāti Hurungaterangi, Ngāti Taeotu and Ngāti Te Kahu.

"Zara is a member of Ngāti Taeotu and we are pleased to walk alongside her as she takes her next steps in governance with this appointment. Her research background and financial acumen lends itself well to this future director role," said trustees Hoki Kahukiwa and Veronica Butterworth.

"Her commitment to Te Ao Māori, interest in driving equitable opportunities and outcomes for Māori, and her relationship management capabilities ensure that the relationship between the hapū and Scion will continue to grow."

Collaboration key to science in region

Iwi, community and business leaders from across the Bay of Plenty-Waiariki met with science leaders in October to hear how science can better contribute to the future of the region.

From left: Chief executives Chelydra Percy from GNS Science, James Stevenson-Wallace from Manaaki Whenua Landcare Research, Julian Elder from Scion, Sue Bidrose from AgResearch, Mark Piper from Plant and Food Research, and Institute of Environmental Science and Research Environment Group general manager Wim Nijhof.

The Science New Zealand board, made up of the chief executives of New Zealand's seven Crown Research Institutes, held its bimonthly meeting at Scion in Rotorua.

The board later toured Scion and attended an evening function with representatives from businesses, councils and iwi.

At the function, the chief executives outlined work their organisations are doing in the region, including biodiversity restoration, tackling invasive species and pathogens, using land resources effectively, and working to improve the overall health and wellbeing of New Zealanders.

They all reiterated the importance of incorporating mātauranga Māori with the sciences and cross-CRI collaboration.

LEFT TO RIGHT, FROM TOP:

- *Te Ao Māori interim research group leader Selwyn Insley welcomed guests to Te Whare Nui o Tuteata.*
- *AgResearch chief executive Sue Bidrose talked about the work the CRI was doing in the Bay of Plenty.*
- *Science New Zealand chief executive Anthony Scott, left, with Hēmi Rolleston.*
- *Scion chief executive Dr Julian Elder speaking to guests.*
- *Invited guests included Rotorua mayor Tania Tapsell.*
- *Representatives from businesses, councils and iwi were invited to the evening function.*
- *Dave Binnie from Tūaropaki Trust, left, speaks with James Stevenson-Wallace from Manaaki Whenua Landcare Research.*
- *GNS Science chief executive Chelydra Percy.*
- *Matetu Herewini from Te Rūnanga o Te Whānau a Apanui.*

The future is based in biology

Scion is leading New Zealand in fermentation technology, using bacteria and yeast to convert industrial waste streams and greenhouse gases into high-value products.

Scientific breakthroughs in the study of nature and how to mimic it have fuelled a biotechnology revolution. Scion is leading the way for New Zealand in this area and supporting industry to solve some of the world's biggest environmental challenges.

Nature is the ultimate designer, thanks to evolution, demonstrating the fundamental adapt-or-die philosophy that underpins the very essence of life.

Why is this more relevant than ever? Because globally we are facing environmental threats never seen in our history. And currently, our reliance on fossil fuels and petrochemical resources for medicine, food security, fuel and energy are absolute.

The ultimatum we and the climate are currently facing has given rise to the biotech revolution, fuelled by an ever-increasing understanding of biology at a molecular level. And not a moment too soon.

Biotechnology is biology wrapped in engineering principles. And it isn't just a buzz word – biotech is a critical tool in our fight against climate change and preserving our way of life for the future.

It encompasses a wide range of areas that will allow us to transform global and local economies through wide-spread innovation, tackling challenges in food and fibre production, and creating the potential to engineer and produce new bio-sourced products, ingredients and materials – including invaluable new medicines and therapies.

This, combined with using local feedstocks and waste streams, will help combat climate change, safeguard supply chains and create a more sustainable, circular bioeconomy.

> "We are growing our capabilities and investment in people and infrastructure to be the research partner industry needs."
>
> ALEC FOSTER

The role of industry

The need to find alternatives to fossil fuels is imperative. And the area that will have the most impact will be in the industrial biotech space. Why? Scale baby, scale.

With 97 million barrels of fossil fuel produced every single day world-wide for chemicals, polymers and fuel, solutions need to be at scale, or the impact just won't be big enough, or quick enough.

Industry itself is increasingly working towards addressing the climate crisis, minimising carbon and waste emissions, and finding alternatives to petrochemicals and fossil fuels. As the world looks for greener, more sustainable solutions, industrial biotech becomes even more critical.

In New Zealand, there are several companies recognising this emerging opportunity and working hard in this space.

Scion also sees the critical role biotech at scale will play and is investing heavily in both infrastructure, capabilities and people to work alongside industry for change.

Scion's biotech focus

Industrial biotech is going to be the primary mechanism to replace petrochemical-derived products, with a big focus on scale, commodity materials and products, as well as low-cost, high-volume feedstocks.

This is a key focus for Scion as it responds to the needs of industries looking to deliver bio-based products and ramp up production.

There has been increasing investment in the development of bioplastics, bioconversion of organic waste materials, conversion of C1 gases (carbon dioxide, carbon monoxide and methane) into useable products, and scaling fermentation processes.

A number of commercial partnerships have been developed with exciting Kiwi companies and start-ups working in these areas, to help prove the technology and assist in scale-up.

Scion scientists have been working alongside many of these partners in the lab to help development – highlighting a seismic shift in how Scion works with industry.

Experienced team

Scion is leading New Zealand in the biotech space under the experienced stewardship of Dr Alec Foster, who heads Scion's bioproducts and packaging portfolio.

Foster oversees research with nearly 100 companies, as well as large internal research projects.

He brings a wealth of experience in the synthetic biotech and genetic engineering space. With a professional background spanning both Europe and the United States, he formerly oversaw one of the world's largest industrial biotechnology research programmes.

PhD student Jorge Campos has joined Scion's team, working in gas fermentation and novel microbes.

Scion's investment in automated fermentation equipment is accelerating the research pipeline to commercialisation.

"My goal at Scion is to use biotechnologies to protect New Zealand. Industrial biotechnology is also one of the biggest ways in which we're going to meet our sustainability targets and is the only viable option for producing bio-based plastics and petrochemical alternatives that will create real impact, at scale.

"In a petrochemical society, we rely on oil for medicines, plastics, energy – we need to shift away from that."

Scion microbial biotechnology team lead Christophe Collet also plays a pivotal role.

Before joining Scion eight years ago, Collet led fermentation operations for LanzaTech, involving the development and scale-up of fermenting carbon monoxide (specifically from steel mill waste gases) into chemicals such as ethanol. LanzaTech is now home to the most successful carbon recycling technologies on the planet.

Investing in capability

Working closely together over the past 18 months, Scion's industrial biotech portfolio has grown exponentially. The team has expanded, there's been investment in new automated fermentation equipment and there are ongoing efforts to expand the laboratories.

> "We see great value going forward with Scion, not just for creating sustainable aviation fuel, but how we can repurpose forestry residues into other sustainable fuel products."
>
> SEAN SIMPSON, LANZATECH

All in the hopes of accelerating the research pipeline to commercialisation.

Scion is leading New Zealand in fermentation technology, which uses bacteria and yeast to convert industrial waste streams and greenhouse gases into high-value products.

Scion has recently invested significantly in capability to allow more optimisation at a smaller scale with Sartorius ambr 250ml bioreactors, resulting in faster scale-up pathways.

Sartorius is considered the gold standard of bioreactors and Scion's are the only ones available in New Zealand for commercial use.

"We have the only lab in New Zealand that uses Sartorius fermentation units at multiple scales – 250ml, 10L, 100L," Foster says.

"This means methods, processes and optimisations can be transferred reliably not only within the lab, but between most leading labs internationally. It also has a benefit of technology transfer as processes can be scaled up with far greater predictability."

Scion's bioreactors are currently booked up six months in advance, with demand only growing from industry.

Scion is not only looking to support research but ensure impact.

"One big challenge for New Zealand is transferring research from the laboratory to creating impact at scale. CAPEX investment is too great a risk," Foster says.

"We are working with government and industry to change this, investing in capacity and partnerships to help de-risk and prove the technology. We are connecting New Zealand companies to world-leading organisations."

Working alongside industry

Foster's involvement has helped bring a more commercial aspect to the science. This, combined with the depth of growing expertise within the team, has resulted in several new commercial partnerships.

Scion is currently working alongside two companies to help secure funding bids and build pilot-scale plants in New Zealand, with another five commercial science and research partnerships currently in place.

One such partnership is with Plentyful, set to scale up production of PHAs (polyhydroxyalkanoates – biopolymers with similar characteristics to petroleum-derived polymers), turning organic waste from industry into bio-based materials like plastics and resins, as an alternative to oil-based plastics.

Scion is working alongside Plentyful to establish a pilot-scale plant in Marton, utilising significant waste streams from food, viticulture and wood.

> "The move to working with Scion has enabled us to access the technology and expertise for larger biotech processing, which was needed to produce more material to work with for prototyping."
>
> ANDY HERBERT, HUMBLE BEE BIO

Managing director Jayden Klinac says Scion and Plentyful are aligned with research that supports the development of New Zealand's circular bioeconomy.

"At Plentyful, we envision a New Zealand where technology meets sustainability, turning yesterday's waste into tomorrow's resource.

"Partnering with Scion, we're scaling innovations that promise a cleaner, resource-efficient future, ensuring 'waste' becomes a word of the past for the coming generations."

Scion is also working with geothermal research and innovation company Upflow to build a pilot-scale plant that turns carbon dioxide and methane emissions into animal feed.

Synergy in science

This year has also seen Scion develop a working relationship with Humble Bee Bio, a biotech company designing and commercialising biomaterials from a protein produced by bees.

Humble Bee Bio technical director, Andy Herbert, says the company is on a mission to develop biomaterials for a range of applications where petrochemicals are currently being used.

"We aim to create high-performance, renewable and biologically derived materials that replace and displace those currently produced from petrochemicals.

"As a society, our scale of consumption is enormous. We need solutions to be at scale as well. If New Zealand wants to do things in this space we need to find ways to think at scale and attract the investment required to do that.

Biotech is a critical tool in our fight against climate change.

LanzaTech co-founder Sean Simpson is partnering with Scion to tap into world-leading expertise in repurposing forestry residues into sustainable fuel products.

"Scion is the leading organisation in New Zealand in terms of thinking and science around this, understanding the need to move from development in the lab, through to prototyping, demonstration and eventually commercialisation."

Humble Bee Bio looks specifically at a novel structural protein produced by a species of solitary bee, in the form of a 'silk' which it uses to wrap its larvae in while they pupate (grow). The silk has similar characteristics to cellophane.

The partnership with Scion came about in 2023, and Herbert says it has "put a rocket under the prototype process".

After establishing the protein chemical story of the bee and its silk, and what genetic information could be translated into producing proteins for particular materials, the last 12 months have been about prototyping.

"The move to working with Scion has enabled us to access the technology and expertise for larger biotech processing, which was needed to produce more material to work with for prototyping."

Herbert says end products could be used for things such as coatings, fibres and films.

> "The opportunity for New Zealand is to use what we have in abundance – like wood fibre, for example. That not only adds value to waste streams but creates domestic economic security."
>
> SEAN SIMPSON, LANZATECH

"The work we've done with Scion has unlocked the ability to make prototypes at scale, which has been pivotal in moving us towards being able to more quickly test materials and their performance."

Working with Scion has provided the flexibility, knowledge and collaboration that complements Humble Bee Bio's expertise and ethos, he says.

"It's been a hand-in-hand piece of process development, which speaks to the flexibility of both organisations."

Outcomes at scale will be king

LanzaTech co-founder and one of the world's most successful biotech entrepreneurs, Dr Sean Simpson, says the urgency around scaling up and normalising sustainable industrial production systems is palpable.

"Climate change is now literally killing people. We've got to change the system. You never change a system by fighting it, we've got to change it by coming up with a new system that works better.

"Biotech will underpin big industrial outcomes and greater security of supply – especially for New Zealand.

Scion's biotechnology team (back row from left) Alyesha Candy, Tasman van der Woude, Diahanna O'Callaghan, Sumanth Ranganathan and Reid Dale; (front row from left) Carla Cronje, Nabangshu Sharma, Christophe Collet, Jessica Harris and Alec Foster.

"There are a lot of biomass and waste resources in New Zealand that we're not adding value to. That resource could be used to create other industries domestically, as well as securing domestic supply chains and key resources."

LanzaTech and Air New Zealand have recently partnered with Scion to investigate the creation of a sustainable aviation fuel production facility here in New Zealand, using forestry residues.

"Working with Scion gives us world-leading expertise in this space, where the residues are and how to think about the likes of costing. The more bankable proposition we can present, the more likely it will lead to a commercial outcome.

"We see great value going forward with Scion, not just for creating sustainable aviation fuel, but how we can repurpose forestry residues into other sustainable fuel products.

"We need a greater focus on execution, scale-up and pathways to commercialisation. It's all about creating outcomes."

This is supported by Scion's portfolio leader and world biofuels expert Paul Bennett, who is leading the Sustainable Aviation Fuel (SAF) research.

Bennett says working with a range of companies, including LanzaTech, demonstrates how connected the research across Scion is.

"Biotech spans the high volume, low value to low volume paradigms."

Foster says that is the role Scion is stepping up to play in New Zealand – enabling industry to translate better technologies and scale-up to commercialisation domestically.

"We are growing our capabilities and investment in people and infrastructure to be the research partner industry needs."

Looking local

Global scale leads to conversations around feedstocks and the need for keeping it local – not only for minimising carbon emissions.

Simpson says feedstock is what countries and industry need to focus on to develop sustainable systems for creating alternative fuels and chemicals.

"The opportunity for New Zealand is to use what we have in abundance – like wood fibre, for example. That not only adds value to waste streams but creates domestic economic security."

Keeping it local will also contribute to sustainable GDP growth, high-value regional jobs and a significant reduction in CO_2 equivalents.

Where to from here?

Biotechnology is creating a paradigm shift and it's critical New Zealand keeps up with the rest of the world.

But Foster acknowledges that we can't do it all.

"We're too small and the cost is too great."

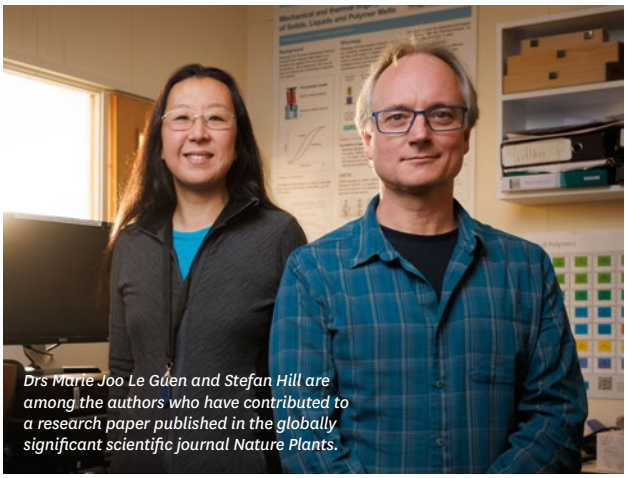
Building solid relationships globally will ensure New Zealand has access to the very latest in research and technology. This, alongside further investment within the organisation, are key drivers for Scion in accelerating research and capabilities for New Zealand.

Care to be part of the [r]evolution?

To learn more about how Scion's biotechnology research can support your organisation's goals, please contact alec.foster@scionresearch.com.

Prestigious publishing honour

Two leading researchers have earned the equivalent of an Olympic gold medal in the world of science.



Drs Marie Joo Le Guen and Stefan Hill are among the authors who have contributed to a research paper published in the globally significant scientific journal Nature Plants.

Drs Marie Joo Le Guen and Stefan Hill are among the authors who contributed to a research paper published in the scientific journal *Nature Plants* – one of the most respected scientific journals in the world. *Nature* covers a wide range of disciplines, and its articles are known for their high impact and global significance.

Becoming a published author in any of the *Nature* journals is considered highly prestigious in the academic community – an achievement not lost on the Rotorua researchers.

"Getting into *Nature* is something you hope for," says Hill, Scion's portfolio leader for High Value Biorefineries. "As a group, we submitted the manuscript earlier this year and, as with most journals, the reviewers were very picky, but this process felt like it was next level.

"They question all aspects of the science, so when you finally receive an email that tells you your manuscript has been accepted, you feel elated. It's nice to see that our science is of a level that is deemed worthy of being included in a journal like *Nature*."

Their research paper, titled *Ectopic callose deposition into woody biomass modulates the nano-architecture of macrofibrils*, was led by Dr Matthieu Bourdon of the University of Cambridge, and involved 33 researchers from more than 20 universities or research organisations around the world.

The research showed how trees could be genetically modified to produce wood that is easier to process into biofuels and chemicals that can replace those made from fossil fuels. They did this by genetically changing the trees so they produced more of a type of sugar called callose in their wood. The Scion scientists were able to develop and apply new methods to help confirm if the changes were working in the way the scientists hoped.

Hill said Scion was approached by Bourdon following previous work with another researcher on the University of Cambridge-led team.

"Matthieu contacted us because the team needed to understand how genetic modifications had changed the walls of cells in the trees' wood. They needed to know whether modifying the trees to produce more callose in their cell walls changed the size and distribution of nanometer-scale pores in those cell walls.

"Trees have evolved strong cell walls so they can grow tall. While this is a smart idea if you're a tree, it makes it hard for us to break wood down and turn it into chemicals that can replace those made from the petroleum industry."

The team needed to know whether callose was causing the changes in the wood that would make it easier to process.

Hill and Le Guen used a technique called differential scanning calorimetry to precisely measure how changes in the freezing point of water in the wood samples related to the differences in nano-pore size and distribution resulting from the genetic changes to the trees. The pair's results ultimately supported the overall outcomes of the research.

International collaboration

Le Guen says the experience shows that Scion can collaborate with the top tier universities in the world.

"Cambridge University is still the number one university globally, and they invited us to participate, which is wonderful recognition of our science capabilities at Scion, as well as an opportunity to learn from the best.

"What's more, the analysis work we've set up from this project is really useful for all the other science that Scion is doing. It gives us a whole new way of looking at cell wall architecture, which complements all our work to understand biomass better.

"This is critical to our mission to support New Zealand's transition to a circular bioeconomy."

Another benefit is that it has opened further collaboration with Biomata, a new international associated laboratory, led by Scion and French research organisation INRAE.

Bourdon says Scion's research was an essential part of the overall study.

"We managed to genetically introduce callose into wood, but our prior analysis surprised us by suggesting that this polymer did not interact with other wood components. However, some experiments showed that the modified wood was able to absorb more water, which we thought could be because we had also changed the wood's nano-pores.

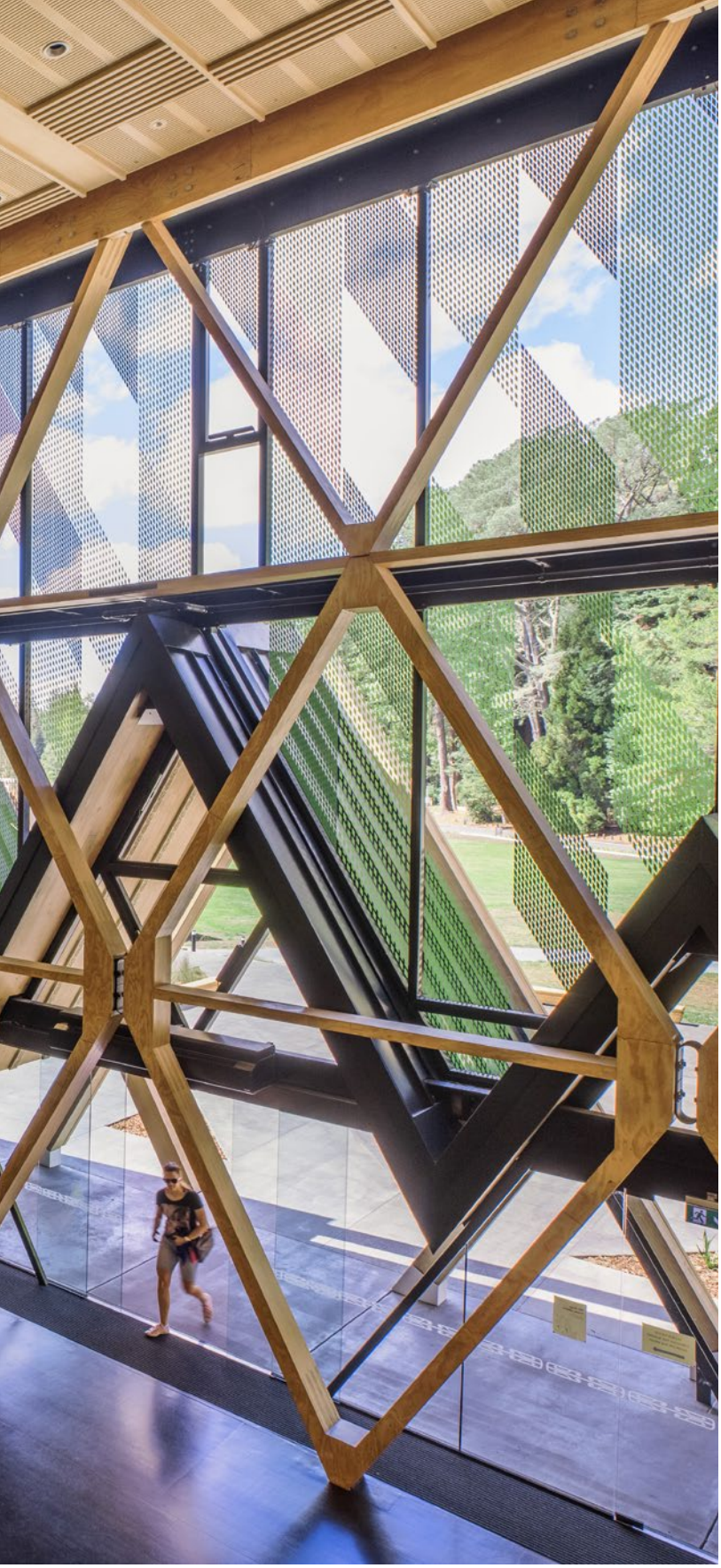
"From there, the collaboration with Scion was paramount to experimentally confirm this hypothesis and nail down the physical effect of callose introduction on the engineered wood ultrastructure. This final piece of data allowed us to finalise our model of action describing how callose introduction can mediate an increase in wood digestibility for wood biorefinery pipelines."

Nature has been publishing in the United Kingdom since 1869. The journal has a long and prestigious history of featuring ground-breaking scientific research. Just as winning an Olympic gold medal is the pinnacle of athletic success, so is publishing in *Nature* for scientists. Both achievements represent reaching the very top of their respective fields.

Global significance

of Te Whare Nui o Tuteata recognised

> Te Whare Nui o Tuteata building represents a global shift in the way buildings can be designed, prefabricated, assembled, and disassembled.
>
> JUDGE'S NOTES, NEW ZEALAND TIMBER DESIGN AWARDS



Sustainable Development Award winner Te Whare Nui o Tuteata.

Scion's timber innovation hub shines a light towards the future of timber construction in NZ, award judges say.

Scion's award-winning timber innovation hub, Te Whare Nui o Tuteata, has been given another tip of the hat, this time at the New Zealand Timber Design Awards.

The prestigious awards, now in their 48th year, are run by Timber Unlimited and highlight the latest advances in New Zealand's timber construction capability. The winners of the 12 categories, plus a supreme winner, were announced at a gala dinner in Auckland on November 2.

Te Whare Nui o Tuteata won the Sustainable Development Award and was highly commended in the Innovation Timber Engineering Award category won by Nelson Airport.

The Sustainable Development Award celebrates buildings that have achieved low environmental impact and enhance New Zealand's unique society and environment, while the Innovation Timber Engineering Award honours engineering and construction innovation that maximises the use of timber with exciting solutions.

Judges for the Sustainable Development Award sang the praises of the building designed by Irving Smith Architects, RTA Studio and Dunning Thornton Consultants.

"[The] building represents a global shift in the way buildings can be designed, prefabricated, assembled, and disassembled," one judge noted.

"The timber diagrid structure provides a visual aesthetic that brings warmth and expression to the interior."

The second judge said: "This building shines a light towards the future of timber construction in Aotearoa New Zealand and will help pave the way for ways of designing and building with wood that make use of a wide range of materials and available technology for creating timber buildings."

A judge in the Innovation Timber Engineering Award category said the highly commended Te Whare Nui o Tuteata was of "global significance".

"The innovative structural engineering design of this project is based on a deep understanding of timber properties and how timber buildings can be prefabricated and pieced together to form extraordinary buildings."

Another said the building "set out to explore the frontiers of timber engineering".

"The Scion building serves as an exemplar of how timber engineering innovation can ensure the sustainable use of the valuable renewable resources that forests provide for building our future."

Te Whare Nui o Tuteata means the great house of Tuteata. Tuteata is the ancestor of the three hapū who are tangata whenua here – Ngāti Hurungaterangi, Ngāti Taeotu and Ngāti Te Kahu – and the hapū gifted the name to Scion.

The building, officially opened in 2021 by then Prime Minister Jacinda Ardern, has pioneered sustainability and design using engineered wood products and won several domestic and international awards. The design uses a diagonal-grid (diagrid) timber structure, and was embodied-carbon neutral at completion.

This year, Scion sponsored the new Hybrid Building category in the NZ Timber Design Awards, celebrating buildings using timber in combination with other materials.

The category was won by Nelson office Wall-E designed by Irving Smith Architects using timber and concrete to maximise the natural inherent qualities of the individual materials.

Judges said the building was "an outstanding example of ingenuity" that "elevates simplicity to a level of sheer elegance".

The awards are hosted by Timber Unlimited, which is funded by MPI and supported via a consortium including BRANZ, NZ Timber Design Society, Scion and the Wood Processing Manufacturers Association.

Innovation Timber Engineering winner Nelson Airport. Photo: Jason Mann.

The winners

Residential Design, Single Family Dwelling:	Studio house by William Samuels Architects (Nelson)
Residential Design, Multi-Unit Dwellings (< 3 storeys):	90 Carrington Rd by RM Designs & Engco (Auckland)
Commercial & Public Building Design:	Green School – Kina by Boon (Taranaki)
Mid-rise Building Design:	Clearwater Quay Apartments by Pacific Environments (Christchurch)
Interior Design:	Learning from Trees by Andrew Barrie Lab (offshore)
Exterior Structure Design:	Horoeka by David Trubridge (Rotorua)
NZ Specialty Timber Award:	Te Rau Karamu Marae by Architects and Te Kahi Toi (Wellington)
Sustainable Development Award:	Te Whare Nui o Tuteata – Scion Timber Innovation Hub by Irving Smith Architects, RTA Studio and Dunning Thornton Consultants (Rotorua)
Hybrid Building Award:	Wall-E by Irving Smith Architects (Nelson)
Innovation Timber Engineering Award:	Nelson Airport by Studio Pacific Architecture, Dunning Thornton, Gibbons Naylor (Nelson)
Innovative Timber Manufacturing & Technology:	Lightweight Timber Research Structures by Andrew Barrie Lab & Batchelar McDougall
Student Design Award:	The Vertical Stage by Gregory Mann (independent)
Supreme Award:	Green School – Kina by Boon (Taranaki)

Early success
for expanded use for young tōtara

Thermally modifying tōtara to increase durability opens new doors.

Scion senior technologist Rosie Sargent.

It could only be a matter of time before a locally grown indigenous and specialty wood species is seen on the outside of iconic buildings in Aotearoa if early research results are anything to go by.

Scion scientists have been researching whether thermally modifying tōtara could enhance its durability enough for exterior building uses, opening the door for a wider range of products and applications.

Thermal modification is a well-established method in which timber is heated to high temperatures without oxygen. The process enhances wood dimensional stability – meaning it shrinks and swells less with changes in moisture content. A high degree of modification can increase wood durability making it more likely to be suitable for exterior uses like cladding and decking.

Radiata pine is not naturally durable but has been successfully thermally modified to increase durability and this product has been commercialised for cladding.

Scion's research into thermally modified tōtara began around 2017 using relatively young trees from Northland – about 80-years-old.

Tōtara (*Podocarpus totara*) was chosen because it has natural durability and tests have been done with both the generally non-durable sapwood – living, outermost portion – and potentially durable heartwood – dead, inner wood.

Testing is also being done on the exotic species Mexican cypress (*Cupressus lusitanica*).

Scion senior technologist Rosie Sargent says while any thermally modified species will have some improved durability, tōtara and lusitanica have been the most successful to date. To get sufficient durability for New Zealand conditions, the wood must be modified at very high temperatures.

"It's a question of does it perform for specific applications and can you do it without destroying the wood."

After thermal modification, the wood is tested for durability using long-term accelerated field tests and fungus cellar stakelet trials. The tests are chosen with the aim of being able to assess if the product can meet building and durability standards.

The fungus cellar creates ideal fungus growing conditions to speed up decay. Small wooden stakelets are left in the controlled high-decay situation and the level of decay is assessed over time and can be compared to the performance of known products.

The stakelets remain in test until all are rotted away. The thermally modified tōtara has been in the fungus cellar for about six and a half years, and the lusitanica for more than three years. In comparison, untreated radiata pine stakelets can severely decay in as little as six months.

In the field, durability testing is being done on accelerated decking and L-joints made from thermally modified tōtara and lusitanica as per international testing protocols.

> "We're finding that it increases the durability of both the sapwood, which isn't durable at all, as well as the heartwood which is."
>
> ROSIE SARGENT

Both species have been in field testing for about two years. Tests can take anywhere from five to 10 years and non-durable wood such as radiata sapwood will fully decay much quicker.

While testing in both the field and fungus cellar is ongoing, early results are positive, Sargent says.

"We're finding that it increases the durability of both the sapwood, which isn't durable, as well as the heartwood which is."

Interim portfolio leader (Trees to High Value Wood Products) Elizabeth Dunningham says it is important to have data about indigenous products and trees to make good planting and product development decisions, as existing data is limited. She says there were also strategic reasons for choosing tōtara.

Scion is directly involved with Taitokerau Māori Forestry Inc. as partners in the Tōtara Industry Pilot. This resulted in new markets for the farm-based tōtara, with the view of developing a regional industry.

Chairman of Taitokerau Māori Forests Inc, Ernest Morton, says the group supports Scion's work: "Tōtara haemata (Lofty leader). He Rākau Rangatira o te Ngahere (Chief of the Forest)."

For more information contact rosie.sargent@scionresearch.com.

Bridging the gap

Waitaki District Council's existing Waitaki Bridge during flooding in July 2022.

Scion's role in Waka Kotahi New Zealand Transport Agency's carbon zero mission.

Achieving New Zealand's net carbon zero goals by 2050 requires looking at every aspect of life – even the roads we drive on.

And work that Waka Kotahi New Zealand Transport Agency is doing with support from Scion and other industry partners could help bridge the gap between where we are and where we need to be by 2050.

For the first time in 50 years, Waka Kotahi is piloting the construction of timber bridges, representing an exciting step in its transition to a low-carbon transport system.

Waka Kotahi chief engineer Sulo Shanmuganathan says the organisation's vision is for a low carbon, safe and healthy land transport system and Scion's knowledge about the durability and longevity of Glulam – glue laminated timber made by gluing layers of boards together – has been key to informing the timber bridge pilot and helping achieve its wider vision.

"Through the government's Carbon Neutral Government Programme, we are focused on playing our part to accelerate emissions reductions in the public sector by lowering our embodied carbon materials and using more sustainable construction options than what we conventionally used," she says.

"The mahi we're doing with Scion is very important because the far-reaching positive impacts of using more sustainable materials will benefit both the community here and now and will carry forward for future generations.

"We want the right people involved and of course Scion is very important for the development of timber bridges because they already have the depth of expertise and research developed over more than 70 years."

Scion's Tripti Singh and Dave Page advised Waka Kotahi on the durability of preservative-treated Glulam in New Zealand. Preservative-treated, radiata pine, glue laminated bridge beams have been in service for 60 years in New Zealand and show few problems with durability associated with decay.

Shanmuganathan says these findings gave Waka Kotahi confidence in Glulam and the ability to press ahead with its wooden bridge pilot.

Any bridge would likely take a hybrid approach combining other materials for fixing.

"Long term we want to see Glulam readily available and designers capable of using the product and timber like they use other conventional materials. Raising awareness in the sector for designers and construction is crucial for us as we transition to a low carbon, climate resilient transport system that will create a better tomorrow for us all," she says.

Timber is also lightweight and more sustainable as it can be sourced locally.

> Scion is very important for the development of timber bridges because they already have the depth of expertise and research developed over more than 70 years.
>
> SULO SHANMUGANATHAN, WAKA KOTAHI

Collaboration is key

A timber bridges focus group has been formed with Scion, the Scion-managed Timber Unlimited brand, Timber Design Society, and government ministries. The group meets quarterly and earlier in the year members visited Norway to learn more about timber bridges at the World Conference on Timber Engineering.

Waka Kotahi was also invited to a meeting of government agencies about barriers, opportunities, activities and possibilities for collaboration regarding using timber in the built environment.

Singh, who leads timber durability research at Scion part-time, says interacting with industry professionals in the timber focus group with Waka Kotahi has been "incredibly rewarding and enriching".

"It has allowed the exchange of valuable knowledge and insights."

Shanmuganathan says there has already been plenty of interest in timber bridges with designs for Onetai Bridge between Paeroa and Kōpū due to go out for tender for construction. It will be the first bridge built using timber in New Zealand in 50 years.

Councils are also interested. Waitaki District Council has a 120-year-old timber bridge due for renewal and would prefer replacing it using materials, such as timber, that have a resilient history and may perform for another 120 years.

Council major transport projects project manager Mike Harrison says the council included the bridge renewal in its 2024-2027 National Land Transport Plan funding application and is engaging a design consultant to explore options that deliver a whole of life best value and cost-effective structure.

"While the build funding is not locked in yet, council and Waka Kotahi are investing in the design and consenting phase to become a deliverable project, as shovel ready as possible.

"This project is of a scale where all the industry partners can gain experience and knowledge for the future. Learning from the past where materials and workmanship has stood the test of time will inform future decision making."

Statement architecture

Scion Forest to Timber Products general manager Henri Bailleres says timber bridges have the potential to be "one of the most impactful showrooms for timber in the country".

"The engineering requirement is extreme. Materials have to survive for 100 years, they have to bear dynamic load and they are exposed to many hazards. If we can make timber bridges, we build proof of the high value of timber as a construction material."

Scion principal researcher Doug Gaunt says timber bridges provide an opportunity for creative and statement architecture.

"Everything we do to trap a bit of carbon from the atmosphere into permanent structures is a good thing."

Timber Unlimited technical manager Bjorn Stankowitz was in the group that travelled to Norway.

He says the group toured bridges in Europe looking at structures and durability and spoke with overseas practitioners to inform Waka Kotahi.

He says if proper maintenance plans and protective detailing are used, wooden bridges are extremely durable.

They also pulled together a "bridge CV" containing statistics and specifications of multiple bridges for comparison purposes.

"That gives a good idea of the difference in approach to certain structural systems and ways to approach durability."

Scion's Forests to Timber Products lead Henri Bailleres with NZTA chief engineer Sulo Shanmuganathan.

Solution to widespread problem vital

Scion senior technologist Sean Taylor says a solution to CCA timber is vital.

Scientists believe there could be a future for CCA timber at the end of its useful life.

Every year, thousands of tonnes of CCA-treated timber are sent to secure landfills.

There are currently limited disposal options for the timber, which has been treated with a mix of copper, chromium and arsenic.

One of the most widely used wood preservatives worldwide, chromated copper arsenate (CCA) enhances the durability of wood, meaning timber products are more resilient to decay and insect attack.

It is commonly used in construction, landscape gardening and horticulture with hundreds of CCA-treated posts per hectare in vineyards.

But at the end of its life the wood has limited reuse value and, due to environmental challenges with the treatment components like arsenic, limited disposal options.

Incineration or pyrolysis is technically challenging. Most of it goes to secure landfills. Exactly how much is sent to landfill is hard to quantify because CCA makes up a portion of demolition waste which is often unsorted. A 2021 Ministry for the Environment report showed almost three million tonnes of class 2 to 5 waste is sent to landfill each year. Construction and demolition waste could be in classes 2-4 and contain CCA timber.

Scientists at Scion have been researching removing CCA from treated timber at the end of its life and separating it into individual elements.

Senior technologist Sean Taylor discovered there could be a way to remove CCA from the timber in 2015 and began research to find an efficient removal process.

By 2017 he had figured out how to remove it from up to about 350 kilograms of hogged (shredded) timber at a time, achieving 95% removal at both bench and pilot scale.

The early successes led to a $163,000 Waste Minimisation Fund grant to continue investigating the feasibility of remediating treated timber.

Taylor has made good progress removing CCA and recovering the copper and arsenic, but more work needs to be done recovering individual elements – particularly isolating a high enough percentage of chromium.

“The issue became how can we get the metal components out and how can we isolate them individually?” Taylor says.

While a future use for the remediated timber and recovered elements would need to be determined by users, once successfully isolated, the elements could then be reused in things like electronics or compound metals, keeping them in the circular bioeconomy.

"If you're just taking it out of the timber and putting it into a bucket, you're just moving the problem around."

Funding the solution

Taylor says a solution to CCA timber is vital because putting it in the landfill or worse, burning it without suitable technology and infrastructure, is "not the wise or right thing to do long term".

Taylor, and Distributed and Circular Manufacturing portfolio leader, Marc Gaugler, hope by showing industry that CCA removal is possible there will be interest in funding the solution to the problem.

Gaugler says we need to find solutions that align with circular bioeconomy goals, make the most of resources and recover materials.

"Because it's CCA-treated it's not going to degrade in many, many decades – that is why we make it. However, it's an organic material going into landfill," he says.

"Scion's Circular Manufacturing programme aims to show wood materials can go into circularity beyond burning … We can use new technology to solve hard and old challenges."

Gaugler says Scion has shown there are end-of-use options for CCA-treated timber, but it needs to happen on a large scale. The question is who pays for resource recovery and waste management addressing the issue and adding value by eliminating a problem.

Taylor and Gaugler suggest selling recovered timber and chemicals could be a way to offset processing costs, and mobile technology would avoid the need to ship waste timber for processing.

Around the world, other countries have already stopped or restricted the use of CCA or established viable disposal options.

Ministry for the Environment's Waste and Resource Efficiency director Shaun Lewis says the ministry is focused on initiatives that enable the Emissions Reduction Plan 2023-2025 actions and the current Waste Strategy. For end-of-life wood products, this centres on reducing and diverting construction and demolition waste from landfill towards more beneficial uses.

> "If you're just taking it out of the timber and putting it into a bucket, you're just moving the problem around."
>
> SEAN TAYLOR

"The ministry is collaborating across government and with industry on reducing construction waste, recovering resources, and exploring more circular options for construction materials.

"There is a particular focus on treated and non-treated timber and addressing the challenge of separating these processed wood products at the end of their life to enable more circular end-of-life options from a waste hierarchy lens."

He says Scion's work, supported by the Waste Minimisation Fund, helped address some of these challenges.

For more information contact marc.gaugler@scionresearch.com.

The CCA treated timber, right, can be remediated to keep it in the circular bioeconomy.

Tissue culture
for the 21st Century

Scion is rewriting the rulebook on tree propagation, ushering in a new era for forestry. It's a world where trees are beginning their lives in a lab and where scientists are harnessing the power of AI and machine learning to boost productivity. Buckle up because the future of forestry has arrived.

The current approach to propagating forestry trees as varietals to deliver the very best trees into our forests is a labour-intensive exercise. Scion is partnering with Forest Growers Research (FGR) and industry on the *Tissue Culture Techniques for the 21st Century Forests* project which uses somatic embryogenesis as a reliable propagation method to ensure consistent results.

Scion has a long history of growing plants from seed, and propagation techniques that create new plants from cuttings, grafting and layering. This project is exploring the potential of how we can create new trees by growing plant cells in culture in a petri dish – a process that doesn't require seeds to germinate. Scientists working in Scion's tissue culture labs are using a technique called somatic embryogenesis that is playing a critical new role in clonal propagation for woody plants. The research is advancing knowledge to help improve ways the forestry industry can rapidly grow new trees from proven and high-performing genotypes.

Scion's science lead on the project, Dr Jana Krajňáková, explains there is an urgent need for cost-effective, efficient tree vegetative propagation (bio)technologies for supporting the development of precision forestry, and delivery of forest products and services.

The FGR-led programme is funded by the Forest Growers Levy Trust (FGLT), MBIE, and Strategic Science Investment Fund, and aims to produce a reliable and cost-effective tissue culture

Pinus radiata micro plugs propagated via tissue culture.

process by using bioreactors and other high productivity systems to quickly produce small, rooted plantlets. The work will make dramatic improvements in the delivery of genetic gain and future biotechnology developments into tree stock.

Tissue culture and somatic embryogenesis

Somatic embryogenesis is a process that takes immature embryos, formed after pollination, from green cones. These embryos are then induced to produce masses of cells which contain many tiny somatic embryos. The embryogenic mass that originated from one immature zygotic embryo is called a cell line. These cell lines can be encouraged to form mature embryos that develop into seedlings which are acclimatised to nursery conditions and finally planted in the forest. This process is an extremely attractive option for the rapid reproduction of genotypes with proven performance.

Each tree species and cell line (genotype) within a single species requires its own set of instructions to get to the end goal – a robust plant.

Krajňáková stresses the complexity of figuring out the best conditions for a multitude of different cell lines.

"Tissue culture can be considered advanced cooking – it is more art than science."

The current approach for somatic embryogenesis starts with a cell line and uses a semi-solid media for supplying the required nutrients. A potentially more efficient approach with liquid media in bioreactors is also being explored.

Temporary immersion bioreactors

Scion is the first institute to be investigating temporary immersion bioreactors for *Pinus radiata*. Using these bioreactors is a step towards automation and scale-up; instead of manually transferring somatic embryos between petri plates, the embryos grow in a liquid media in the bioreactors. Temporary immersion bioreactors of coniferous somatic embryos are not well studied. Scion has tried *Pinus radiata*, redwoods, and Douglas fir in the bioreactors; redwoods are the most promising at this stage.

A new germination protocol

Scion tissue culture scientist Cathie Reeves has successfully developed a simplified propagation protocol that condenses the germination phase from five weeks to 10-14 days. The results showed greater survival rates and quality of the plants, which validates the shortened protocol – leading to reduced costs.

Reeves says "better quality plants mean better overall survival because the costs due to loss of plants is reduced".

"We are also looking at ways of further reducing the timing and even removing an entire step involved in the process, which would further reduce costs."

Krajňáková says one of the key outcomes is the relationship and development of trust between Scion and our industry partners in working with cell lines.

"Sharing the results with partners so far, our approach has created more openness," she says.

> "Sharing the results with partners so far, our approach has created more openness."
>
> CATHIE REEVES

FGR *Tissue Culture Techniques for the 21st Century Forests* programme manager Russell Burton says the project is building the industry's body of knowledge. "The more sharing we have, the more we all learn and the more New Zealand increasingly gains from the programme."

In the current *Pinus radiata* somatic embryogenesis process, the resilience of tissue-cultured plants, when transferred to the nursery, is poor. Root systems are often a limiting factor for their clonal deployment potential due to scarcity of roots, cessation of their growth and unbalanced architecture.

Machine learning

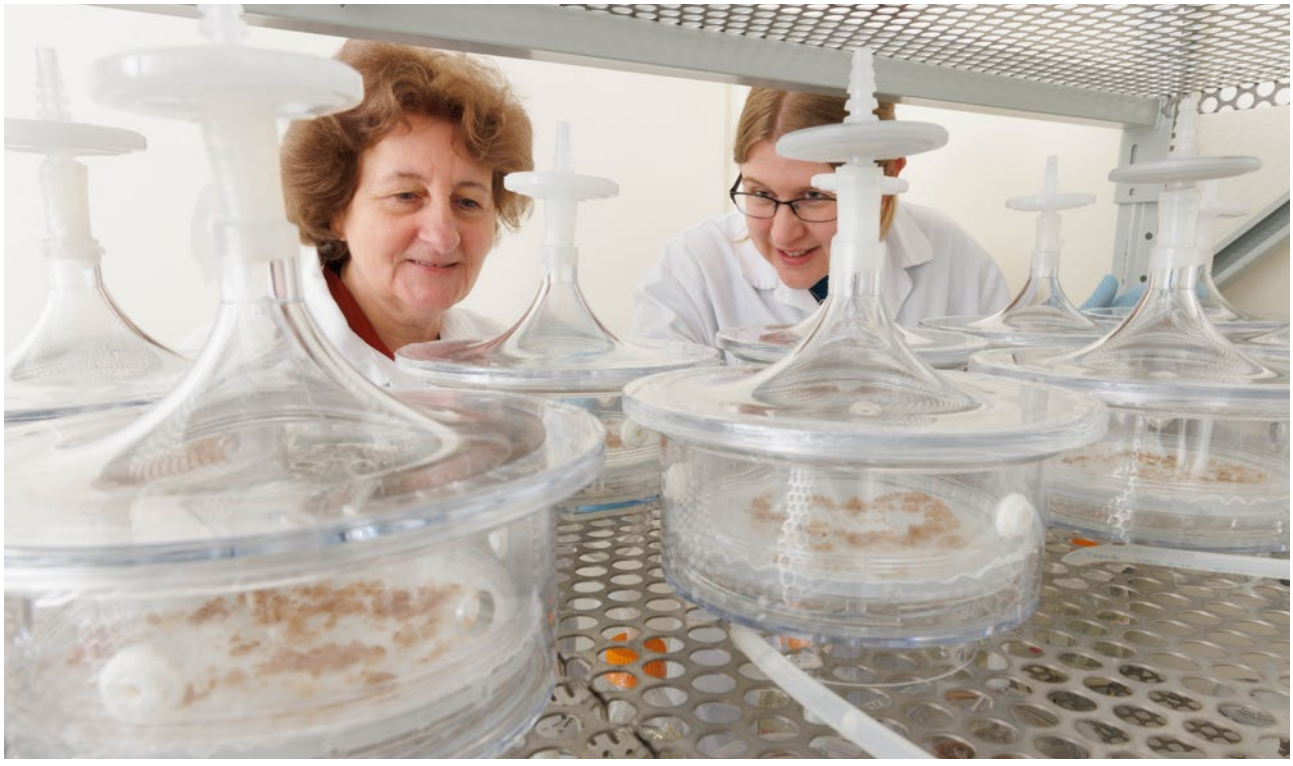
Machine learning wasn't part of the original programme but after the first year it was highlighted as an opportunity to improve productivity. A small pilot project indicated the promising potential for increased productivity and greater automation. Since that time, additional resources have been injected into the programme in response to industry interest, and machine learning is now an integral part of the project.

The machine learning research is a bit like weather forecasting – it is based on repeated, high-quality inputs to predict which embryos are likely to thrive. The team is embracing modern technologies and increasingly using automation, which allows for more accurate measurement of somatic embryos, helping the selection process and making it more efficient.

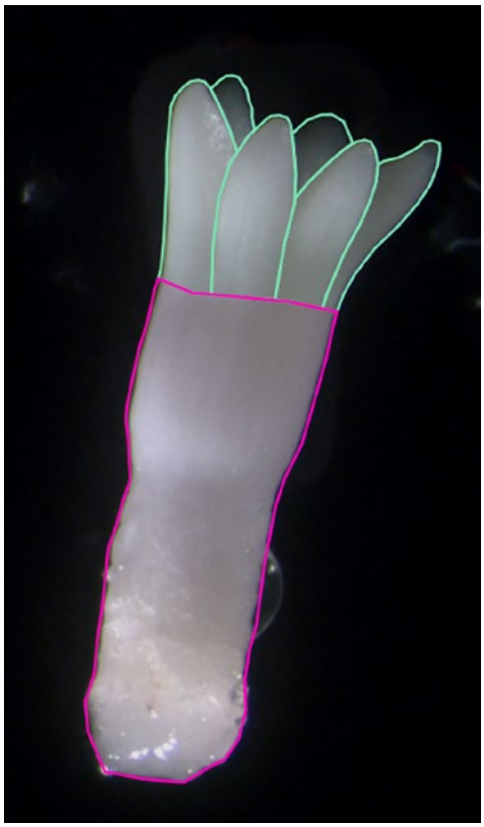
The potential impact of this machine learning and artificial intelligence has been recognised by the forestry industry. FGR awarded Scion data scientist Sam Davidson the Young Researcher award for his machine learning work on this project at the FGR annual conference in September 2023.

FGR chief executive Paul Adams says Davidson is showing real passion for how the area of machine learning and artificial intelligence could create opportunities in forestry.

"In the four years since graduating, he is making a significant contribution to science and programmes of value to the New Zealand forestry industry."



Dr Jana Krajňáková and Dr Taryn Saggese with temporary immersion bioreactors.



Somatic embryo with different sections outlined.

Cathie Reeves holds a tray of plantlets propagated via somatic embryogenesis.

The scientific excellence of Scion's tissue culture team was also acknowledged with the Science of International Quality award from FGR. This was based on the team's ability to build key collaborations with world-leading international teams, and the number of scientific publications and speaking opportunities the team has produced in under four years.

International Union of Forest Research Organisations (IUFRO)

Krajňáková is an integral part of the upcoming International Union of Forest Research Organisations (IUFRO) conference, hosted by Scion in Rotorua. This event will bring together researchers, university professors, and PhD students from around the world to collaborate, exchange knowledge, and address specific research topics in forestry, and more generally woody plants.

> "Tissue culture can be considered advanced cooking – it is more art than science."
>
> DR JANA KRAJŇÁKOVÁ

The upcoming sixth international conference of IUFRO 2.09.02 unit, titled *The might of vegetative propagation for healthy and productive forests to face climate challenges*, will take place over five days, in March 2024. Previous conferences have been successfully held since 2010 in several countries, including the Republic of Korea, Czech Republic, Spain, Argentina, and Portugal.

"IUFRO serves as a platform for scientists and experts from around the world to collaborate on various aspects of forest research by facilitating communication and promoting the exchange of knowledge and expertise.

"A level of prestige comes with being the host organisation. It demonstrates our leadership, expertise, and commitment to evolving knowledge in vegetative propagation technologies, while providing the opportunity to highlight our recent advancements in this area."

Additionally, Rotorua is scheduled to host the second international conference of IUFRO unit 1.01.04, focused on reinvigorating planted forest establishment research, in early 2025.

Tissue Culture Techniques for the 21st Century Forests is a partnership led by FGR and supported by Scion's science expertise. It began in 2019 and funding is provided for at least seven years from FGLT, MBIE and SSIF. The programme has collaborated with Georgia Institute of Technology, USA, The Natural Resources Institute of Finland, and Otago University.

Learn more about the sixth international conference of IUFRO 2.09.02 unit here:

Future-proofing our forests

Research provides a beacon of hope for foresters grappling with a disease impacting tree health and timber growth.

New research and smart technologies are offering hope and solutions to foresters waging war against a silent enemy in our pine plantations.

Red needle cast (RNC), an unyielding fungal-like disease, has silently been affecting pine trees in New Zealand since at least 2008. Infections cause pine needles to lose their colour and fall to the ground, with research showing how defoliation can impact growth for three years after the trees show symptoms.

Scientists from Scion's Resilient Forests Research Programme are at the forefront of New Zealand's response, with their work providing hope for forest growers striving to mitigate the combined impact of invasive pathogens and climate change's impact on tree health, and on the timber industry's growth and productivity.

Dr Stuart Fraser, a research group leader in Scion's Ecology and Environment team, has spent more than six years exploring red needle cast disease and possible control measures. In 2021, forest pathologist Emily McLay joined him on the frontline to further unravel its mysteries.

Caused by infection from *Phytophthora pluvialis*, the disease is predominately found on the East Coast and in the Central North Island, but more reports are being received from Northland to Southland.

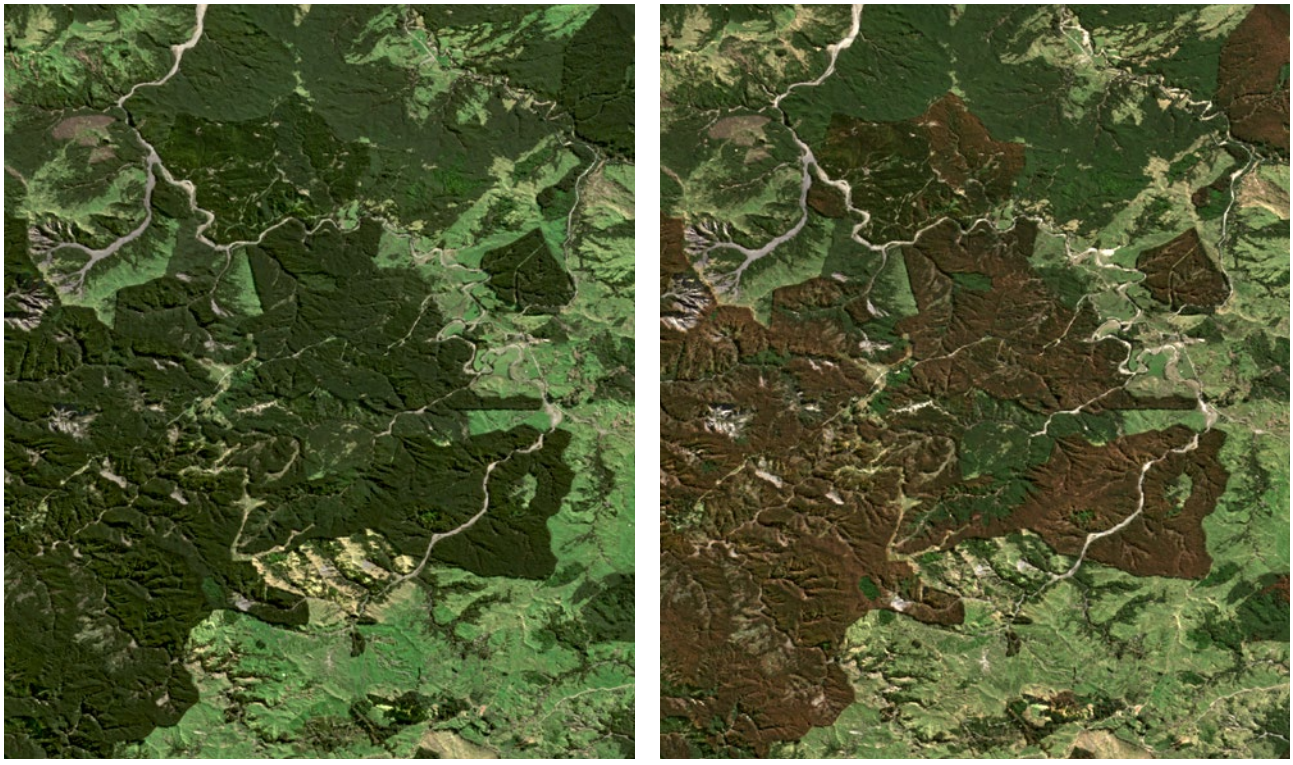
"We thought there were disease seasons, but the 2022-23 season essentially didn't end because we had such a long, wet summer," McLay says.

"Normally over summer when it's drier and hotter, you get a reset in the disease cycle because the weather typically stops it from progressing. But extended wet seasons are reasons why the disease has been so prevalent this year. It's just built and built."

She suggests there is a likely climate change element at play, with extreme wet years promoting the disease's proliferation.

"We are in a new normal," she says.

The alternating cycle of La Niña and El Niño weather patterns has exacerbated the issue. When New Zealand experiences wetter than usual years, like the recent La Niñas, it provides the ideal breeding ground for RNC.



Satellite images from August 2022 and 2023 illustrate the impact of red needle cast on East Coast forests.

Dr Stuart Fraser inspects pine needles for the disease under a magnifying glass.

Cracking the disease code

The key to combatting RNC lies in understanding the intricacies of its life cycle. McLay has been working in the lab with a focus on research to understand how temperature and moisture drive different processes in the disease cycle. "It's a targeted study that we can use to build epidemiological models so we can predict when these big years might happen," she says.

This research has shed light on the pathogen-host interaction and how the environment influences it. RNC completes its life cycle on the needles of radiata pine trees and is a very 'plastic' pathogen that can very quickly respond to environmental stimuli. "This allows the pathogen to save its resources until the perfect conditions to release spores and infect its host," she says.

> "The goal is not just to treat the disease but also to do so in a way that's environmentally responsible and economically viable."
>
> DR STUART FRASER

Temperature and wetness are the dynamic duo fuelling RNC's relentless attack. While these factors are inherently linked to seasonal changes, McLay's research aims to separate and analyse their individual impacts on different stages of the disease cycle.

"One of the challenging aspects about field trials is that there's co-variation. Winter is typically colder and wetter, whereas summer is warmer and drier. When it comes to building a model, it's really hard to pull those apart." Her research, therefore, focuses on teasing out the influence of temperature and wetness, shedding light on their distinct roles.

Monitoring support

To support the forestry industry and Scion's pathologists to better understand the extent of RNC, Scion's Remote Sensing and Geospatial Intelligence team provide monitoring support. Using satellite data, they can map the spread of the disease across forested regions. However, this poses its own set of challenges.

Monitoring forests for disease from space can be a bit like looking at the world through a straw. While they can detect the disease when it reaches the upper canopy, the lower branches, where RNC typically starts, often escapes detection. The key to more accurate detection and modelling lies in receiving tips from industry about areas where RNC is suspected.

Former team lead Grant Pearse explains, "We use free, coarser resolution satellite imagery to identify areas that might have disease expression. But it can generate some false positives for various reasons.

"The presence of RNC can only be confirmed through the purchase of very high-resolution satellite imagery from a commercial provider for more detailed mapping. To make our modelling more accurate, we'd love to hear more from industry about areas where RNC could be impacting forests. Having more accurate data means we'll need to investigate fewer false positives long-term.

"Ideally, we are looking for larger areas of trees affected by RNC as satellites struggle to detect a few roadside trees, for example."

It further supports the argument that the battle against RNC is not one that can be fought in isolation. McLay, Fraser and their team stress the importance of collaboration, particularly with industry professionals with intimate knowledge of forest conditions who can provide information that helps to validate the models being developed.

Creating decision tools

As the battle against RNC intensifies, the need for practical solutions becomes increasingly evident. Copper, a familiar ally to foresters, is emerging as a potential saviour.

Copper has been used in low doses as a control tool for Dothistroma needle blight, a fungal needle disease similar to RNC, for about 60 years. The Central North Island is considered 'ground zero' for Dothistroma in New Zealand and its effectiveness has been duly tested in pine plantations. Fraser has been at the forefront of researching copper treatments for RNC since 2017.

Significant RNC outbreaks in 2015 and 2016 in several Central North Island plantations prompted Mike Baker, national forestry manager at Manulife Forest Management (NZ), to contact Scion pathologists to propose the first operational-scale copper trials. This began an ongoing partnership between Scion and Manulife, with copper trials implemented and assessed in mature stands at Kinleith Forest annually from 2017.

Results from the 2017 and 2019 trials demonstrated that cuprous oxide applied at the standard dose currently used to control Dothistroma significantly reduced RNC severity.

These trials were also the first to investigate optimal spray timing for control of RNC, testing the hypothesis that late summer or autumn sprays may be best. Spray treatments in November, February and April (or May) were tested in 2018 and 2019; however, no consistent effect of spray timing was observed. Generally, disease severity was reduced under all three spray timings compared to the unsprayed control. Disease levels were relatively low during the period when spray timing was tested, but it's hoped copper trials on East Coast forests will shed more light on the effectiveness of copper under greater disease pressure.

While there's already strong signs that copper is an effective tool to curb the spread of RNC, Fraser cautions that its application needs to be carefully considered.

"The goal is not just to treat the disease but also to do so in a way that's environmentally responsible and economically viable."

Emily McLay's research aims to develop a model to predict red needle cast disease outbreaks.

A glimpse into the future

As we strive to protect New Zealand's planted forests from RNC, hope is emerging.

McLay's research is building towards the development of a prototype model that will provide predictive insights into disease outbreaks. This tool, while a few years from being rolled out commercially, will empower foresters with the information needed to take timely, preventative action.

Combined with the satellite-based monitoring framework developed by Scion and Indufor, and ongoing copper treatment research, they are revolutionising disease management.

"It's not just about reacting to outbreaks but proactively identifying and addressing potential trouble spots," McLay says.

> "Understanding the disease's behaviour in the context of changing environmental conditions is crucial for mitigating its impact."
>
> PAUL ADAMS

Forest Growers Research chief executive Paul Adams says Scion's research offers industry a beacon of hope for safeguarding New Zealand's forests and sustaining the timber industry.

"It holds immense value for our forestry sector. Understanding the disease's behaviour in the context of changing environmental conditions is crucial for mitigating its impact."

Adams adds that the collaboration between scientists and forestry professionals underscores the importance of a collective effort in combating RNC.

"The potential use of copper treatments is promising. Combined with the development of predictive models and satellite-based monitoring, these research efforts will help our future forests be more resilient in the face of climate change."

The Resilient Forests Research Programme has been funded to the tune of more than $18 million over five years from Scion's Strategic Science Investment Fund and the Forest Growers Levy Trust.

Rare beetles and promising finds

Scion entomologist Carl Wardhaugh examining some of the beetles collected from Kinleith Forest.

Almost 10,000 beetles were collected in efforts to find out how forest harvesting may affect biodiversity, and the results may be surprising.

Harvesting a pine plantation significantly disturbs the ecosystem within it. But promising Scion research shows insect communities could recover when new stands are planted.

Scion entomologist Carl Wardhaugh recently researched biodiversity in Kinleith Forest by looking at beetle species collected from second and third rotation pine stands and native forest remnants. Beetles were chosen due to their high species richness and varied ecology.

Between December 2019 and March 2020 almost 10,000 beetles from 555 species were collected from traps at 15 sites in Kinleith Forest.

> "It looks very promising that the insect communities recover when you get a new rotation."
>
> CARL WARDHAUGH

The sites included five each of second rotation pine, third rotation pine, and native forest remnants. At each site, three flight intercept traps were placed in the forest canopy, three were placed at ground-level, and three pitfall traps were installed to collect crawling species. This allowed for species collection from each vertical stratum in the forest.

The collection data was used to estimate beetle diversity in different forest stands.

"What we expected to see was a decline in insect diversity with an increasing number of rotations. The land's been under pine for an extra 30 years, there's been an extra harvesting event which is a major disturbance event, so we expected to see more species dropping out of the system," Wardhaugh says.

"We actually found the third rotation sites were more diverse than the second rotation."

The extrapolated data led to estimates there were 666 beetle species to be found in native forest and 561 across the pine plantation sites – 383 species in second rotation and 456 species in third with some repeated species.

Pine stands supported only about 30% fewer beetle species than native forest.

Rarely collected beetles were also found including *Brounia thoracica* which is only known from 12 specimens collected over the last 150 years. The last was collected in 2003 on Great Barrier Island. During the trapping, four were collected from canopy traps.

Very little is known about the beetle so in addition to preserving the specimens in Scion's insect collection, individuals are being photographed, and one has been sequenced and stored in a -80°C freezer for potential future molecular work.

They collected seven of the rarely collected *Rhipistena lugubris*, a parasitoid of longhorn beetles and a *Taphropiestes watti* which lives in bird nests.

> "Forests are being increasingly portrayed as biodiversity deserts and those of us that work in forestry know that this is just a complete fallacy."
>
> SALLY STRANG

"There's been very little collection of insects in the forest canopy in New Zealand so some of the rarely collected things we caught in canopy traps are likely to be canopy specialists," Wardhaugh says.

Beetle reinvasion

The reason for increased biodiversity of third rotation stands is unclear but could be anything from site characteristics to accumulation of resources over time, he says.

All the stands were the same age, harvested around the same time, well distributed, and proximity to native forest didn't appear to be a factor.

Compartment size and a mosaic of different age stands also affect biodiversity.

"It looks very promising that the insect communities recover when you get a new rotation," Wardhaugh says.

Between December 2019 and March 2020 almost 10,000 beetles from 555 species were collected from traps at 15 sites in Kinleith Forest.

"I think what's happening is most of the beetles we collected from our sites have reinvaded from adjacent pine sites ... When you've got this big mosaic across the landscape of different age stands, all those mature stands end up becoming their own refuge and that's where those insects radiate out from."

Wardhaugh says most native species are forest-adapted and pine stands become a valuable environment after canopy closure.

"What most native species really want is a shady, humid, damp, cool environment.

"Pine provides the kind of conditions they quite like, particularly when you get the development of a native understory."

Wardhaugh says the work helped show pine plantations were more than a "big green desert".

At least 80% of the beetle species in both pine and native forests were endemic and there was no difference in the proportion of native versus exotic species across forest types.

About 10 to 15% of the collected species could not be identified as definitely exotic or endemic but Wardhaugh says the unidentified specimens are likely to be native because, in general, introduced species tend to be more well-known and therefore easier to identify.

Future research

Wardhaugh is writing the information into a paper but discussed the findings at the Environmental Forestry Conference earlier this year.

He hopes to seek external funding to look at how biodiversity varies across the country.

He says to make more solid findings, assessments would need to take place in forests nationwide.

"What we really need is a large foundational piece of research to assess the biodiversity value of plantation forests in New Zealand."

Manulife Forest Management (NZ) environment manager Sally Strang, who chairs the Forest Owners Association's Environment Committee, says they were blown away by the findings including the number of beetles present, range of species and high prevalence of indigenous species.

"Forests are being increasingly portrayed as biodiversity deserts and those of us that work in forestry know this is just a complete fallacy.

> These insects will reinvade and we're not seeing any evidence of species dropping out of these systems because of harvesting events.
>
> CARL WARDHAUGH

Scion entomologist Carl Wardhaugh.

"A number of past studies have focused on threatened species that utilise the forest such as kiwi and bats, which rely on the presence of invertebrates as a food source ... Carl's work has really emphasised why the insect feeders are doing so well out there in our forests, including second and third rotation forests."

She says finding rarely found species was a bonus.

"It is vital that we continue to support biodiversity studies in our forests to better understand the role that working plantation forests can provide to preserve some of New Zealand's unique biodiversity and the true biodiversity benefits of our forests as compared to other land uses."

Planted forests
a big economic contributor

Mountain biking tourism pumps $112m into the NZ economy each year and employs hundreds.

Planted forests are currently the most important mountain biking destinations in New Zealand, new research has found.

As a major driver of activity in the regions, several sectors, including tourism, reap the economic benefits of mountain biking.

In a research project funded by Forest Growers Research, Scion senior research economist Richard Yao and resource economists Julio Botero and Saeed Solaymani looked at the economic value of mountain biking and its wellbeing benefits. They also looked at the role of planted forests compared to other mountain biking destinations.

Findings show mountain biking tourism pumps $112.3 million into the New Zealand economy each year providing full-time employment for hundreds nationwide.

Most of the economic benefits went to five sectors: transport (18%), accommodation (16%), rental and hiring services (14%), food and beverage services (14%), and retail trade (11%). Forestry reaped 0.5% of benefits.

Yao says, "while the economic benefits derived directly from mountain biking in the forestry sector may be relatively small, the contributions of forestry assets to mountain biking activities are significant".

Resource economist Saeed Solaymani and Scion senior research economist Richard Yao.

As part of the research, carried out in May and June 2023, thousands of mountain bikers were surveyed about where they biked and their relevant spending.

The researchers used an input-output model to assess economic impacts and found mountain biking generated $112.3m. Of this, transport contributed $20.2m from expenses like air travel, petrol, and shuttles. Accommodation made up $17.6m, rental and hire services $16.3m and food and beverage contributed $15.2m.

Retail contributed $12m, manufacturing, professional services, construction, primary manufacturing and financial and insurance contributed a collective $18.9m and other sectors contributed $11.5m. Forestry received $261,000 of economic benefits.

The report says the findings highlight the "diverse industries" that benefit from mountain biking visits and how these contribute to economic growth.

Frequency and distance

Of the 2073 mountain bikers surveyed, 79% biked at least once a week, and 91% went on distant trips (more than 120-minutes one-way).

Seven of the 10 most visited local sites were in planted forests, with Whakarewarewa Forest taking the top spot with 36.3% of visitors followed by Wellington's Mākara Peak (14.8%) and Woodhill in Auckland (10.8%).

Four of the 10 most visited sites by distant visitors were planted forests.

The team used survey data to simulate 'what if' scenarios determining the impact locations had on distant mountain biking visitors' wellbeing.

Using the travel cost economic valuation model, they assessed the additional satisfaction derived from mountain biking activities. The model considered the opportunity cost of travel time and the expenses associated with traveling to and from the site, as these factors could reflect the value of the trip to an individual (e.g. their willingness to spend both time and money on the trip).

The opportunity cost of travel time was estimated using an equation that considers an individual's hourly wage and round-trip travel time.

This information was then used to evaluate the impact of not allowing distant visitors to mountain bike in the four most-frequented planted forest sites (Whakarewarewa, Queenstown Bike Park, Christchurch Adventure Park and Hanmer Forest Park). The analysis shows a cumulative loss in wellbeing value of about $4.2m per year for distant visitors based on a travel cost analysis.

Yao says if the other six non-planted forest sites closed this would lead to a wellbeing reduction of $2.6m illustrating the higher contribution planted forests make to the wellbeing of mountain bikers.

> While the economic benefits derived directly from mountain biking in the forestry sector may be relatively small, the contributions of forestry assets to mountain biking activities are significant.
>
> RICHARD YAO

He says the outcomes from the multi-site travel cost model show that the value of the extra satisfaction derived from visiting the top four planted forest locations surpasses that of visiting the leading six non-planted forest sites.

The non-planted forest sites included Paparoa National Park, Coronet Peak, The Gorge Mountain Bike Park, Park Glendhu Bike Park, Great Lake Trails and Craigieburn Trail.

"This emphasises the higher value placed on planted forests as mountain biking sites," Yao says.

He says one explanation could be the quality and convenience of trails, or the wider variability of the trail challenge levels found in planted forests. Factors explaining why mountain biking sites in planted forests might be valued more than other areas will be determined in a future study.

Cyclists' spending

The survey also asked respondents how much they spent on mountain biking.

Local visitors spent an average of $735 on food and drinks, $694 on transport, $2032 on access fees or entry permits, $2655 on gondola rides, lifts, and shuttle fees, and $4592 for bike or gear rentals.

Distant visitors spent an average $7814 on food and drinks including dining out, $8504 on transport, $3223 on access, $4657 on gondola and shuttle rides, $6311 on bike or gear rentals and a whopping $11,963 on accommodation per year.

Retail and rental and hiring services predominantly benefit from local mountain biking visits while distant visits benefit accommodation, transport and food and beverage sectors.

The study also looked at jobs created through mountain biking, concluding local visitors generated 30 full-time equivalent (FTE) jobs while distant visitors created 137 FTE in the Bay of Plenty alone. Nationwide, more than 700 FTE were created.

The research was funded by Forest Growers Research. Chief executive Paul Adams says the research provided interesting insights and prompted questions around how forest growers could leverage the economic benefits.

A 2022 report called Impact of Mountain Biking assessed how much mountain biking related visitors spent in Rotorua and estimated they contributed a total of $139.8m to the local economy. The report used different research methods and analysis models, drawing on a range of data sources, while this study drew directly on the survey results.

Harnessing the power in nature to combat pests

After more than 10 years of research, a new biocontrol tool has been released to help combat a beetle destroying valuable Eucalypt plantation forests in New Zealand, highlighting that the solutions can often be found in nature.

> Biocontrols can be risky, but the cost benefits when it works is huge – 100 to one. And when it works, it should work forever.
>
> DR TONI WITHERS

The value of Eucalypts

Forestry and wood products are a big earner for New Zealand – $6.6 billion in 2022 to be exact. Much of this comes from radiata pine, but a small yet important part of New Zealand's diversified forestry industry are Eucalypts.

Eucalypts are highly valued for pulp and paper, with additional benefits in farm forestry, shelter trees, soil erosion, carbon sequestration and amenity planting, as well as a growing resource for naturally durable wood.

The most common species, *Eucalyptus nitens*, packs a particularly weighty plantation punch by supporting our primary export industry.

How so? This fast-growing hardwood species' short-fibre pulp has valuable characteristics which help create rigid cardboard packaging, which the export industry, particularly fresh produce, relies on to store and ship products around the world.

Yet these small but mighty plantation forests have been under attack since the introduction of the Eucalyptus tortoise beetle (*Paropsis charybdis*) from Australia more than 100 years ago.

The beetles cause serious damage, feeding on foliage and significantly reducing tree growth. The cumulative effect can also cause trees to die completely.

Scientists have unleashed a torrent of revenge upon this pest starting as far back as the 1950s but haven't managed to eradicate it or fully prevent the damage it causes.

The latest in protection

Recently, however, there has been a breakthrough with the introduction of a biological control agent into New Zealand from Tasmania, Australia to control the larvae of the Eucalyptus tortoise beetle – in the form of a small wasp.

A natural predator of the beetle, this parasitoid wasp (*Eadya daenerys* – and yes, this particular sub species was lovingly named by a Game of Thrones enthusiast, after the mother of dragons) was released into Eucalyptus plantation forests in December 2022 and January 2023 at sites in the Central North Island and Southland.

Releasing the wasps has been over a decade in the making, overcoming numerous scientific hurdles and setbacks. Turns out they have proven much more challenging to rear than the beetle they attack.

CLOCKWISE FROM LEFT:

The team attached leaves with beetle larvae to Eucalypt trees after the larvae was already parasitised by the wasp in Scion's laboratory.

Research led by Dr Toni Withers and Mike Davy led to the release of the parasitoid wasp.

Released into planted forests, the parasitoid wasp begins its journey as a biocontrol tool in the Central North Island. Pictured (left to right): PF Olsen forest manager Steve Lee, Oji Fibre Solutions forest resource manager Lawrie Scott, Scion senior entomologist Dr Toni Withers, Scion senior entomology technician Mike Davy, Oji Fibre Solutions fibre procurement manager David Fox, and Scion research group leader Dr Stuart Fraser.

What is a parasitoid?

Parasitoids live most of their lives attached to, or inside, a single host. In this case, adult Eadya wasps lay eggs inside larvae of the Eucalyptus tortoise beetle.

The parasitoid larvae feed within the host beetle larvae for about 15 days. They then emerge, killing the host, and pupate (grow) out of sight within holes in the soil, where they spin themselves into a silken cocoon. After hibernating for 10 months, the adult wasp hatches and the whole process begins again.

A significant amount of testing and re-testing was undertaken before the Environmental Protection Authority agreed the wasp poses a minimal risk to New Zealand's native or beneficial beetles. There's also no risk to people, as the Eadya wasps don't sting or develop colonies like German wasps, for example.

Bad-news beetle

Scion senior entomologist Dr Toni Withers has been working on stopping this destructive beetle for the past 25 years.

"It's not an easy beetle to overcome because there aren't many natural predators in New Zealand and the adult beetles are very robust, meaning they're prolific breeders and hard to kill."

Eucalyptus tortoise beetles produce two generations a year, meaning numbers grow at an alarming rate. Both larvae and adult beetles eat large amounts of young eucalypt leaves for many months of the year, causing widespread havoc.

Management of the beetle to-date has largely been through aerial spraying. But industry has been committed to finding sustainable alternatives.

Scion, along with industry partners Oji Fibre Solutions and Southwood Exports, have been working alongside the Ministry for Primary Industries to co-fund this Sustainable Food and Fibre Futures project.

Why biocontrol?

Biocontrol uses natural enemies to reduce pest populations in countries where they have been unwelcome invaders. It often involves the importation of a specialist insect parasitoid from the pest's native environment where predator and prey have evolved together.

New Zealand currently has three previous biocontrol agents, a ladybird, and two tiny egg parasitoids called *Pteromalids*, to help make a population impact on the adult Eucalyptus tortoise beetle, with insufficient success seen thus far. The Eadya wasp introduces another tool at the larval stage and is hoped will make more of an impact.

"This is another weapon in our armoury, adding to what's already been established," Withers says.

"Biocontrols can be risky, but the cost benefits when it works is huge – 100 to one. And when it works, it should work forever."

The Eadya wasp was first discovered as a potential biocontrol agent 12 years ago in Tasmania. Scion has worked closely with the University of Tasmania, as well as other specialists from around the world, to understand the wasp down to a molecular level.

Some of this work resulted in describing four different species of the wasp genus, previously unknown.

The power of partnerships

Withers says the support from industry has been huge.

"There's been a real drive from industry to push the science forward and it's been amazing to get the support we have."

Oji Fibre Solutions group manager Environment and External Relations Philip Millichamp says the company has a strong history working alongside Scion.

"Scion is a key partner for us, particularly when it comes to innovation efforts around sustainability and creating a more circular bioeconomy.

"As a company, Oji is driven by sustainable values, including the aspiration to have zero environmental burden. Part of that challenge has included looking at alternative pest control regimes, including biological controls.

"Eucalypts create high-value products, and we can't easily change the species of tree in our mix, as they are important to the characteristics of the products we make.

"We hope the release of the wasp will make a difference. It won't be an overnight fix, so in the meantime we are continuing to look at other environmentally friendly options, which includes working with Scion on more benign pesticides and growing beetle-resistant Eucalyptus varieties."

The release

A small number of adult female wasps and over 10,000 Eucalyptus tortoise beetle larvae with the parasitoids living inside their bodies were released in December 2022 and January 2023. One third were released near Kinleith in the Central North Island, and the remaining two thirds in Southland. There is another release planned for this summer.

Having played the long game thus far, it may take another three or more years for the real impact and benefits of the wasp to be seen in plantation forests.

> "Three quarters of all the attempted forestry pest biocontrol projects in New Zealand have succeeded in establishing a natural enemy to provide biocontrol."

Where to from here?

This summer, scientists will not only release a second wave of wasps and infected larvae, they will also re-visit previous release sites to try and find any visible signs of the wasps. But Withers says it will be like looking for a needle in a haystack.

To-date, three quarters of all the attempted forestry pest biocontrol projects in New Zealand have succeeded in establishing a natural enemy to provide biocontrol.

"Despite only having two summers of releases, it is absolutely possible to establish a species with small numbers. Now it's just a matter of waiting."

Mike Davy and the Scion team in action.

UAVs for pest control take off

Research into unmanned aerial vehicle (UAV) use could open doors for 'burgeoning' practice, but refinement is key to combating plant pest incursions.

Dr Justin Nairn and Dr Andrea Grant researched the social acceptance and practicalities of UAV use for aerial spraying.

It's 1999. The painted apple moth has been discovered in West Auckland. With the risk it could cause severe damage and financial losses to multiple industries and native and amenity trees, a multimillion-dollar response begins.

The eradication includes an extensive aerial spraying programme involving fixed-wing aircraft and helicopters. Given Ministry of Agriculture and Forestry estimates the moth could cause economic impacts of up to $356 million over 20 years if established, the extensive reaction is warranted despite some reluctance to spraying in an urban environment.

Seven years, $65m and about 70 sprays covering thousands of hectares later, the apple moth is eradicated.

Over the years, Scion researchers have been looking for new ways to tackle future pest and insect outbreaks. Ways that are more targeted and don't require aerial spraying using such imposing aircraft.

And the work shows UAVs could be used for targeted spraying in urban biosecurity, once we understand what issues could emerge for people when using UAVs for this purpose.

> "There is no one tool that will work in every situation so it's important we maximise what's in our toolbox so we can better tailor our responses."
>
> BRENDAN GOULD

Could UAVs be the new frontier?

Scion has been involved with incursion responses and field research in aerial spray methodology for a long time, including when the painted apple moth was discovered. Research into both the social acceptance and practicalities of aerial spraying using UAVs specifically began around 2015. Several years and trials later, researchers are finalising their findings.

Plant Protection Physics and Chemistry team lead Dr Justin Nairn says his team's work falls under the Better Border Biosecurity (B3) collaboration – a multi-partner joint venture researching ways to reduce the entry and establishment of new plant pests and diseases in New Zealand.

The research looked at the efficiency of spraying using UAVs in general, then using them to spray a specific biological insecticide.

"One of the big things that's coming into plant protection is precision spraying – applying things as accurately as possible and minimising off-target spray," Nairn says.

Alongside that, a team of social scientists looked at how accepting people were of UAVs and how to co-design responses.

UAVs can fly closer to the target than a helicopter – about 2m versus 10m-plus – have a smaller footprint and fly slower meaning down draft can help drive the spray through the canopy.

In aligned research, Dr Andrea Grant helped run focus groups looking at social and cultural considerations. They included social researchers from other Crown Research Institutes, UAV researchers, Māori involved in forest protection and management, and forestry managers.

Focus group participants discussed social and technical aspects identifying emerging issues like human health, safety and ethics, professionalisation, Te Tiriti partnerships, communication and engagement, capacity and capability.

'Burgeoning' tool tested

In March 2021, Nairn's team used a fluorescent dye to measure the efficiency of spraying with UAVs.

Approval was sought from Ngāti Hurungaterangi, Ngāti Taeotu and Ngāti Te Kahu whose whenua in Rotorua is where the testing took place.

A T16 drone, weighing 41kg fully loaded, made 10 flights measuring wake velocities and eight spraying dyes, passing over a tree on Scion's campus four times each flight.

Sonic anemometers measured wake speed, while collectors placed through the canopy and on the ground, captured dye penetration levels and drift outside the target area.

They found the UAV wake drove the dye deep into the canopy and wind levels affected how far it veered off target.

The next step was an insecticide trial.

They wanted to use Foray48B which is a BTK (*Bacillus thuringiensis var. Kustaki*) bio-insecticide impacting Lepidoptera (moths specifically), but availability of the insecticide delayed the trial until February this year.

Another challenge was droplet size. A small droplet size typically gives better coverage but is more susceptible to wind drift.

The team created a dilution with the same portion of active ingredients in larger droplets to determine if they would adequately penetrate the canopy and provide sufficient coverage.

The findings are being written but Nairn says the use of UAVs for pest control is "burgeoning" and operation hurdles are reducing as technology advances, addressing cost and technological barriers like weight and flight time.

"As they become more useful people are more accepting of paying the cost."

Overcoming social, cultural challenges

Before the most recent field testing, Grant held a co-design workshop with people from agencies including the Ministry of Primary Industries, Te Uru Rākau, Department of Conservation, Civil Aviation Authority and Te Tira Whakamātaki.

Grant says some social and cultural challenges identified included making off-the-shelf tools fit for purpose, ensuring people were sufficiently trained, and safety and operational ethics were considered.

She also looked at using ethical co-design as a framework for biosecurity incursion responses that are inclusive, based in Te Tiriti and enable Māori innovation.

She says participants noted the role for mātauranga Māori and need to work with Māori in research, policy, operation and capacity, developing relationships and resources that enable Māori participation.

There also needs to be a balance between engaging communities ahead of any response, and the need for fast action sometimes.

"This action-engagement trade-off needs more strategic attention and communities' role in biosecurity operations could be better developed.

"If community concerns are not addressed and they have no opportunity to respond to planned operations, they may lose confidence and support for urban biosecurity operations in future."

Te Tira Whakamātaki chief scientist Dr Simon Lambert says much of the Māori economy is in the primary sector and therefore highly reliant on the environment.

"Māori are increasingly aware of the vulnerability of their assets and cultural capital to biosecurity events and are not opposed to technological innovation but insist on early and ongoing engagement by researchers and regulators."

Staff preparing the first trial which used collectors, placed through canopy and on the ground, to capture how deeply the dye penetrated and drifted.

Proactive biosecurity system

B3 director Dr Desi Ramoo says the research completed by Nairn's team using UAV platform technology is a great example of adapting existing technology to be an applied biosecurity tool.

"We must be prepared with a number of solutions developed from Western science and mātauranga Māori to ensure we are ahead of the game and move from a reactive to proactive biosecurity system. To set us on the path to achieve this, building relationships with Māori is an essential requirement for all B3 research projects. Our aim is research projects that will be the catalyst that builds enduring partnerships which enable rapid response when the need arises."

Brendan Gould from the Forest Owners Association says successful intervention relies on the ability to respond but community impacts and implications need to be considered.

> "If community concerns are not addressed and they have no opportunity to respond to planned operations, they may lose confidence and support for urban biosecurity operations in future."
>
> ANDREA GRANT

"There is no one tool that will work in every situation so it's important we maximise what's in our toolbox so we can better tailor our responses.

"Having more tools means we can better engage communities to develop effective strategies that can be rapidly deployed but that minimise potential impacts and are socially acceptable."

He says engagement before an incursion is important but challenging without knowing where and when one might occur.

Engaging at a generic level means getting an idea of what impacts and implications might arise during a response and previously engaged groups can help develop tools or inform others.

"These projects have been hugely informative in terms of pre-engagement and have and will provide hugely valuable tools and information that we can draw on both before and during a response."

Nairn's work was part funded by Better Border Biosecurity (B3) while Grant's was part funded by Forest Growers Research Trust. Both were funded by Scion's Strategic Science Investment Fund.

Protecting native taonga

Conservation efforts step up to protect vulnerable species from myrtle rust.

Scientists and a Jobs for Nature team are in a race against time to save vulnerable native species under threat from myrtle rust in the Rotorua lakes area.

With fears mounting that species endemic to New Zealand could be wiped out by the fungal disease, researchers will be collecting more crucial data over summer to understand its spread.

But this research is more than just data collection; it's a powerful study of resilience and nature's battle for survival.

The full impact of myrtle rust on the health of ramarama, rōhutu and their hybrids was revealed over spring and summer in 2022-23. This followed efforts to identify species populations around lakes Rotoiti, Rotomā and Okataina by the Scion-led Myrtle Rust Jobs for Resistance programme – Te Rātā Whakamaru.

This summer researchers are extending the programme to include more sites around Rotorua and, for the first time, mapping populations of pōhutakawa, northern rātā and maire tawake (Swamp Maire).

Climate change casts a long shadow over this research. As temperatures rise and conditions shift, the prevalence of myrtle rust on vulnerable native species is expected to follow suit. The next phase of the three-year programme aims to anticipate these changes by revealing locations around the Rotorua lakes where target species comes under the most disease pressure.

New sites for monitoring include Whakarewarewa Village and potentially Mokoia Island, providing researchers with the unique opportunity to study the impacts of myrtle rust in different environments, such as those with geothermal activity.

"Researchers have never explored how myrtle rust behaves in a geothermal environment, so this study is set to generate valuable new insights," Scion forest pathologist Darryl Herron says.

Scion is planning to combine satellite imagery with deep learning AI technology to map populations of pōhutakawa around the lakes before using the Te Tira Rātā (field work team) to confirm and validate the data from the ground.

Dr Tanya Robinson, Manahautū general manager for Whakarewarewa – Living Māori Village, says they are very happy to support the research.

"We are so pleased to be able to tautoko this kaupapa and the work of the team, as they study the effects of geothermal activity on myrtle rust and map out the populations of pōhutakawa.

"We know this will benefit taonga rākau in the village, and we're also keen to see how the project grows and passes on great benefits for many different roopu and rohe across the motu. Our manuhiri and education programmes will also benefit, as we encourage our kaiarahi guides to be sharing information on this important programme and the work of Te Rātā Whakamaru."

Myrtle rust on ramarama in the field.

Forest pathologist Darryl Herron shows Rotoiti 15 Trust chair Arapeta Tahana where cuttings are showing signs of new growth.

Breeding for resistance

As well as monitoring sites for signs of myrtle rust, work will continue on nurturing the cuttings of ramarama, rōhutu and their hybrids taken from the field over winter. The cuttings have been propagated in Scion's nursery in the first stage of a long-term resistance breeding programme.

Herron says myrtle rust's spread over 18 months had created a sense that conservation efforts were at a critical stage.

"The population size of *Lophomyrtus* trees around the lakes area is quite small, and without any interventional management, we're likely to lose them completely.

"With myrtle rust impacting these populations, we've realised how important it is to propagate cuttings before myrtle rust decimates them and we lose all access to their fruit or seeds in the future."

Ramarama, rōhutu and their hybrids belong to the *Lophomyrtus* genus and are part of the myrtle family that is at risk from the infectious airborne fungus. Regular field visits have confirmed the presence of myrtle rust in targeted populations and an overall decline in tree health.

Where myrtle rust was found in 2022-23, Te Tira Rātā (field work team) identified parts of the tree that were most affected and how the disease was impacting its reproduction.

"The disease targets new leaf growth," Herron says. "If a tree is constantly impacted by myrtle rust it will start to die back and eventually it will stop producing fruit or seeds that would usually fall to the ground. You'll see fewer young saplings emerge and those that do are vulnerable to infection – that's when you stop getting natural regeneration in the forest."

Engagement with mana whenua

Te Rātā Whakamaru started in April 2022 and is delivered in partnership with Rotoiti 15 trust. It is funded by Jobs for Nature/ Mahi mō te Taiao through the Department of Conservation – Te Papa Atawhai.

With support from Scion scientists, 10 full-time staff have been trained as field technicians and are employed to carry out surveillance work in Bay of Plenty native forests and at Scion.

Engagement with mana whenua has been a core part of the programme. Before cuttings of ramarama, rōhutu and their hybrids could be removed from the field, Scion and Te Rātā Whakamaru sought permission from hapū and explained how cuttings could be used to preserve the genetic diversity of the local populations and bred for myrtle rust resistance.

Project technical lead Dr Jacqui Bond says while the outlook for the species appeared dire, a positive has been the relationships built with mana whenua and the trust they have in the team to take cuttings.

Hōmiromiro (field technician) Otaki Grant says the message received from mana whenua is clear. “They don’t want to idly stand by and watch the species decline. Their permissions for us to take cuttings was pivotal in allowing the tree breeding phase to begin.”

Rotoiti 15 Trust chair Arapeta Tahana says mana whenua are deeply concerned about the impact myrtle rust is having on plant and tree species in Rotorua. “From a Māori world view, we are connected to nature, so these species are our family. Not only do we, as guardians, have an obligation to look after the natural world, but we also feel an innate obligation to look after our older brothers and sisters that came before us in the ngāhere. We see the trees as part of our whakapapa and identity, so we are very motivated to help them.”

Working in the forest was restoring lost connections with their whakapapa, and helping to unlock a sense of purpose for many employed in the Te Rātā Whakamaru programme, Tahana adds.

“Part of our journey as Rotoiti 15 is about reconnecting people to nature and letting them feel that love. Out of that builds a passion for conservation and that desire to find solutions.”

Developing new protocols

Herron says the team’s learnings could form the basis for cutting protocols that could be applied to other indigenous species as well. The long-term aim is to grow trees from cuttings and seeds that demonstrate a natural resistance to myrtle rust infection.

“It’s unclear why some trees are infected and others aren’t. Is it because the disease hasn’t reached them in the field, or is it because they have some tolerance? These are the questions we want to answer,” Herron says.

Another major challenge facing researchers is the time it takes to breed for resistance, as native trees grow very slowly compared with commercial species like radiata pine or eucalypts.

Hōmiromiro (field technicial) Otaki Grant updated everyone on efforts to propagate the cuttings during a recent hui.

“It’s our hope that we identify some myrtle rust-tolerant individuals in the field and protect them by taking cuttings, propagating them and growing them into a tree,” Herron says. “Together with our partners, we hope to grow the seed, plant them and keep screening those individuals.

“As you do with traditional breeding, we’ll keep repeating that process to find the strongest and most disease-tolerant individuals. But this process requires a multi-year programme that will operate beyond the terms of what Jobs for Nature is currently funded for.”

The Te Rātā Whakamaru programme is funded by Department of Conservation – Te Papa Atawhai. It is among a suite of research involving more than 30 Scion scientists who have been working towards protecting our most vulnerable myrtle species from myrtle rust since the disease was discovered on mainland New Zealand in 2017.

Te Rātā Whakamaru has strengthened connections between Scion, Rotoiti 15 Trust, mana whenua and the Department of Conservation.

Fostering global connections

Te Ara Pūtaiao travelled to Ottawa and Vancouver in Canada and Honolulu, Hawaii.

Māori leaders from NZ's Crown Research Institutes went on an indigenous knowledge exchange to share knowledge and form links.

A group of Māori leaders from New Zealand's Crown Research Institutes (CRIs) has shared indigenous knowledge and formed connections with indigenous groups in North America during a two-week knowledge exchange.

And the relationships formed are just the beginning.

Scion's Te Ao Māori and Science Services interim general manager Shontelle Bishara is a member of Te Ara Pūtaiao, a pan-CRI Māori Leadership Group working to create space and opportunities for iwi and hapū to lead, collaborate and grow mātauranga Māori across Aotearoa's CRI system.

Te Ara Pūtaiao travelled to Ottawa and Vancouver in Canada and Honolulu, Hawaii for a two-week indigenous knowledge exchange in June and July.

They visited government agencies and not-for-profits, schools and universities, and met with indigenous peoples working within and with those organisations.

The aim of the exchange was to share indigenous knowledge and approaches to working with science and towards improved outcomes to major global challenges.

> "As climate change further impacts our environments, using indigenous knowledge is vital."
>
> TANIA GERRARD

Canada and Hawaii were chosen because of existing relationships between some of the Te Ara Pūtaiao members and indigenous communities and researchers in those countries, as well as the similarities in challenges and opportunities to Aotearoa New Zealand.

Shontelle says similarities included the connection to the environment, intergenerational aspirations, shared values, and a common desire to grow the pipeline of indigenous researchers.

She enjoyed seeing young, indigenous people in leadership and visiting the Ottawan social enterprise Indigenous Clean Energy. It promotes indigenous inclusion in Canada's energy futures economy and indigenous leadership and collaboration with players in that space.

"While I was there, I was thinking about the impact that Scion is driving in the bioenergy space and the circular bioeconomy, and the collaborative opportunities Scion could potentially pursue with Indigenous Clean Energy," Shontelle says.

"I liked their model and strategy in terms of investing in building the capability and capacity of indigenous communities to be able to participate in the clean energy space."

She says Indigenous Clean Energy was extremely open to sharing what they had learned through focusing on Canadian indigenous communities.

Indigenous research strategy

The group also went to the Social Sciences and Humanities Research Council – Canada's federal research funding agency to promote and support research and training in humanities and social sciences.

The agency facilitated an indigenous research strategy which took two to three years to pull together and has an indigenous leader advisory group.

"I thought it was great that they took the time to develop that strategy with time, investment, then follow through."

Shontelle says the group was also honoured to participate in traditional ceremonies while in Canada, including smudging – a cleansing ritual – and attending a pow-wow – gathering to celebrate and honour traditional dancing and singing.

During the knowledge exchange, the group identified areas for immediate collaboration like climate change, energy security, food security and sovereignty, and rongoā.

Te Ara Pūtaiao was deciding on future partnerships and pathways from the trip but Shontelle says it could act as a conduit to bridge connections.

"For early career researchers, part of growing their science pathway is building international connections. Te Ara Pūtaiao could act as a facilitator to initiate these."

Building relationships

The group also hopes to harness and apply science and indigenous knowledge in a way that enables global collaborative research programmes and keep building and formalising global indigenous relationships.

From Shontelle's perspective she wants to build relationships and facilitate connections between Scion and the organisations the delegation visited. She says collaboration opportunities could be aligned with Scion's impact areas, including indigenous value chains and clean energy.

Tania Gerrard (Ngāti Porou) who is GNS Science's general manager of Māori and Stakeholder Relations chairs Te Ara Pūtaiao.

She says the trip played into one of the directions of the Te Ara Paerangi White Paper which presents a vision for New Zealand's public research science and innovation system.

The paper suggests facilitating and fostering global connectivity and international partnerships.

She says the trip facilitated deepening global connections.

"As climate change further impacts our environments, using indigenous knowledge is vital.

"There is a major opportunity for global collaboration."

The other members of Te Ara Pūtaiao who went on the trip from June 22 to July 5 included Gerrard, AgResearch Urungi director Māori Strategy Chris Koroheke (Ngāti Maniapoto), Callaghan Innovation's chief Māori government engagement officer Henare Johnson (Ngāti Whare), ESR's general manager of Māori Impact Jymal Morgan (Ngāi Tahu), and NIWA general manager of Māori and Pacific Partnerships Marino Tahi (Ngāi Tūhoe).

> "While I was there, I was thinking about the work we're doing in the bioenergy space and thinking what connection we'd be able to make there."
>
> SHONTELLE BISHARA

Te Ara Pūtaiao members including Shontelle Bishara (kneeling centre).

Steam tram
powered by trees

Forest residues have successfully replaced coal as a low carbon fuel source in a large-scale, partnership trial with the Museum of Transport and Technology (MOTAT).

Two hundred and fifty kilograms of biofuel briquettes were supplied to MOTAT to power steam tram no. 100 on Live Day.

It was out with the coal and in with the biofuel for steam tram no. 100, which operated on a renewable energy source made from trees at MOTAT Live Day on August 20.

The biofuel was developed by Scion under its Integrated Bioenergy portfolio. Live Tram Day was the project's largest trial to date, with 250 kilograms of biofuel briquettes supplied to MOTAT to keep the little tram that could, running all day.

It was also a chance to highlight the opportunities available as New Zealand transitions from fossil fuels to renewable energy sources, to reduce our greenhouse gas emissions.

More than 1100 visitors attended the museum's annual tram celebration with tram no. 100 the most popular of the day. Scion's biofuel performed well, with valuable feedback provided by MOTAT tramway volunteer, Tony Messenger, who has worked with tram no. 100 for more than 50 years.

"The fuel burned cleanly with minimal smoke and noticeably less fumes. You certainly did not get that taste in your throat or smell in your clothes that you get when burning coal," he says.

"The briquettes allowed a better fire grate covering than coal and as a result, the boiler steamed well and easily maintained pressure. We were able to maintain a more constant, steady fire and that is a plus.

"We would be very happy to switch to this fuel in place of coal."

Scion scientist Karl Molving noted further work is required to reduce the volume of briquette dust and further improve combustion performance. Both coal and briquette ash samples were collected for testing.

Scion anticipates its briquette ash will be cleaner and less corrosive, which should improve boiler lifespans.

From forest to fuel

The briquettes are made using forest residues such as bark, branches, and low-quality stem wood – all woody biomass that is currently seen as a waste product in the industry. Scion is on a mission to unlock the potential of this 'waste', seeing opportunity in the estimated 4 million tonnes of harvest and thinning residues that currently remain in production forests.

While more than 2 million tonnes of coal were burned in New Zealand in 2022, there has never been a more critical time to find an alternative to fossil fuels.

Scion Integrated Bioenergy portfolio lead Paul Bennett believes forestry may hold the solution for providing coal burners with a clean and renewable energy source.

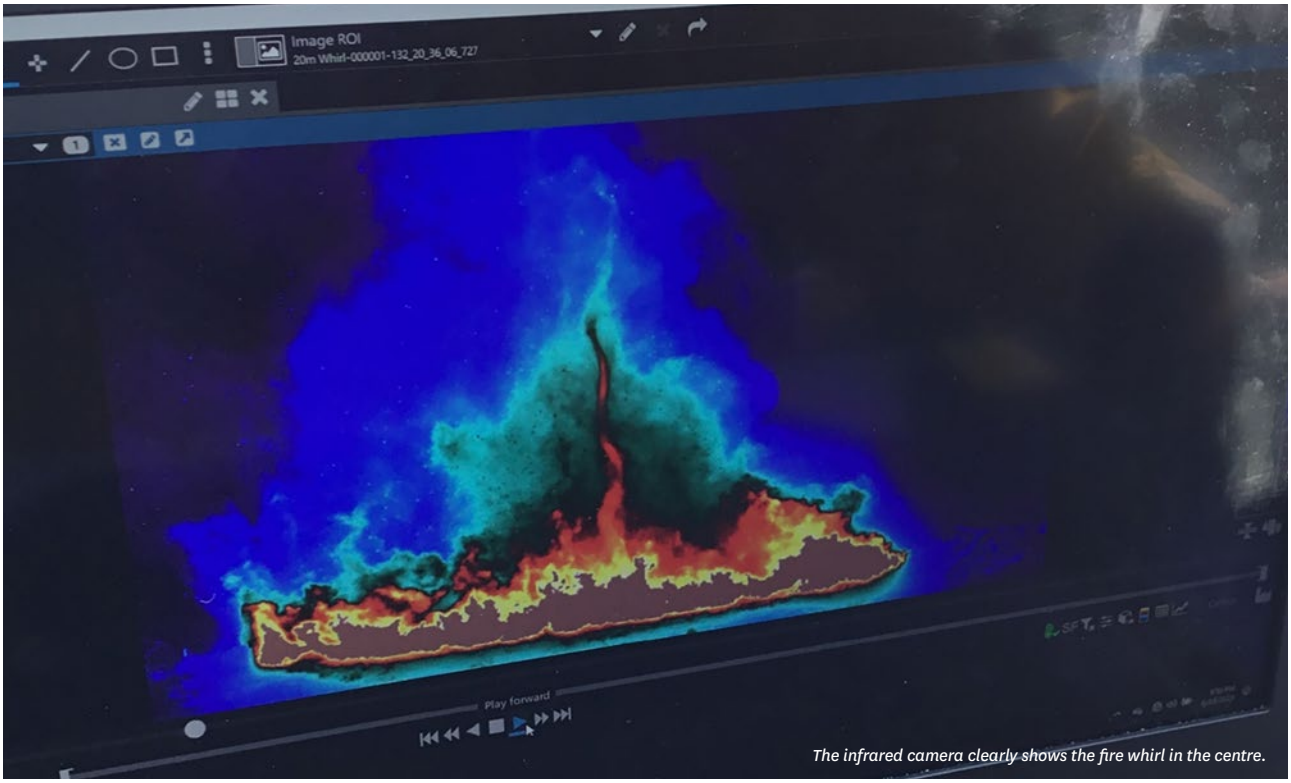
"Energy use contributes to around 90% of New Zealand's carbon dioxide emissions. If Aotearoa is going to achieve its net zero target, it needs to address emissions from energy use.

"This is currently the most achievable target for New Zealand to reduce carbon emissions. However, it's not a target that can be achieved only by Scion. It requires connections with the industry and the public.

"To bring biofuel to the market and successfully replace coal, the technology needs to be tested at a range of scales. This partnership with MOTAT was the ideal first step to demonstrate the effectiveness of biomass briquettes at a larger scale, with a like-minded company that wants to reduce its environmental impact," Bennett says.

Learn more about the Solid Biofuels project on our website:

Fire whirl research
aims to safeguard firefighters



The infrared camera clearly shows the fire whirl in the centre.

Alpine ranges leading to Aoraki / Mount Cook were the backdrop to world-first research where smoke devils and fire tornadoes took centre stage.

Scientists from Scion, USDA Forest Service, University of Canterbury and the US National Centre of Atmospheric Research achieved a world first by successfully generating fire whirls on slash piles near Twizel this year.

The activity was part of ground-breaking research aimed at protecting firefighters and communities from the devastating impact of future wildfire events.

Fire whirls/vortices, or fire tornadoes, occur during extreme wildfire events around the world, and are a major safety hazard to firefighters in the field. However, until May, they had never been deliberately created in the field and at scale.

The research team was made up of New Zealand and international researchers studying extreme wildfire behaviour as part of a programme funded by the Ministry of Business, Innovation and Employment (MBIE).

Jason Forthofer, a researcher with the USDA Forest Service, is a leading expert on wildfire vortices who has been studying fire whirls in a laboratory environment. He says generating a fire vortex had never been attempted anywhere in the world outside a laboratory before the experimental burns in New Zealand.

Scion science lead Shana Gross says the experiments were designed to isolate the fire whirl outside a wildfire and study the factors that cause fire whirls to form.

"We are still analysing the data, but we have learned that there are several elements that contribute to the formation of a whirl, including the fire's configuration relative to wind, wind shear, fuel moisture and the high release of energy coming from multiple sources that intersect. We also know as the inflow increases, the probability of whirl formation decreases."

A 'watch-out' situation observed at the experimental burn is to be aware of changes in smoke direction – if the horizontal smoke plume suddenly becomes vertical a whirl may form, Gross says.

Research collaboration

Scion's strong relationship with Fire and Emergency New Zealand (FENZ) was a key factor in locating the research in New Zealand. The Twizel area was chosen because of the landowner's support and the favourable experimental conditions that factored in topography, weather and vegetation. FENZ provided operational support during the field work, with crews from several Mid-South Canterbury volunteer brigades and the Department of Conservation onsite for each burn, helping to extinguish the piles once the scientists finished their monitoring and assessments. Each burn day also provided valuable training opportunities for FENZ, giving new team members exposure to incident management.

Twenty-four scientists were involved in the field work, with nine wilding pine slash piles of various sizes burned over four days.

After igniting the 20-metre-wide slash pile, the research team was able to generate a 'smoke devil' that took up the flame and generated a fire whirl. This whirl was the longest sustained whirl achieved during the research trials. Instruments on site recorded at 10 to 100 times per second.

The research group committed more than NZ$477,000 worth of sophisticated equipment to monitor, measure, and analyse the fire whirls. Data was collected using high speed thermal infrared cameras, visual cameras, UAVs, heli-kites and LiDAR technology on loan from San José State University. The team used the equipment to measure the temperature inside the fire whirl, the inward wind flow, and atmospheric conditions.

Boosting knowledge

In preparation for the experiments, four sets of wilding pine slash piles were established. The site was previously covered in wilding pines and was partially burned in the Pukaki Downs wildfire in September 2020.

The first of the burns took place on May 2 when five-metre diameter piles were ignited. The 10, 30 and 20 metre-diameter piles followed over different days. The team observed that even with low intensity fires, the smoke plume stood up despite continuous light wind, just before the vortex formed. This has previously been observed on large fires and scientists say observing it in lower intensity fires may indicate that this is a pattern that will hold in variable conditions.

Scion research lead Hugh Wallace says the experiments were a valuable data collection exercise.

"With every fire whirl experiment the team learned the sensitivities of the variables that produce fire whirls in forest debris and wilding pines.

"These burns were aimed at increasing our understanding of thresholds; atmospheric, environmental, fire intensity and fuel condition that must be crossed to generate a fire whirl. When these are understood, we can better predict their cause and spread."

The research in Twizel successfully generated fire whirls in the field – a world first at this scale. After igniting the slash pile 20 metres in diameter, the research team was able to generate a 'smoke devil' that took up the flame and generated a fire whirl.

Smoke devil: The vortex formed on ignition, picking up both smoke and dust. Dark smoke in a vegetation fire indicates a hot fire, with the fine fuels of the wilding pine slash burning rapidly. During the experiment, any dark smoke quickly disappeared as the fire increased in intensity.

Global threat rises

Worldwide and in New Zealand, the occurrence of extreme wildfire is accelerating, affecting both rural communities and those at the rural-urban interface. The direct cost of wildfire on New Zealand's economy in 2020 was $142 million. By 2050, this is predicted to cost $547m each year due to the changing climate.

While a growing number of fire whirls are being recorded globally, studying a fire whirl in a running vegetation fire is nearly impossible as so little is known about what triggers their formation, Forthofer says.

"Improving firefighter safety is always a top priority and this research helps by making it easier for firefighters to see when the conditions are right for a vortex to form."

The activity was part of the Scion-led Extreme Wildfire Research Programme. With investment from MBIE, it runs until early 2026.

A fire whirl as viewed by a UAV used to capture the experiment.

Wilding offenders:

A new hybrid pine?

Scion ecologist Matt Scott surveys an aggressive lodgepole pine re-invasion following control operations.

Scion's wilding pine research is providing insights into tackling re-invasion risks and developing management strategies to break the cycle of treatment and re-invasion.

Wilding conifers are a major threat to New Zealand's environment and economy. Understanding how these species invade and re-invade the landscape is critical to win the battle against these invasive trees. Re-invasion is a complex puzzle and Scion's research supports a nationally coordinated approach to control these problem pines.

New Zealand is a testing ground and our research helps with global understanding of what drives such biological invasions. Together with collaborators, Scion's invasive plant ecologists in the Vive la résistance (VLR) research programme have sampled hundreds of plots, measuring thousands of trees across five regions of New Zealand (Kaweka Range, Molesworth, Craigieburn, Mackenzie and Mid-Dome) to quantify re-invasion following control.

Scion's VLR programme leader Thomas Paul has been researching wilding pines since 2016. He says New Zealand wilding pine invasions and their control is far further developed than in other countries across the southern hemisphere.

"This gives us the unique opportunity to study this situation and provide critical learnings to reverse invasion impacts and the know-how to manage wilding invasions and their re-invasion cycles."

Preliminary results show that current control measures such as hand weeding, felling or herbicide application are unlikely to achieve eradication, and re-invasion is occurring.

One of the reasons for this could be that New Zealand may host a unique hybrid of *Pinus contorta* (Lodgepole pine), the worst wilding offender.

This hybrid produces larger cones and more viable seeds – both traits that could contribute to increased invasiveness. The supposed hybrids might also possess adaptations facilitating reinvasion, but also making populations resilient to climate change.

Biosecurity New Zealand National Wilding Conifer Control programme manager Sherman Smith values Scion's expertise. "The return of wildings to each control site can be wildly different. There are many different methods we use at different sites and in different environments.

"The new insights from Vive la résistance will help us understand their effectiveness on a longer scale than we have so far and give us greater information on how control methods are influencing re-invasion.

"Working with the team from Scion to support this research is definitely adding value both ways."

The wilding pine problem

Wilding pines are introduced species, such as Lodgepole pine, that have become invasive in susceptible environments. If not managed well, they threaten native ecosystems and the biodiversity within them, impact production lands (grazing) and change the vistas of iconic landscapes.

Wilding pines already cover more than 1.8 million hectares of New Zealand with further conservation and productive land threatened over the next 30 years.

The New Zealand Government established the National Wilding Conifer Control Programme (NWCCP) in 2016 to deal with this growing problem but continuous management is required. One-off treatments cannot eliminate wildings and prevent the re-invasion of cleared land – repeated cycles of maintenance are necessary.

Vive la résistance – managing wilding conifer re-invasion

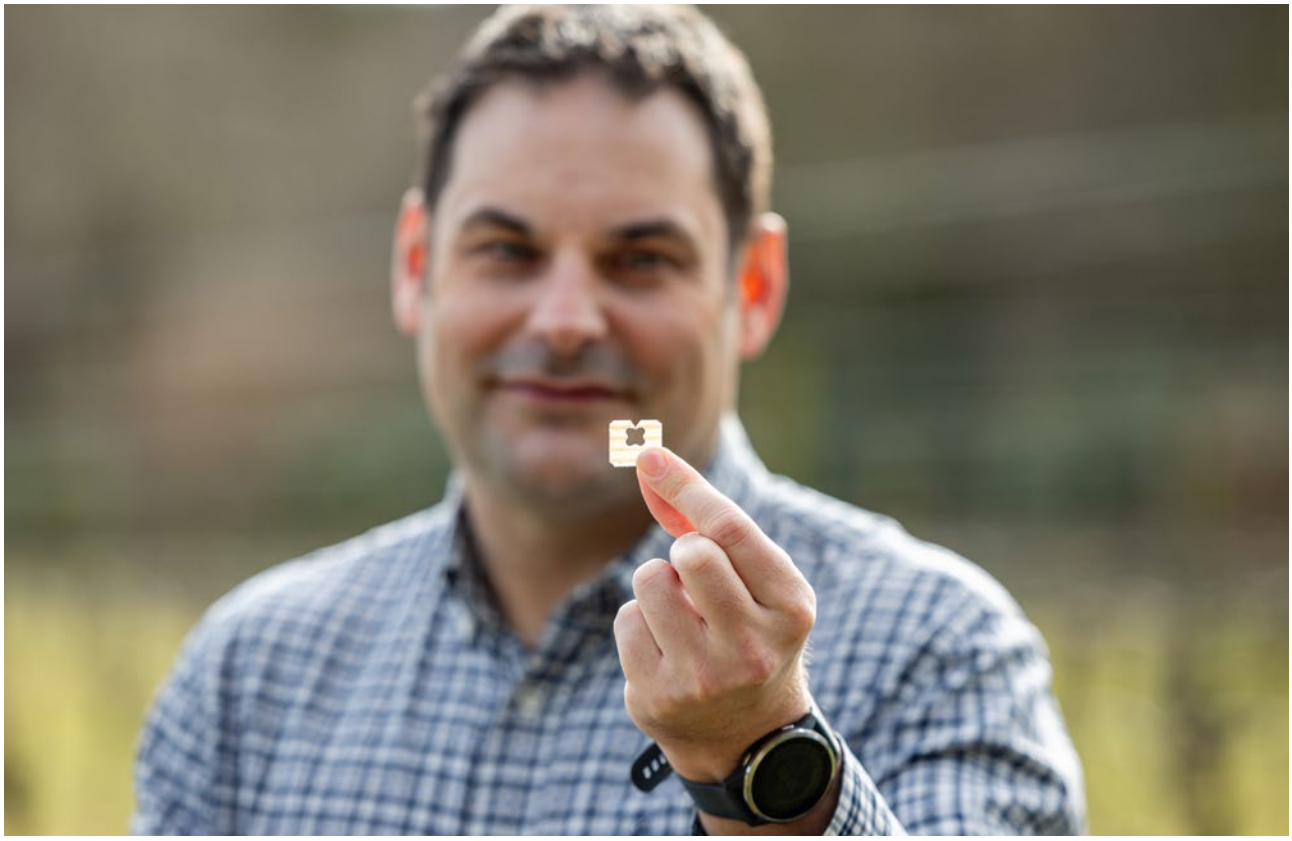
The Scion-led programme is an MBIE Endeavour-funded five-year research programme awarded $12.85 million in 2021. The team provides ongoing evidence-based operational and technical advice to support the NWCCP activities managed by Biosecurity New Zealand, a part of the Ministry for Primary Industries. VLR research results have already been implemented in large-scale aerial spray trials, planning and quality assurance measures of ground-based operations and providing science-based monitoring and advice on best practice guidelines for aerial spray operations.

The highly collaborative programme involves researchers from Lincoln University, University of Canterbury, Manaaki Whenua, Australian National University, and the National Centre for Atmospheric Research (USA). The NWCCP also contributes programme support.

The VLR programme is helping to understand the drivers of re-invasion risks. The knowledge gained will help with a move towards effective wilding pine management practices to break the inevitable cycle of treatment, re-invasion, and re-treatment.

Learn more:

Biodegradable vine clips go global



PolyNatural® general manager for Sales and Marketing, Gareth Innes, with the biodegradable vine clip.

Solving the problem of microplastic pollution in vineyards has led to even more eco-friendly products for one company.

A successful research partnership with Scion is bearing fruit for a Christchurch company exporting biodegradable vine clips and filling demand from global winegrowers for more sustainable practices on their vineyards.

Starting this year, PolyNatural® has taken commercial orders for its eco-friendly vine clips from vineyards across South Australia and New Zealand. Made from biodegradable polymers and waste materials sourced from wood processing, the vine clips are designed to replace traditional plastic clips that are used to hold nets over ripening grapes to keep birds and other pests away. About 30 million of these plastic clips are used by the New Zealand wine industry every year.

Reaching the export milestone follows extensive product development and trials on vineyards in New Zealand and comes five years after the first prototype clip was created by Scion scientists in collaboration with PolyNatural®'s parent company EPL.

PolyNatural® general manager for Sales and Marketing, Gareth Innes, says the commercialisation process has been a journey of discovery.

> Scion's research support and the feedback we received during trials has helped us to create a world-class product.
>
> GARETH INNES

"Good things take time and we've spent several years collaborating with Scion by testing formulations, using different materials and doing a lot of field research to develop a product that we're confident winegrowers are very satisfied with.

"Scion's research support and the feedback we received during trials has helped us to create a world-class product that is helping the global wine industry combat a major environmental issue."

Stamping out plastic waste

Vine clips and netting are essential to wine growing operations for pest management and to prevent fruit loss. But after six to eight weeks, nets are removed, and clips fall to the ground. This leaves a growing pile of non-degrading plastic littering vineyards that, over time, contributes to microplastic pollution.

With the viticulture industry keen to adopt more sustainable practices and stamp out plastic waste, Scion began developing a faster-degrading vine clip made of grape marc and bioplastic. Led by researchers Dawn Smith and Stephanie Weal, Scion trialled different prototypes in the field, testing numerous formulations before arriving at the right mechanical and physical properties.

> Everyone knows that they can't recycle their way out of the environmental plastic problem.
>
> GARETH INNES

In 2020, EPL took up the challenge of improving the clip even further and getting it ready for production at scale. "The technology and materials that we're using now are different to what they were five years ago, but we couldn't have achieved what we have if it wasn't for the work that Scion did in those early trial stages," Innes says.

In 2020 EPL and Scion were recognised at the Sustainable Business Awards by winning the award for Outstanding Collaboration for the work on the predecessor to the PolyNatural® vine clip.

The vine clips are 100% biobased using renewable materials that have no petrochemicals or toxic additives and comes from waste generated from processing wood. That waste is then fermented using micro-organisms and shaped to create a durable clip that can fully degrade in the right soil conditions.

Opportunities ahead

Lessons learned during the commercialisation process and further market research has sparked additional biodegradable products for the horticulture, viticulture and marine industries.

To support demand for riparian planting and land revegetation projects, PolyNatural® began trialling biodegradable plant protectors in 2021 to improve the survival rates of young plants from pests and the elements. The product range was launched commercially earlier this year.

PolyNatural® is also working on eco-friendly ties for the kiwifruit industry. "There's huge market demand for our prototype as we estimate the industry uses about 100 million plastic ties every year to hold their vines down," Innes says. Currently, most vine ties end up on the ground.

New Zealand's fishing and aquaculture industries are also set to benefit from PolyNatural®'s technology and business growth. It is part of a collaboration that is working to solve the problem of plastic waste at sea caused by abandoned or lost fishing gear. Early testing is underway of a new biobased material that could be used in a range of durable products designed to fully biodegrade in marine and freshwater environments.

Industry benefit

Scion business development manager Jeremy Warnes says the PolyNatural® and Scion partnership has been a real success story.

"While not exclusive, our trusted relationship with them dates as far back as 2007 when we started throwing a few ideas around with EPL and exploring ways we can work together to have a positive impact on the environment.

"Our scientists provided biopolymer expertise and research that has helped to kickstart these commercial products. But EPL and now their business unit PolyNatural® must be given enormous credit for developing the technology further and for getting the vine clips market ready."

Several New Zealand winemakers have successfully trialled the clips, including Cloudy Bay Vineyards in Central Otago and Marlborough. Central Otago Vineyard manager Derek Beirnes describes them as the "perfect product."

"Each clip does what it needs to do, whilst being environmentally friendly."

As well as targeting the Adelaide wine growing region, PolyNatural® is planning to export its vine clips to Canada and France, with support from New Zealand Trade & Enterprise.

Innes says winegrowers around the world are hungry for sustainable products. "Everyone knows that they can't recycle their way out of the environmental plastic problem. We're very proud of the mahi tahi (collaboration) that has gone into these products, which are providing solutions for New Zealand, in New Zealand, with benefits to the world.

"These products are the future for industry."

Vine clips and netting are essential to wine growing operations for pest management and to prevent fruit loss.

Recognising staff achievements

Scion's leadership in biofuel, microplastics and climate change adaptation was celebrated by Scion and peers at the 2023 Science New Zealand Awards.

Scion's high achievers have been recognised at the 2023 Science New Zealand Awards.

Scientists from all seven Crown Research Institutes and Callaghan Innovation were represented at the awards ceremony in Wellington on December 6. The awards were in three categories – Early Career Researcher, Lifetime Achievement and Team.

Scion chief executive Dr Julian Elder says the awards are a fantastic opportunity to connect with others in the science and innovation space and acknowledge achievements.

"The awards show the depth and breadth of the important work we do at Scion and the effort our staff put in every day."

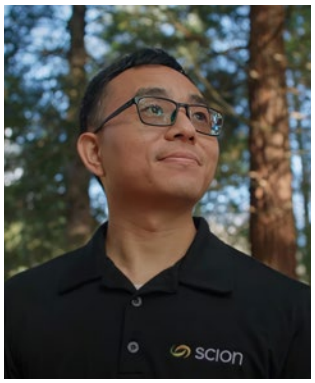
A friendly face and mentor to many, Dr Bing Song received one of eight Early Career Researcher Awards.

Since joining Scion in 2019, Song has been a primary author on eight papers and one international report, a corresponding author on six papers, and co-authored another 12 papers. To date, 31 of his 25 papers have been published in Q1 journals.

He leads the Solid Biofuel project, which was recently showcased at MOTAT, Auckland's Museum of Transport and Technology, when biofuel briquettes were used to power a 132-year-old steam tram.

Song also actively reviews papers for journals in his field, PhD theses for universities and is an editor of two international academic journals. Song works to mentor and grow his colleagues.

The Team Award recipient from Scion was the microplastics team. The team has been working to address a major knowledge gap in environmental science in New Zealand, asking how much microplastic is in our marine environments, what is it, where is it coming from and what environmental consequences does it have?



(L) Early Career Researcher awardee Dr Bing Song, whose award was received on his behalf. (R) Individual/Lifetime Achievement Award recipient Dr Tanira Kingi.

The team has contributed to a wide range of programmes including fundamental research, community engagement and outreach, and commercial projects with New Zealand businesses.

The insights from this research will lead to strategies to reduce microplastics pollution and its impact. Risk assessment and education around reducing microplastic pollution will be the next steps.

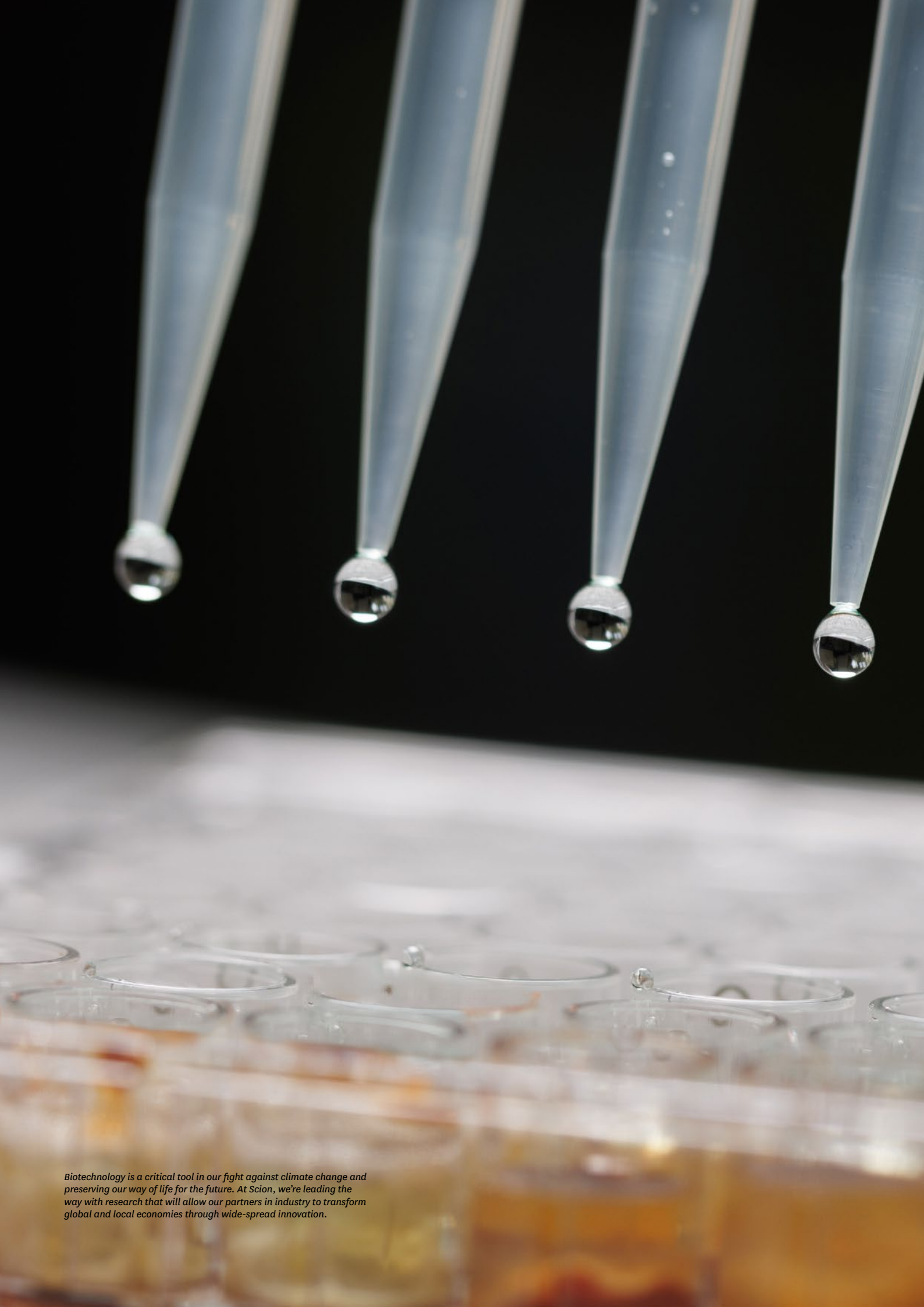
The third award category was the Individual/Lifetime Achievement Award presented to Scion emeritus scientist Dr Tanira Kingi (Ngāti Whakaue, Ngāti Rangitihi, Te Arawa, Ngāti Awa).

His more than 30-year career has covered agriculture, forestry and horticulture. In his time at Scion as research leader in primary industry systems, Kingi worked collaboratively with teams across the organisation, providing mentorship and strategic advice.

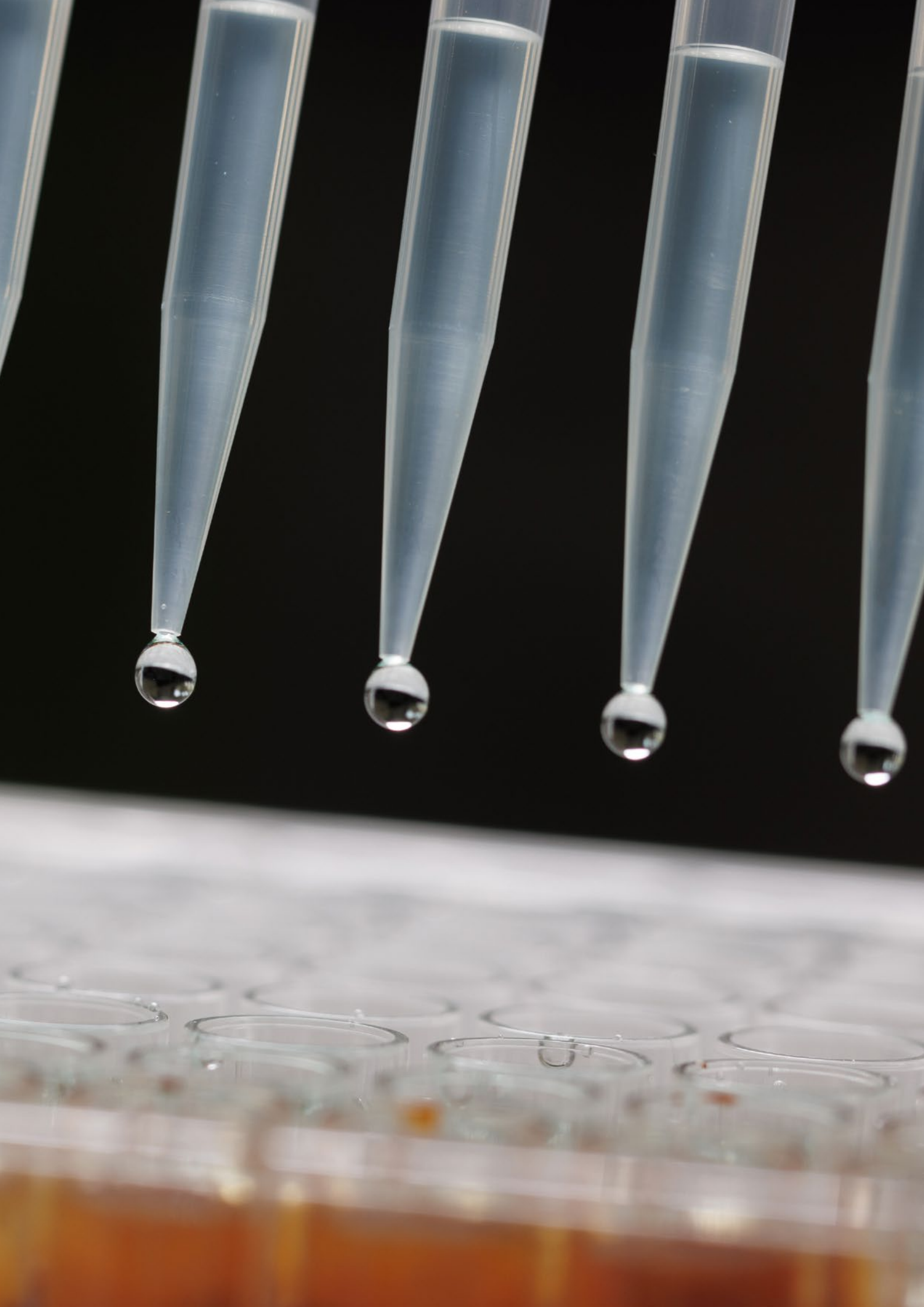
He now provides strategic direction as an emeritus and holds several government and ministerial advisory group appointments, including serving as a Climate Change Commissioner.

His ethos centres around developing research that has impact and drives change. His work has included invaluable contributions to environmental sustainability, land use optimisation, and business resilience.

The microplastics team (from left): Lloyd Donaldson, Beatrix Theobald, Ross Anderson, Ben Davy, Kate Parker (project leader), Robert Abbel, Anna de Lena, Maxime Barbier, Steph Davy, Jamie Bridson, Queenie Tanjay. Not pictured: Regis Risani.



Biotechnology is a critical tool in our fight against climate change and preserving our way of life for the future. At Scion, we're leading the way with research that will allow our partners in industry to transform global and local economies through wide-spread innovation.

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