SCION™
FORESTS ▪ PRODUCTS ▪ INNOVATION

2021 ANNUAL REPORT
HIGHLIGHTS

Annual Report 2021 Highlights

Presented to the House of Representatives pursuant to section 44 of the Public Finance Act 1989.

Our Annual Report is presented in two parts – Highlights (Part A) and Reports and Financial Statements (Part B). Together, both documents fulfil our annual reporting responsibilities under the Crown Research Institutes Act 1992 for the year ended 30 June 2021.

The Reports and Financial Statements (Part B) includes the employment and environmental reports, directors' report, performance targets and financial statements.

Our Annual Report is also available in digital format at www.scionresearch.com/annual-reports

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Cover: *Scion's new innovation building – Te Whare Nui o Tuteata.*

Previous pages: *The wooden ceiling in Te Whare Nui o Tuteata was inspired by the structure of the radiata pine genome with the arrangement of lights reflecting the Matariki night sky.*

Contents

At a glance

Operating revenue **$61.1m** Last year: $57.9m

Total comprehensive income **$4.9m** Last year: $5.5m

Return on equity **9.3%** Last year: 11.8%

Full-time equivalent staff **328**

294 Rotorua **2** Wellington
32 Christchurch (includes fixed-term, student and postdoctoral staff)

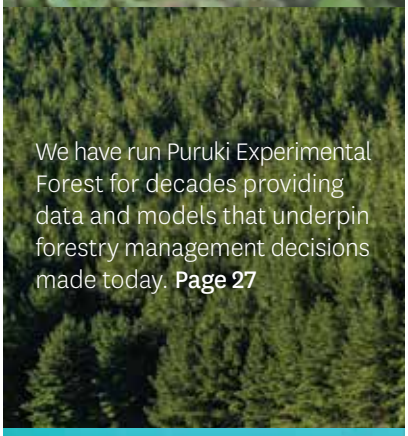
Published refereed papers **144**

96.56 rolling 5-year weighted average H-index

Commissioned reports to users **262**

We are putting partner aspirations at the centre of our Te Ao Māori approach; to build resilient, enduring partnerships to go beyond Vision Mātauranga. **Page 10**

We are improving propagation techniques and technologies to accelerate production and establishment of indigenous trees. **Page 20**



We have run Puruki Experimental Forest for decades providing data and models that underpin forestry management decisions made today. **Page 27**

We are using our wood pulping experience with partner AgriSea NZ making novel seaweed gel products that could replace fossil fuel-based products. **Page 28**

Vision, mission and strategy

Our core purpose

To drive innovation and growth from New Zealand's forestry, wood product and wood-derived materials and other biomaterial sectors, to create economic value and contribute to beneficial environmental and social outcomes for New Zealand.

Trees are remarkable, renewable resources. Planted as forests, and used in products and materials, trees have a powerful potential to be at the heart of a low-carbon, biobased future New Zealand.

Our vision

Prosperity from trees - Mai i te ngahere oranga

Our mission

Enhancing New Zealand's prosperity, well-being and environment through trees - Kia piki te ora, te taiao me te whai rawa o Aotearoa mā te ngāherehere

Scion's Strategy to 2030, sets out three research impact areas that focus our expertise to deliver on our aspirations for New Zealand and supporting the Government's goals.

Our research impact areas are:

Forests and landscapes. To grow healthy, resilient forests that are planted primarily for their standing-forest benefits.

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

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

Chair and Chief Executive overview

Challenges, celebrations and change

The 2020-21 year was both challenging and promising as we, like many other companies and organisations, returned from COVID-19 lockdowns to face a new normal imposed on us and as shaped by us.

With support from the Government we were able to maintain our science capability throughout the year. While COVID-19 delayed the joint MBIE-Scion work on long-term funding solutions for Scion we did complete the penultimate step in this work, which was the external science review. This review, indeed, validated our capability and future direction. We look forward to exploring the options identified to address our funding going forward.

New Zealand's planted forests, which give us wood and much more, is where our nation needs to look to help shape a sustainable future that responds to global and local forces for economic and environmental change. We see this happening by valuing the forestry sector as a rich strategic resource.

The science skills shortage resulting from border restrictions was challenging and continues to be so. Historically, Scion has relied on attracting more skills to New Zealand to enhance the expertise available here. Currently only 60 per cent of our scientists are homegrown, and they work alongside colleagues from Europe, USA, Asia, Middle East and Latin America. While we have initiatives to develop domestic research talent, Scion must continue to import additional skills to enable excellent science and upskill our local workforce. At the same time, we are at risk of losing our valuable and talented visa-holding scientists for whom the situation remains stressful as their pathway to residency is long, unknown and expensive.

Despite these challenges, we had much to celebrate in the year. Our proud moments were the honour bestowed on us by Ngā Hapū e Toru, Ngāti Hurungaterangi, Ngāti Taeotu me Ngāti Te Kahu o Ngāti Whakaue, who blessed and named our new innovation building in October 2020 followed by the official opening of the building – Te Whare Nui o Tuteata – by the Prime Minister in March 2021. As our new front door, Te Whare Nui o Tuteata, represents what is possible with wood when imagination, belief and skill combine.

New Zealand's planted forests, which give us wood and much more, is where our nation needs to look to help shape a sustainable future that responds to global and local forces for economic and environmental change. We see this happening by valuing the forestry sector as a rich strategic resource.

Our right tree, right place, right purpose approach has our research focused on the things that matter for New Zealanders – enhancing indigenous forestry, mitigating climate change and improving environmental outcomes, and replacing the petrochemical-based economy with one that is circular and biobased providing truly sustainable processes and products.

Some highlights of our research concluded or ongoing in the 2020-21 year are described in this report including the roll out of Ellepot propagation technology to efficiently supply trees for forestry, revegetation and restoration projects. Industry partners involved will benefit from easier, faster and cheaper planting.

Tested over years by Scion entomologists, a biological control agent for the destructive giant willow aphid was approved for release in New Zealand. Monitoring showed that not only did the agent – a tiny parasitoid wasp – overwinter, it multiplied exponentially with phenomenal spread. Beekeepers, river managers, soil conservationists and farmers directly benefit from this success.

A 30-year experimental monitoring of forest ecosystem nutrient levels and forest productivity on sites throughout New Zealand was competed by Scion scientists. The results, published in 2021, showed that soil nutrient levels and forest productivity can be maintained with site-specific management. The knowledge gained has led to changes in forest management and strengthened our relationship with the industry.

Puruki Experimental Forest, managed by Scion, is an exemplar of a sustainably managed, highly productive radiata pine planted forest that also delivers multiple ecosystem benefits. Results from Puruki have been critical to development of nationally important tools, including C-Change, used for government carbon reporting, and the nutrient balance model NuBalM.

From research into growing forests sustainably, we also apply our science capability into manufacturing sustainably. A collaboration using our wood pulping expertise resulted in a novel seaweed gel product poised to take off. Our approach with partner AgriSea New Zealand will accelerate new, domestic nanocellulose-based

business opportunities playing an important part of the emerging high-value biomanufacturing sector.

Our "Clothes to roads" story introduces our work with textile recycling company Usedfully® where textile fibre is processed into unusual, yet very promising applications such as roading. Among the benefits of diverting textile waste from landfill is the potential for substantial reduction in GHG emissions.

Alongside the delivery of excellent science, our staff were engaged in co-designing our organisational realignment that proceeded throughout the year. The purpose of this reshaping was to ensure science capability and supporting systems and processes are aligned with our "Strategy to 2030".

COVID-19 has continued to be front of mind for everyone, so it is pleasing to report on our contribution to the fight against this pandemic. Scion's biotechnology team has been working with CVC (COVID-19 Vaccine Corporation Ltd) on an experimental vaccine, which is now in pre-clinical testing.

Alongside the delivery of excellent science, our staff were engaged in co-designing our organisational realignment that proceeded throughout the year. The purpose of this reshaping was to ensure science capability and supporting systems and processes are aligned with our "Strategy to 2030". We recognise that the process was unsettling and wish to thank all Scion employees for their patience and understanding. Now with the new science operating model in place, and the functional/support model almost complete we look forward to next year where we embed new ways of working.

Our revenue exceeded our expectations this year and coupled with the COVID-19 response and recovery funding (CRRF) support of $4.8 million resulted in total revenue of $61.1 million, up 5.5 per cent or $3.2 million on the prior year. Given the delay in the long-term funding review we continued our cost containment leading to a profit after tax of $4.7 million, similar to last year's $5.4 million result.

The next financial year is expected to have its challenges as we aim to grow our revenue and despite the CRRF coming to an end we are experiencing delays, resource limitations and cost escalation because of the disruption the global pandemic continues to cause.

Like last year, we again wish to express our pride in Scion's people for delivering excellent results in an environment of continued change. Our new leaders, appointed both within and externally, embraced their new roles quickly and provided a solid foundation for Scion to identify and prioritise the future research needed to bring maximum benefit for New Zealand and its people.

We also thank retiring directors Dr Barry O'Neil and Colleen Neville who both contributed hugely to Scion's direction and growth over the terms they served.

To all our customers and partners, we sincerely thank you for your contribution to Scion throughout the year.

Dr Helen Anderson QSO
Chair

Dr Julian Elder
Chief Executive

Welcome to Te Whare Nui o Tuteata

Removing our gates and welcoming the community onto our Rotorua campus through our unique new building heralded the start of a new era for Scion.

Before the doors opened, we were very honoured to be gifted a name for the building from mana whenua in a ceremony on 29 October 2020. The name 'Te Whare Nui o Tuteata' acknowledges Tuteata, the tupuna or ancestor of Ngāti Hurungaterangi, Ngāti Taeotu and Ngāti Te Kahu (Ngā Hapū e Toru).

"The gifting of our tupuna name signifies the beginning of a special relationship between Ngā Hapū e Toru and Scion, and its noteworthy partnership and cultural intent for the future," said hapū representative Veronica Butterworth.

Chief Executive Dr Julian Elder said, "We are honoured that the building has been gifted a name with such mana, and we will continue to uphold the mana of Tuteata by acknowledging the distinctive history of his land and working with his people".

The hapū have been integrated into the design of the building, and the triple peaks over the entry way represent the three hapū.

Te Whare Nui o Tuteata doors opened to the public in January 2021 drawing in many summer holiday visitors.

The Prime Minister, Rt Hon Jacinda Ardern officially opened Te Whare Nui o Tuteata on 31 March 2021 accompanied by Minister of Research, Science & Innovation, Hon Dr Megan Woods and 500 guests. Community,

Cutting the ribbon – mana whenua Veronica Butterworth and Diamond Marunui with Prime Minister Jacinda Ardern and Scion CE Dr Julian Elder.

innovation and partnerships were celebrated at the event.

Te Whare Nui o Tuteata showcases the latest in engineered timber products and manufacturing techniques within its bold and innovative structural form, while using products that are designed for our climate and meet our preferences for sustainability and environmental performance.

A powerful sustainably message is knowing that New Zealand's radiata pine forests can regrow the amount of timber used in the building in just 35 minutes.

The design creativity and technical innovation evident in Te Whare Nui o Tuteata is being recognised in New Zealand and overseas in architectural and engineering awards.

Open daily, Te Whare Nui o Tuteata comprises an exhibition area, public café, main reception, meeting rooms and work spaces. Upper floors are used by staff, tenants and local enterprises wanting a stimulating, shared working environment. For our 32 tenants within Te Papa Tipu Innovation Park, the building provides an enticing place for their staff and visitors to meet.

Partnering and co-innovation with Māori

Scion's commitment to support the development of more Māori-led research saw the establishment of a new Te Ao Māori Research Group within Scion. Comprising a team of 12 kaimahi currently, the team will grow further to ensure delivery against Scion's Strategy to 2030 and the Māori Forestry Futures Strategy which will in due course influence the way that Scion makes operational, investment and values-based decisions.

Our aim has been to put partner aspirations at the centre of our Te Ao Māori approach; to build resilient, enduring partnerships to go beyond Vision Mātauranga. Scion recognises that partnerships with Māori – as well as new and emerging industries, and central and local government – are critical to driving innovation from New Zealand's forestry to achieve impact. We have listened to Māori experiences within the science system and acknowledge there is more that we can do to advance Māori interests and commit to meaningful and more satisfactory collaboration.

The Te Ao Māori Research Group will continue to build on three existing focus areas – Māori partnerships, mana whenua and Māori cultural competency – as well as strengthen our support for Māori-led and kaupapa Māori-based science and research.

Te Ao Māori research

At the heart of our Māori research sits people, whenua, the taiao and resources. The exercise of kaitiakitanga over indigenous flora and fauna, land, water, forestry and other natural resources places responsibility for taonga (mātauranga Māori assets and cultural treasures) use with Māori. Scion acknowledges the Treaty of Waitangi, and as a Crown research institute we are committed to giving meaningful effect to the Treaty partner relationship.

Also, we give effect to the significant and unique impact that Māori people, resources and knowledge can contribute to New Zealand and global forestry and biobased futures. This means recruiting, developing and promoting culturally skilled scientists and researchers to deliver quality outcomes in science and impact through these specialist areas of knowledge. This will be Scion's commitment to Aotearoa in years to come.

We have appointed leadership into the strategic areas of the business with two wahine Māori working as portfolio leads to drive research, science and innovation projects designed to achieve impact in: Restoration, Protection and Mauri of Te Waonui a Tāne, and Distinct Value of Indigenous Wood Products. These leaders along with others in Te Ao Māori Research Group will be leading our representation, and continuing to introduce our partners into emerging Māori IP, Māori genetics, and Māori data sovereignty forums and discussions.

Māori cultural competency

Scion has an important role in enabling the advancement of Māori aspirations to achieve transformational impact in regional communities. To do this effectively, it is crucial that we keep our staff culturally safe, equip them for quality engagement and demonstrate our commitment to working in a quality way with tangata whenua.

Scion will continue to invest in our people to increase capability and capacity. Over the past 12 months we engaged the services of Te Whenua Consulting to provide advice on training and deliver Treaty of Waitangi/Wai 262 workshops to more than 70 staff including our executive and Board. These workshops provided our staff with greater insight into how Te Tiriti applies in our work and society in general, and particularly the consideration we must give to Wai 262 when embarking on our science and research projects.

With the development of critical capabilities in Scion, the space created will enable Scion and Te Ao Māori to achieve mutually beneficial outcomes.

Scion Chief Executive Dr Julian Elder and Chair of Scion's Board of Directors Dr Helen Anderson to the left with mana whenua representatives Veronica Butterworth and Hokimate Kahukiwa.

Mana whenua at Te Papa Tipu

We are immensely proud of our distinctive relationship with mana whenua - Ngāti Hurungaterangi, Ngāti Taeotu, Ngāti Te Kahu (Ngā Hapū e Toru). Providing on-site residence for a mana whenua representative has enabled a more meaningful partnership to occur, and Scion has embraced the leadership, advice and guidance generously provided by mana whenua.

Ngā Hapū e Toru gifted the name of their eponymous ancestor, Tuteata, for the grand new whare 'Te Whare Nui o Tuteata'. Scion acknowledges and embraces the duty of care for the name and the cultural and partnership intent.

A kawenata (covenant) is being developed between Scion and Ngā Hapū e Toru to formally establish an enduring and intentional partnership.

A new position was created within Scion, co-appointed with mana whenua and supported by Te Uru Rākau and Timberlands, to provide a permanent voice and continued participation of mana whenua at Te Papa Tipu.

Māori partnerships

Scion's relationships with Māori have significantly improved in recent years and as a consequence, Māori world views and aspirations for economic, environmental and social well-being now find themselves woven into our own mission – "Kia piki te ora, te taiao me te whai rawa o Aotearoa mā te ngāherehere".

The following projects show how the work and aspirations of Te Ao Māori endure through our research, science and innovation.

Forestry plan for Tūhoe Tuawhenua Trust

In partnership with the Tūhoe Tuawhenua Trust and Manaaki Whenua Landcare Research our role in this One Billion Trees partnership is to provide advice on the implementation of a forestry plan for the trust, assessment of establishment trial plots, propagation experiments with selected species, support for seed collection, growing, propagating and transplanting, along with analysis of data collected and reporting.

The trust aims to enrich their forest from a number of perspectives – biodiversity, cultural value, carbon and production potential in areas such as honey or timber. The trust also seeks to enhance their science and propagation skills through this project.

Mai te rangi ki te whenua, mai te whenua ki te rangi

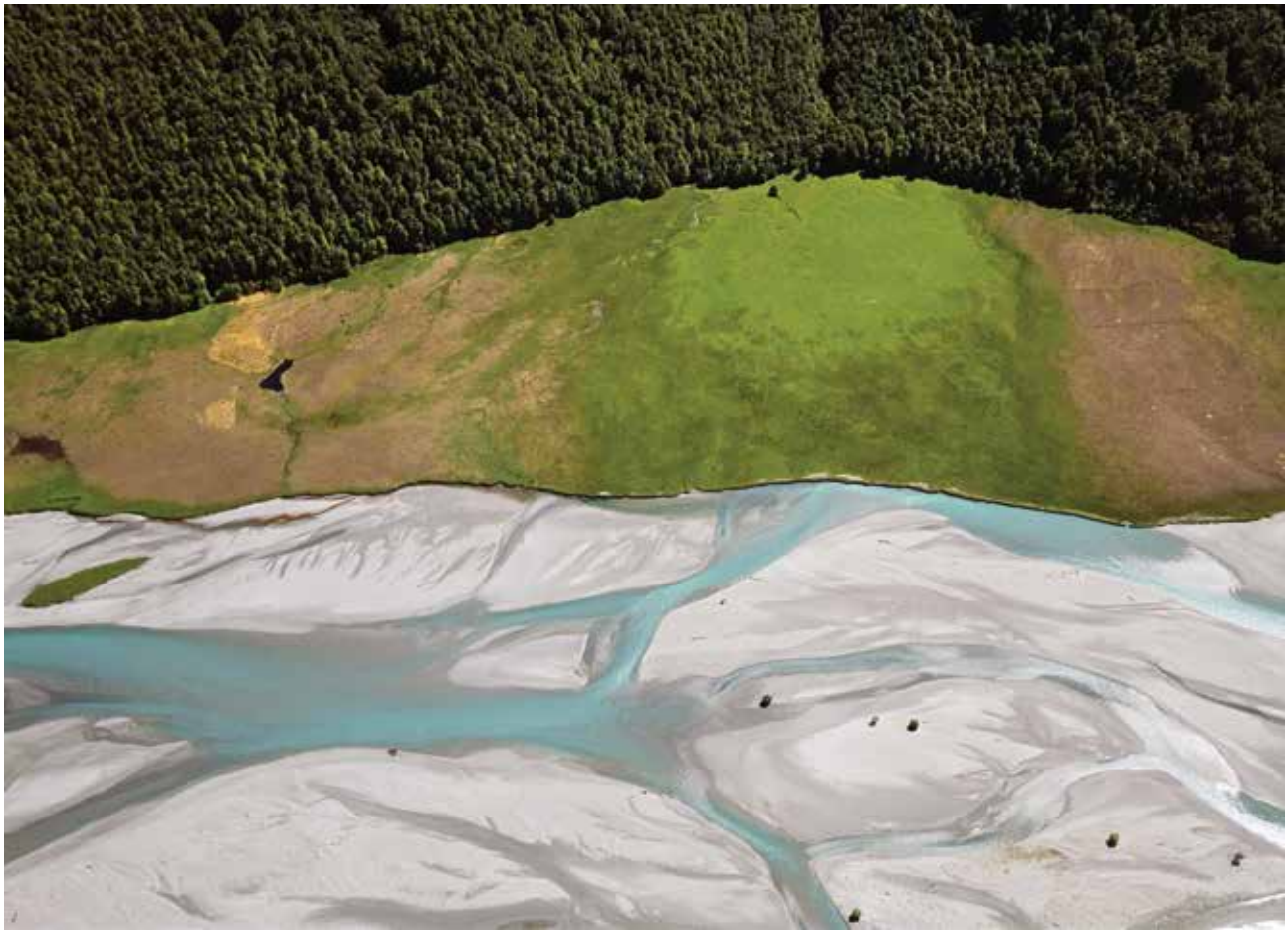
Land, water, climate and communities in New Zealand are part of a large web of interconnected systems undergoing significant change owing to numerous events of natural and anthropogenic origins. With increasing frequency of disruption to these systems the adverse impacts to the physical and spiritual well-being of the environment are felt by Māori.

Scion recently completed a literature review applying kaupapa Māori methodology, resulting in the identification of five actions that support the well-being of land, water and indigenous people from a uniquely Māori perspective:

- Engage with tāngata whenua to incorporate their values into policies, plans and decisions that affect land and water;
- Strengthen the practice of traditional and contemporary tikanga (holistic methods) on the whenua;
- Support opportunities to enhance kaitiakitanga;
- Conserve and restore wāhi tapu (culturally significant sites); and
- Revitalise the use of traditional Māori place names.

The actions emerged from a range of literature including journal articles, iwi hapū management plans, books, videos and news stories. Issues and considerations surrounding the research and the findings explored data sovereignty, inequitable treatment of indigenous Māori knowledge, communications and limitations of the literature review.

This literature review contributes to the Our Land and Water National Science Challenge to support the development of a free online tool that will record efforts to improve water quality.



Māori digital innovation

Scion has been working with Heritage New Zealand Pouhere Taonga and NIWA as part of the High Impact Weather strand of the Resilience to Nature's Challenges Kia manawaroa – Ngā Ākina o Te Ao Tūroa National Science Challenge on a larger project investigating the impact of weather on New Zealand.

The project will create physical datasets of extreme weather not previously available to researchers and a more comprehensive and collective understanding of these adverse effects on communities, infrastructure and economic activity. For Māori, access to datasets of extreme weather will assist in making informed decisions about those heritage sites that are uniquely important to them including marae, urupā, old gardening sites and archaeological sites to name a few.

As one of the initial outputs to support the larger project, Scion commissioned a Māori Digital Innovation review that looked at the nature of the relationship between indigenous knowledge practices and the regimes of technological design; how can Māori be better engaged in the digital design space; what Māori heritage site factors need to be considered and what forms are likely to be considered 'non-shareable'; and lastly what is being said about digital spaces and the building of resilient indigenous communities.

The review concluded that to develop any digital space for or about Māori would require the development of an ethical approach, policies and procedures in consultation with tangata whenua. The protocols include mātauranga and tikanga Māori lore concepts adopting a collaborative, co-governance and co-design approach that recognises mana whenua.

Although the review investigated Māori in a digital space, the reality is that Māori are already creating innovative designs that adopt a taonga tuku iho methodology and the promotion of reo and tikanga. It is for the science discipline to get to know a Māori worldview to better engage with Māori digital innovation and design. Additionally, the pairing of the two is ideally bringing together the best of both worlds collaborating to achieve creative solutions for future generations.

Recognition for the Tōtara Industry Pilot

The Tōtara Industry Pilot (TIP) was a finalist at the 2021 Primary Industry Awards in the Innovation and Collaboration category. While the Pilot did not win this category, they received special recognition for outstanding cultural collaboration with Māori.

The TIP initiative is a partnership with Taitokerau Māori Forests Inc, Tane's Tree Trust, Te Uru Rākau, Northland Inc and was led by Scion. TIP was a two-year project, which ended in August 2020, that tested the opportunity for a new industry based on regenerating tōtara on private land.

Scion is continuing to provide support to the project lead, Taitokerau Māori Forests Inc, who are looking to commercialise the opportunities identified.

More information on the project can be found here: www.totaraindustry.co.nz

Rewena Tuatahi

A project with Koa Holdings Limited and Massey University has developed potato skin-based packaging for a new healthy and functional traditional rewena bread product. The goal of the collaboration was to add value to the 100-year-old potato sourdough starter culture. During the two-year Vision Mātauranga Capability Fund (MBIE) project, the partners worked together to complete several phases of development, incorporating the documentation of a Māori kai tradition for revival and innovation. The partners are presently planning the next stages.

Replanting Rēkohu

Building on Scion's relationship with Moriori groups on Rēkohu (Chatham Islands), hakapiri seed gathered there have been tended to and grown in Scion's Nursery over the past year. Reaching a viable stage of maturity, these were delivered back to Rēkohu in June 2021 for planting.

This project is the first in a series of kaupapa that will see the replanting of Rēkohu and other islands of the Chathams, along with propagation experiments and establishment trials.

Being 800 km offshore, the Chatham Islands have distinctly unique native species and local conditions. Scion has been building strong relationships with the Chatham Islands over the last four years, supporting Moriori aspirations to build a sustainable future.

Seven generational Taiao and forestry plan for Ngā Ariki Kaipūtahi

This Vision Mātauranga Capability Funded (MBIE) project provides the opportunity to develop Matawhero Marcus Lloyd (Kaiwhakamarumaru (Protector) and Chief Executive Officer of Te Taua o Ngā Ariki Kaipūtahi Ltd) as an emerging iwi researcher while building the foundation for science capability to enable the development of Ngā Uri Taniwha - the seven-generation plan for Te Iwi o Ngā Ariki Kaipūtahi.

Ngā Ariki Kaipūtahi – situated in Turanga (Gisborne) - are co-developing a plan to build iwi and hapū science capability through the guidance, training, mentoring, access and networking offered by Scion two days per month. Their aim is to activate a "well land, well whānau" vision, including research for tribal leaders and landowners to understand and apply scientific methods to Mangatū catchment reforestation, river restoration and environmental plans to develop the skills and cultural futures of their people.

The work will support the wider body of the Iwi Seven Generation vision plan, strategic plans, business plans, funding plans, science plans and work programmes to enable Ngā Ariki Kaipūtahi to successfully manage its forest resources, Treaty settlement assets and taiao aspirations.

This project has a two-way flow of knowledge and transfer because it allows the sharing of mātauranga and values to Scion scientists.

Collaborating for impact

Scion's international and national reach is wide and deep. Through multi-disciplinary collaborations and networks our scientists are at the forefront of the latest thinking, novel approaches and technological advances. Maintaining and building on these linkages is critical for Scion to remain innovative and competitive in the domestic and global markets. Our presence and influence in key networks is well recognised as shown in the examples below.

Collaborating with VITO to produce bioaromatic polymers from lignin

Scion and VITO (Flemish Institute for Technological Research in Belgium) are in the second five-year term of their formal collaboration agreement. The collaboration includes a focus on biomass processing (especially lignin and hemicellulose), joint research on renewable and recyclable materials (with an emphasis on plastics and biopolymers) and scale-up of these technologies.

A specific collaboration is structured around the conversion of wood lignin into valuable bioaromatic chemicals that could replace petrochemicals in materials such as resins, adhesives, foams and coatings.

Scion and VITO have been working on lignin-derived bioaromatics since 2010. Together, the organisations are co-funding postdoctoral researchers that split their time between VITO in Belgium and Scion in New Zealand. Three postdoc fellowships have been funded to date with the fourth to start in September 2021.

Scion brings its expertise in wood chemistry, lignin extraction and separation, and chemical characterisation of products, which complements VITO's experience with technology scale-up initiatives.

Scion's Dr Kirk Torr and Dr Elias Feghali, the first joint postdoctoral fellow, have both been appointed to the science advisory board of a VITO-led project that seeks to set up a unique pilot infrastructure platform for innovative catalytic biorefinery of wood and lignin into functional biobased aromatics.

This work is part of the VITO LignoValue Pilot initiative to design a functioning pilot line in Flanders to produce bioaromatics from lignin/wood. Such a pilot-scale demonstration is crucial to de-risking an innovative 'lignin-first' biorefinery.

"Scaling-up from lab to pilot plant has been a major challenge for Scion in our lignin-based research. It is a privilege to contribute to VITO's industry leading projects, and it's giving us an enviable opportunity to learn from their experience and expertise for our own biorefinery aspirations," says Dr Torr.

The goal is development of a new biochemicals export industry in New Zealand. Extracting maximum value from underutilised forestry residues would support more on-shore wood processing and nearly double sector exports utilising the existing forest estate. As such, forest owners, businesses and companies along the entire forestry value network would benefit, as would local and regional government.

Tissue culture techniques for 21st century forests

Scion is collaborating with the New Zealand forestry industry and global experts to automate tissue culturing to enable new, improved radiata pine genotypes to be deployed more quickly and efficiently.

To achieve this, Scion is working with Forest Growers Research Ltd and international science partners Georgia Institute of Technology (USA) and the Natural Resources Institute of Finland.

Current tissue culture and propagation methods in forestry are labour intensive and take time. This limits the forestry industry from taking full advantage of the benefits of new radiata pine genotypes. The focus of the project is automating the somatic embryogenesis process using temporary immersion bioreactors. A first successful regeneration of radiata pine somatic embryos using the bioreactors has been achieved.

The forest industry will benefit from the greater application of varietals of elite genotypes, whether the end goal is timber production or carbon sequestration.

The project is funded by the Forest Growers Levy Trust and the Ministry of Business, Innovation and Employment.

Consolidating *Cordyline* for green composites

Tī kōuka (*Cordyline australis* or cabbage tree) is being developed as a natural fibre alternative in degradable bioplastics.

Scion brings its expertise and knowledge in polymer composite materials and process engineering to work with experts in mātauranga Māori, who provide traditional tikanga-led fibre collection and extraction techniques in developing natural fibre from tī kōuka leaves for use in degradable bioplastics.

The partners in the project include: ESR and Scion with expertise in bioplastics and chemical extraction methodology; fashion label Natura Aura which holds expertise in traditional high-quality extracting and working with harakeke (New Zealand flax) fibres; Tai Ahu (Hineuru Iwi Trust), advising on the best practice methods to protect mātauranga Māori; and Katarina Tawiri from Manaaki Whenua Landcare Research extending access to tī kōuka and sustainable harvesting practices.

The team has found traditionally extracted fibres are a lot stronger and more aesthetically pleasing than chemically pulped fibres, such as wood, linen and hemp fibres.

Partnering with Māori from the start, and working together, is building the capacity of the research community to genuinely collaborate with Māori organisations and industry, developing innovative technologies and building a sustainable and prosperous future for Māori and all New Zealand.

The work is funded by the Science for Technological Innovation National Science Challenge.

Tree-to-tree robot

Scion's tree-to-tree robot may have a home in Canadian forests helping to prevent and mitigate wildfires.

Scion has been working with FPInnovations, a private not-for-profit organisation that supports the Canadian forest sector, and design and engineering consultants inFact to design and build an improved robot with a chainsaw.

The robot has two arms equipped with mechanical jaws that allow it to 'swing' from one tree to another. Tools can be attached to the base of the jaw system allowing the robot to carry out forestry operations on hard to access, uneven ground.

FPInnovations recognised the potential for the robot to prevent and mitigate wildfire in Canadian forests. Slow-growing black spruce dominates Canada's forest. Even though most trees are small (15 cm diameter), they are very flammable. Operated as a remote-control chainsaw, the robot

can be used to thin the trees around forest communities, reducing the amount of fuel for wildfires and the intensity of any wildfire.

Beyond Canadian forests, the rugged, functional robot has potential thinning applications in New Zealand's and the world's forests.

The tree-to-tree robot was originally conceived at Scion around 15 years ago to revolutionise steepland forest management and harvesting. Original development of the robot was in partnership with the University of Canterbury, Future Forests Research and the Ministry for Primary Industries.

Key to the Myrtaceae of New Zealand

Myrtle rust, which can severely affect many of New Zealand's indigenous trees, shrubs and climbers as well as commonly planted ornamental plants belonging to the Myrtaceae (Myrtle) family, is slowly spreading across New Zealand. The most efficient way to monitor its progress into new areas is for people (our biosecurity team of five million) to report its presence when they see it.

Scion (the home of the National Forestry Herbarium) collaborated with Manaaki Whenua Landcare Research (MWLR), the project lead, with constructing a free interactive online identification key. The work was funded by Biosecurity New Zealand, which is the biosecurity arm of the Ministry for Primary Industries. The completed key went live in 2020 and is available as an app for mobile devices from Google Play and Apple Store and is also online on the MWLR website.

The NZ Myrtaceae Key is a Lucid identification tool containing more than 1,600 fully captioned images of more than 100 of the most common species of Myrtaceae in New Zealand. Of these, 27 species, such as the pōhutukawa, rātā, ramarama, mānuka and kānuka are indigenous to New Zealand. A user enters characteristics of the plant of interest, then the app selects plants possessing those features. As additional features are chosen, the key narrows down the results to one or a few matching species.

The accurate identification of host plants is fundamental to the management of plant pathogens. The app will assist the reporting of myrtle rust occurrences in New Zealand for long-term monitoring and development of management options.

Better forestry modelling with OverseerFM

Scion's nutrient balance model, NuBalM, is at the centre of a new project that will improve the ability of OverseerFM to provide greater management options for planted forests.

Data from afforested, nutrient rich sites are being used to provide NuBalM with new capability to predict how forest management can maximise nutrient uptake and restrict leaching losses in these conditions. OverseerFM software connects farmers with science to support sustainable farm businesses that protect the environment. Building on our ongoing relationship with Overseer, outputs from NuBalM can be used to inform potential enhancements to OverseerFM. This will provide users with more options to forecast the impact of different management options on nutrient losses.

This project is supported by the Sustainable Land Management and Climate Change Freshwater Mitigation Fund.

The marine biosecurity toolbox

Novel substrates that encourage the settlement of indigenous marine species, like green-lipped mussels, will support restoration initiatives and help make coastal marine habitats more resistant to being colonised by invasive species.

Scion is contributing to the Cawthron Institute's Marine Biosecurity Toolbox Programme, collaborating with partners from government, industry, and Māori organisations. The partners aim to reduce biofouling on artificial marine structures (such pontoons, pilings and seawalls) and to encourage the settlement of indigenous species.

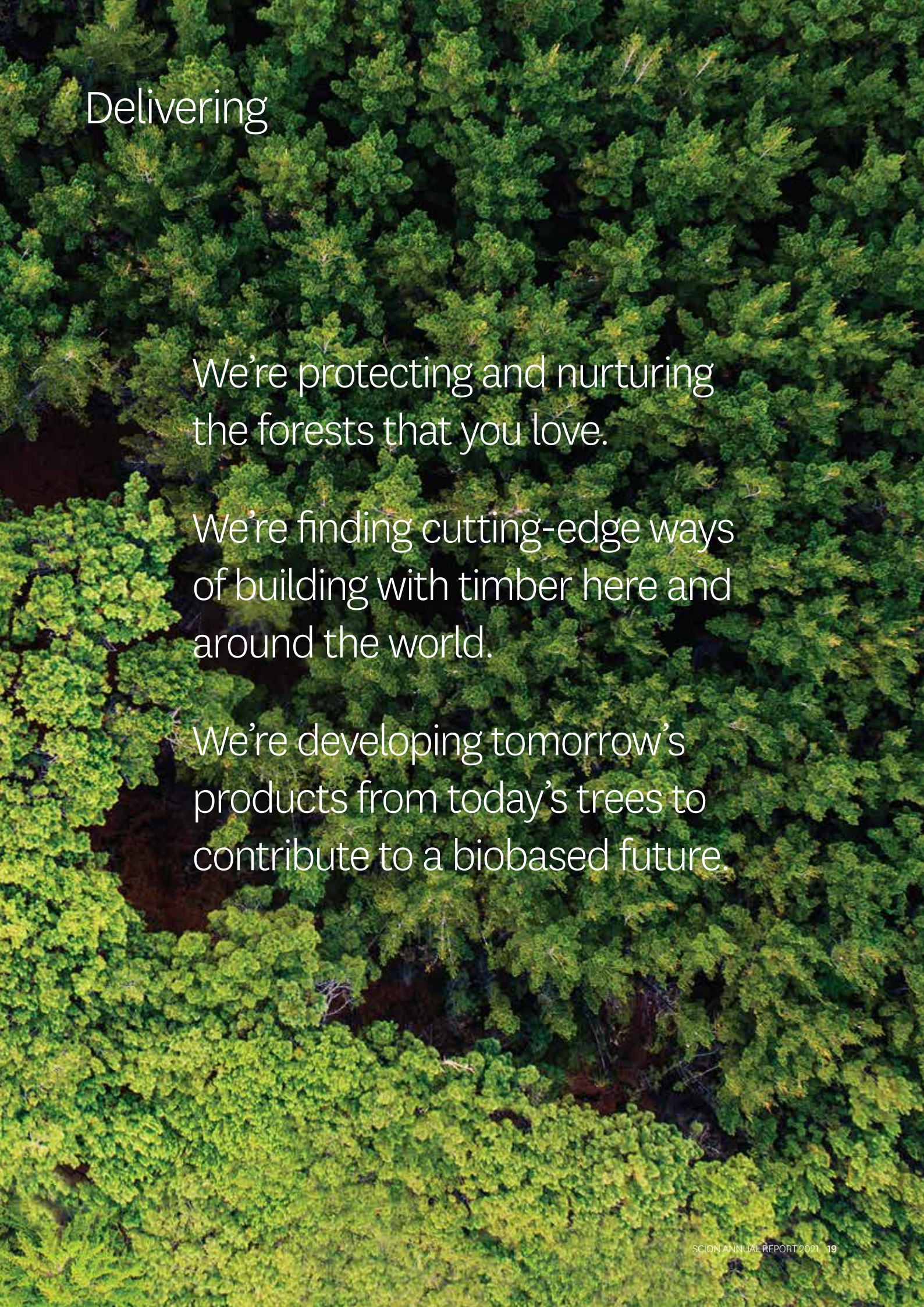
The ability to 'enhance' valued native species, such as green-lipped mussels which have vanished from urbanised locations, can be used to create 'sanctuaries' to help sustain regional populations where traditional food gathering occurs.

Maxime Barbier displays a tile of 3D printed green-lipped mussels with Rob Whitton in Scion's additive manufacturing lab.

Scion has developed artificial substrates in the form of submersible 3D printed tiles modelled from 3D scans of actual mussels and the substrates they were attached to. Cawthron Institute will use the tiles to determine which features of the substrates are preferred by mussel spat. Preferred features will be incorporated into the design of the next iteration of substrates.

Encouraging the settlement of native marine species will support the balance and resilience of indigenous marine ecosystems. People that use green-lipped mussels as a source of food will benefit greatly from the growth of mussel populations. Government agencies will benefit from the reduction in the numbers of non-indigenous species, freeing up some of their resources by having fewer invaders to fight against.

The work began in 2019 (and is funded until 2024) by the Ministry of Business, Innovation and Employment and a group of science, Māori, regulatory and industry organisations.



Delivering

We're protecting and nurturing the forests that you love.

We're finding cutting-edge ways of building with timber here and around the world.

We're developing tomorrow's products from today's trees to contribute to a biobased future.

Accelerating the propagation of indigenous trees

The commercial scale production and establishment of indigenous tree species is becoming a reality as tree species propagated in small paper pots survive and thrive.

Collectively, New Zealand nurseries are not currently equipped to deploy indigenous species on the scale required for the One Billion Trees programme and other projects. Problems include collecting and germinating seed and small scale and dated production practices.

Scion has been working since 2019 on improving propagation techniques and technologies. This has included propagation via cuttings, alternative seedling/cutting pots and mechanisation to address production bottlenecks.

Scion has tested Ellepot 700 ml paper growbags, formed and filled using automated Ellepot propagation technology. These growbags can replace the 1200 ml plastic bags normally used for native tree production. Most indigenous tree species can also be established in forestry grade containers (125–310 ml).

Several New Zealand nurseries have subsequently invested in Ellepot machines.

Using Scion's recommendations, nurseries can improve their capacity to supply indigenous trees. Industry partners will benefit from easier, faster, and cheaper planting. The country also benefits as more trees are established, enhancing indigenous biodiversity and increasing carbon sequestration.

Funders
Te Uru Rākau and Bay of Plenty Regional Council

Collaborators
Ngāti Whare (Minginui Nursery), Treeline Native Nursery, Ellepot (Denmark), Rotorua Lakes Council, Tipu Wai Trust

To read a fuller story on this research, visit www.scionresearch.com/ar21propagation

*Ngarimu Mana checks the one-year field height of a wineberry tree (*Aristotelia serrata*), established using a 700 ml Ellepot Ellebag, at one of our Lake Okareka field trial sites.*

"Many New Zealand nurseries have contacted us after visiting Scion themselves or after having spoken to other nurseries who have seen the work being done at Scion with Ellepot. There is very much a move in New Zealand towards more sustainable methods of nursery propagation, and Ellepot ticks many of these boxes, and the results coming out of the work being done at Scion are confirming the many benefits available to New Zealand growers. We at Ellepot are very thankful for the partnership with Scion and look forward to continuing to support the great work being done."

Darran Stone, Sales Manager – Africa, Middle East and Asia-Pacific, Ellepot

"My experience with Scion has been great. I now have 9000 Ellepot natives thriving on my property at Kaharoa. Despite a late planting date on the 23 September 2020, these plants have survived, and thrived, with almost no losses, and no extra help. Many are over 1.2-1.5 m tall now, in just 9 months. The continual progress has astounded me, these are the fastest growing natives I have ever experienced."

Alison Dewes, farmer

"Working on this project with Scion has been invaluable to our commercial nursery in both looking at new ways to accelerate the propagation of indigenous trees and the trials of Ellepot's paper pots, which we see as a must for the future. The Scion team were very professional, were able to substantiate their findings, and gave the entire project credence for the NZ nursery industry.

Diane Coleman, Managing Director, Treeline Native Nursery

Delivering FORESTS AND LANDSCAPES

Photo courtesy of Tasman District Council

Landslide deposition after Cyclone Gita, 2018, at Marahau, Tasman District.

Landslide hazard identification and risk management

Managing debris flow risks has been made easier by new research that maps the potential for debris flows and associated debris floods in individual catchments.

Debris flows are destructive flows of water, rock and soil that can travel long distances even on relatively gentle slopes. Recent debris flow events have highlighted the importance of understanding the susceptibility of harvested sites to debris flows.

Scion spatial specialists worked with the University of Canterbury to estimate slope susceptibility to debris flow and debris floods, and how far a debris flow could extend downslope onto a fan or depositional area.

The information can be used by landowners, councils and forest managers to make harvesting and catchment management decisions. If a catchment is assessed as susceptible to debris flows it should be investigated and risk management plans developed.

The research has been done in collaboration with Tasman and Marlborough District Councils. Research outputs are already being used to assess resource consent applications for forest harvesting.

Funders

Envirolink grant with Tasman and Marlborough District Councils

Collaborators

University of Canterbury, Tasman District Council, Marlborough District Council

"Working with Scion allowed us to access a combination of advanced spatial science and sound forest management thinking. Scion produced an easy-to-use map of potential debris flows to help guide forestry management decision-making and risk assessment. This kind of data-driven analysis is extremely valuable in our work to improve environmental outcomes in our region."

Matt Oliver, Environmental Scientist for Land Resources, Marlborough District Council

To read a fuller story on this research, visit www.scionresearch.com/ar21debris

Sweet success: Biological control of giant willow aphid

A biological control agent for giant willow aphid has been identified and tested by Scion entomologists, approved and released in New Zealand.

Giant willow aphid (*Tuberolachnus salignus*), or GWA, was first reported in New Zealand in 2013. The aphids feed on willow sap, damaging and occasionally killing the trees. They also secrete copious amounts of honeydew, which attracts insects such as honeybees and pest wasps. Honey made from the honeydew is granular and cannot be extracted from the comb, and bees are at risk of being killed by the wasps.

Scion scientists' discovery of a parasitoid wasp in California that preys on GWA brought the possibility of management using biological control (natural enemies) one step closer.

The first parasitoids were imported into containment at Scion in 2017. Stringent host specificity testing using non-target aphid species showed the parasitoid only attacked GWA, and the Environmental Protection Authority granted permission for release in December 2019.

Scion's release efforts have been greatly assisted by beekeepers, regional council staff and others who have received shipments of parasitoids and released them throughout New Zealand. Monitoring has shown that not only did the tiny wasps overwinter, they have multiplied exponentially and spread up to 100 km from the first release sites after one year.

This work directly benefits beekeepers, river managers, soil conservationists and farmers. The general public will also benefit, for example, from riverbanks remaining less prone to erosion and fewer pest wasps.

Funders
Sustainable Food and Fibre Futures Fund, Strategic Science Investment Fund and co-funders

Collaborators
Zespri International, Regional Council River Managers Forum, NZ Honey Industry Trust, New Zealand Poplar & Willow Research Trust, Neil Barr Farm Forestry Foundation, Plant & Food Research, Apples & Pears NZ, Terra Preta Truffles (Australia), Roderick Cameron (Uruguay), Apiculture NZ – Gisborne, Waikato, Southern North Island, Bay of Plenty and Nelson Hubs, Trees for Bees, Wasp Tactical Group, Arataki Honey, Ingleby NZ LP, Manawa Honey, Golden Grove Apiaries, USDA Forest Service, University of Otago, Marin Municipal Water District (USA), Forestry and Forest Products Research Institute (Japan)

To read a fuller story on this research, visit www.scionresearch.com/ar21GWA

Giant willow aphid mummies found on willow stems confirm the parasitoid has done its work.

"Scion has been working closely with the apiculture industry for more than five years on finding a biological control for the giant willow aphid, a destructive pest that has had a significant impact on willow trees and by extension the health of bees and honey production. Scion led extensive research into possible parasitoids of GWA and an application to government for the use of the insect Pauesia nigrovaria *as a suitable biological control was strongly supported by Apiculture NZ. Scion's work has been critical to addressing a serious problem for our industry and we are really pleased with the results of the release programme so far."*

Karin Kos, Chief Executive, Apiculture NZ

"I am hugely impressed with the work and dedication of the team at Scion for finding and successfully releasing a biological control for GWA. As a farmer relying on willows to secure our hill country, as the then Chair of the NZ Poplar & Willow Research Trust and in more recent times the Chair of Apiculture NZ, GWA was a real concern on many fronts. To now have a proven parasitoid wasp preying on these damaging pests is extremely welcome!"

Bruce Wills

Delivering FORESTS TO TIMBER PRODUCTS

Soil sampling in the late 1980s at the Long-Term Site Productivity harvest removal trial at Woodhill Forest, North of Auckland.

Sustaining forest productivity: A 30-year study

Forest ecosystem nutrient levels and forest productivity have been monitored over a complete forestry rotation by Scion researchers.

The results show that soil nutrient levels and forest productivity can be maintained with site-specific management – specifically through the retention of forest harvest residues and the forest floor at low-fertility sites.

The work is part of the global 'Long-Term Site Productivity' trials investigating the sustainability of intensive forest management harvesting practices and the pressures placed on soil resources.

These results give the forestry industry confidence that they can continue to sustainably supply timber, fibre and energy from forest soils that have already supported two rotations. They are also essential for public acceptance of commercial forestry and to meet the requirements of external bodies such as the Forest Stewardship Council.

Other outcomes of the three decades of work include:

- Site-specific management recommendations to support the use of residue for bioenergy.
- Contributing to the development of a New Zealand planted forest specific Nutrient Balance Model (NuBalM).
- Insights into the effects of different harvesting treatments and fertiliser addition on soil biodiversity.
- Underpinning data for planted forest carbon accounting.

The shared knowledge generated has led to changes in forest management and strengthened Scion's relationship with the industry. On the global stage the diverse portfolio of academic papers published from this trial series has reinforced Scion's reputation as a leader in forestry science.

Funders
Ministry of Business, Innovation and Employment, New Zealand Forest Growers Levy Trust Inc, New Zealand Forest Owners Association and New Zealand Farm Forestry Association, Strategic Science Investment Fund

Collaborators
New Zealand forestry companies and managers, University of Toronto; Oregon State University

"Forestry is also about land management and ecosystem resilience. Engaging with Scion researchers to further the science and management of long-term sustainability and resilience of our forests is a key strategy for our company."

Dr Paul Adams, Forest Estate Manager, Rayonier Matariki Forests

To read a fuller story on this research, visit www.scionresearch.com/ar21soil

Forest Flows Research Programme

We need to understand how planted forests affect the flow of water through landscapes to make the best use of land and water while maintaining environmental health.

Scion's Forest Flows five-year research programme is investigating the complex processes of water distribution, use and circulation in forested catchments, and downstream effects.

The goal of the programme is to capture data around key hydrological processes spanning forests and catchments and use the data to create a model that predicts hydrological flow across a range of planted forests that can be used to optimise water use in the wider landscape.

Five primary research catchment sites have been identified across New Zealand's climate zones. Instrumentation to monitor soil-plant-atmosphere interactions that operates as a wireless sensor network has been developed and installed, along with a big data cloud-based pipeline to manage the expected 300,000 observations daily.

Scion is working closely with industry, landowners, iwi, councils and national and international collaborators. The work protects primary-sector productivity and aims to improve water quality and supply and flood mitigation. The forestry sector's licence to operate will be strengthened by demonstrating forests can have positive impacts on water resources. Decision-making on siting new forests will be improved.

Data collection is starting in the second half of 2021.

Funder
Ministry of Business, Innovation and Employment

Collaborators
New Zealand-based collaborators: NIWA, XERRA, University of Auckland, University of Waikato. International collaborators: Meter Group (USA), Virginia Tech (USA), University of Massachusetts (USA), University of Southern California (USA), CSIRO (Australia), Whitegum Forest Natural Resource (Australia), MVARC (Portugal), ARAUCO (Chile)

"Summit Forests NZ Limited manages Te Hiku plantation forest on land collectively owned by four Te Tai Tokerau iwi (Te Aupōuri, Ngāti Kuri, Ngāi Takoto and Te Rarawa). Summit is dedicated to managing the land in an environmentally, culturally, socially and economically sustainable manner. We welcome Scion's research focused on flows from this forest and hope it will help plug some of the hydrological knowledge gaps. In the future the information gathered may be able to provide sound science to management decisions, particularly around wetland setbacks."

Karen Lucich, Environmental Planner, Summit Forests NZ Ltd

"Ngai Tahu Forestry are pleased to partner with Scion on their research project to better understand how plantation forestry impacts the flow and quality of water both within and beyond their forest estate. This project reflects the increasing importance being placed on the protection of our natural resources and ecosystems and Ngai Tahu envisage that the information obtained through the course of this programme has the potential to enhance and strengthen their own beliefs and values with respect to the protection of the land in perpetuity."

Chris Calder, Operations Manager, Ngāi Tahu Forestry

"New Zealand's planted forests are part of a mosaic of land cover, and the relationships between our planted forests and the flow of water in and out of them and the consequent impact on and interaction with the wider receiving environments are not always well understood. Yet water use and flow dynamics are fast becoming a major issue affecting forest owners' licence to operate – both as a result of major rainfall events, and in increasingly dry areas. In drier areas such as Otago, regulators are starting to single out plantation forestry for land use restrictions, and this seems to be based on research that relies on a small number of sometimes quite unrepresentative studies. Scion's Forest Flows research programme promises to significantly advance our understanding of in-forest and catchment flow dynamics, and should deliver robust modelling tools to back up the positive impact of our plantation activities."

Peter Oliver, General Manager, Forest Assets, City Forests Ltd

To read a fuller story on this research, visit www.scionresearch.com/ar21forestflows

Results from the deep learning algorithm showing spot-sprayed radiata seedlings (orange) and patches of native vegetation (light blue).

Monitoring planting success using AI and remote sensing

Scion data scientists working with remote sensing experts Indufor have developed a new commercial service to monitor forest establishment and indigenous biodiversity.

Successful establishment of newly planted trees is critical to optimising financial and environmental benefits. The most practical way to monitor establishment is using remote sensing. Still, the current practice based on unmanned aerial vehicles is expensive and limited in the scale that can be covered.

Scion has used deep learning to develop robust models describing tree location, while Indufor has been using a customised aircraft-mounted sensor suite to collect high resolution data areas. As a result, sprayed spots and irregular forest fragments can be identified, and delineated with polygons to evaluate seedling survival rate and gain a clear picture of any indigenous forest pockets on site.

Indufor had not previously used deep learning. The close collaboration with Scion has led to substantial investment in capability to turn the deep learning model into a commercial service. The commercial service can cover large areas economically. NZ Carbon Farming uses the service operationally and another forestry company is proposing to use this service in their new trial forest in Hawkes Bay.

Beyond monitoring successful forest establishment, an appreciation of indigenous forest fragments will help landowners manage these to preserve and increase biodiversity. Well managed plantation and indigenous forests are vital to New Zealand's economy and long-term climate change response.

Funder
Strategic Science Investment Fund

Collaborators
Indufor and aerial survey operator SKYVUW

"Scion's Geomatics team technical knowledge was instrumental in understanding the science behind the detection routines and giving us the confidence to invest in developing a scalable solution. Indufor's collaboration with Scion within this fast-moving space has been an extremely positive experience and provides a fantastic example of applied science."

Dr Pete Watt, Team Leader, Resource Monitoring & Climate Change, Indufor Asia Pacific Ltd

To read a fuller story on this research, visit www.scionresearch.com/ar21data

Augmented reality improves safety and reduces maintenance costs

Augmented reality can be used to guide machinery maintenance processes on site to improve forest crew safety and harvesting productivity.

A safer workplace is a priority for the forestry industry. Between 2015 and 2019, nearly 500 harvesting maintenance work-related incidents were recorded. As the level of mechanisation in forestry increases, the need for safer machinery maintenance will continue to grow.

Over the past year, Scion has been working with harvest equipment manufacturer Waratah and digital tech developer StaplesVR to create an augmented reality solution to minimise downtime and the potential for accidents during in-field maintenance on the Waratah 622B Harvester Head.

Augmented reality, which superimposes the digital data on the 'real' world, has been incorporated into an in-field servicing tool. The application overlays safety information and provides step-by-step instructions to guide routine maintenance. Guided maintenance has the potential to eliminate unnecessary service expenditure and product malfunction, saving all industry stakeholders money and time.

Funders
Waratah (in-kind), Forest Growers Research, New Zealand Forest Growers Levy Trust Inc and Ministry for Primary Industries

Collaborators
Forest Growers Research, StaplesVR, Waratah Ltd

"The ability to work directly with the industry problem solvers Scion and the industry experts Waratah is an incredibly powerful tool to be able to create meaningful content."

Krystal Paraone, Game Developer & Studio Manager, StaplesVR

To read a fuller story on this research, and for instructions on how you can use your smart device to view the AR harvester head, visit www.scionresearch.com/ar21AR

Delivering FORESTS TO TIMBER PRODUCTS

Stephen Pearce takes tree measurements in Puruki Experimental Forest, managed by Scion under lease from Pāmu.

Puruki Experimental Forest

This forest is an exemplar of a sustainably managed, highly productive *Pinus radiata* planted forest that also delivers multiple ecosystem benefits to society.

Puruki is part of the Purukohukohu Experimental Basin established in 1968 to study the impact of land use and land use change on water quality and yield.

The land that is now Puruki Forest was converted from pasture to pine forest in 1973, then harvested and replanted with second rotation forest in 1997. The second rotation is now 24 years old and approaching harvest.

Fifty years of continuous study of the forest has seen 67 academic papers published and the number is growing. The results have provided invaluable information for the development of New Zealand's nationally important forestry tools including the forest carbon predictor (the C_Change model) and the nutrient balance model (NuBalM).

Data and models from Puruki underpin almost every management decision modern forestry companies make today; something never imagined at the time the forest was established.

As we look to the future, Puruki has the potential to demonstrate new forest systems and adaptive management practices that address the challenges of a changing climate. Access to a network of long-term experimental sites is key to developing integrated research programmes that will secure forest benefits for future generations.

Funders
Ministry for the Environment, NIWA, Forest Growers Research and Strategic Science Investment Fund

Collaborators
NIWA, Pāmu (Landcorp Farming)

"Puruki has shown Timberlands what is possible from a productivity standpoint and really highlighted the importance of forest nutrition. The outcomes from Puruki are helping to inform our research and development programme that is targeting a step change in forest productivity."

Dr John Moore, Research & Development Manager, Timberlands

To read a fuller story on this research, visit www.scionresearch.com/ar21puruki

Commercialising seaweed hydrogels

A collaboration building on Scion's pulping expertise and AgriSea's 25 years in seaweed processing and marketing has resulted in novel seaweed gel products poised to take off.

Jelly-like seaweed-based nanocellulose hydrogel.

A conference encounter with AgriSea New Zealand Seaweed kickstarted a collaboration with Scion. Together, a concept of producing nanocellulose from AgriSea's seaweed waste stream was developed.

Drawing on Scion's wood pulping experience, the seaweed is mechanically processed to extract (nano) cellulose, which is then used to make hydrogels (polymers that can absorb up to 100 times their own weight in water).

Seaweed nanocellulose is a renewable replacement for petroleum-based polymers in hydrogel products, including burn dressings, biomedical engineering applications, drug delivery, cosmetics, and in agriculture supporting plant health.

A successful scale-up trial has provided enough material for further product development. Potential end users of nanocellulose, such as Fisher & Paykel Healthcare, are conducting initial material testing. The technology has been licenced to AgriSea to continue the development of hydrogels.

This project is an exciting example of developing renewable biobased products to replace petrochemical-based products and providing a path for industry uptake. The methods used to make the new nanocellulose hydrogels also require significantly less processing and treatment, resulting in an environmentally superior product.

Using waste streams from the seaweed industry also adds economic value to the aquaculture industry via access to new high-value markets. Our approach will accelerate new nanocellulose based business opportunities in New Zealand, which is a crucial part of the emerging high-value biomanufacturing sector.

Funders
Ministry of Business, Innovation and Employment

Collaborators
AgriSea New Zealand, Bioprocessing Alliance

"It's been an absolute pleasure to work with the Scion team. The entire journey from idea to outcome and everything in between has been brilliant. We see this as a long-term partnership and would highly recommend Scion to others wanting to turn an idea to success."

Tane Bradley, Managing Director, AgriSea New Zealand

To read a fuller story on this research, visit www.scionresearch.com/ar21seaweed

Dr Stefan Hill and Dr Melodie Lindsay (AgriSea) in the front with Sean Taylor, Dr Marie-Joo Le Guen, Dr Yi Chen and Tane Bradley (AgriSea).

Delivering FORESTS TO BIOBASED PRODUCTS

Clothes to roads: Usedfully® textile recycling

Diverse partners have come together to create a circular system to reuse the untapped resource of unwanted clothing and textiles.

Cellulose is currently imported for use as an additive in asphalt roading mix to stabilise it, improve its workability, homogeneity and the strength of the final road. Meanwhile, we have an estimated 220,000 tonnes of fibre in the form of textiles going to landfill in New Zealand every year.

Scion is working with Usedfully® and other partners to create a circular system to reuse unwanted clothing and textiles. Usedfully® and its Textile Reuse Programme Partners Alsco NZ, Deane Apparel and Barkers Clothing are focusing on textile collection and recycling systems and connecting value-chain partners. In parallel, Scion is working on fibre processing, testing and material development; WSP Research on roading material development and testing; and Waka Kotahi on road construction and future infrastructure requirements.

Next steps include scale-up of the refining process to enable roading trials.

Scion and Usedfully® are exploring options for New Zealand's first textile fibre recycling pilot plant, including other applications for the produced fibre, like use in the built environment.

Creating a circular pathway for unwanted textiles and reusing the fibres in roading will reduce the country's reliance on imported products and improve the performance of our roads.

Diverting New Zealand's textile waste from landfills could result in potential greenhouse gas emissions reduction of 400,000 t CO_2e a year.

Funders

Ministry for the Environment, Ministry of Business, Innovation and Employment, and the Textile Reuse Programme Partners Alsco NZ, Deane Apparel and Barkers Clothing

Collaborators

Usedfully® and The Formary, WSP Research of WSP New Zealand Limited, Wellington City Council, NZ roading contractors, Waka Kotahi, Textile Reuse Programme Partners Alsco NZ, Deane Apparel and Barkers Clothing

"Scion's deep knowledge, industry oversight and connections have been key to Usedfully – Textile Reuse Programme's design and delivery of a Circular Economy for clothing and textiles in Aotearoa. Our long term partnership has been an enjoyable relationship that has delivered pragmatic and scalable solutions for a low carbon economy."

Peter Thompson, CEO Usedfully

"It has been a pleasure working with Scion on the project with Usedfully and The Formary. Our mutual enthusiasm for materials science and applied research has created new possibilities for roading materials, and we are delighted to be part of the team on this journey."

Jeremy Wu, Research Manager Transport, WSP Research

To read a fuller story on this research, visit www.scionresearch.com/ar21textiles

Paper-based food-grade filters

Paper-based filter plates embedded with molecular imprinted polymers (MIPs) are cleaning up thanks to a collaboration between Scion and Ligar.

MIPs are polymers designed to capture and remove a specific target compound. This ability to selectively capture and filter material at molecular scale is critical for concentrating, refining and purifying processes.

Embedding MIPs into a filter allows extraction and recovery to be carried out in one step. Ligar, a Hamilton-based company specialising in molecular extraction technology, has been working with Scion's material and pulp and paper experts for two years to develop an efficient paper-based filter plate incorporating MIPs.

The paper plates have been developed as a replacement for commercially available systems. Users can swap existing commercial plates for the paper filters. The filter plates have attracted interest from a range of food and beverage as well as environmental companies. Ligar works directly with businesses to provide customised filter and separation solutions.

This project was a success due to the close collaboration between Ligar and Scion during all development stages.

Scion anticipates that MIPs and filters could play a big role in biorefining addressing one of the biggest challenges of biorefining - separation and purification of the products. MIP technology may be the key to success here.

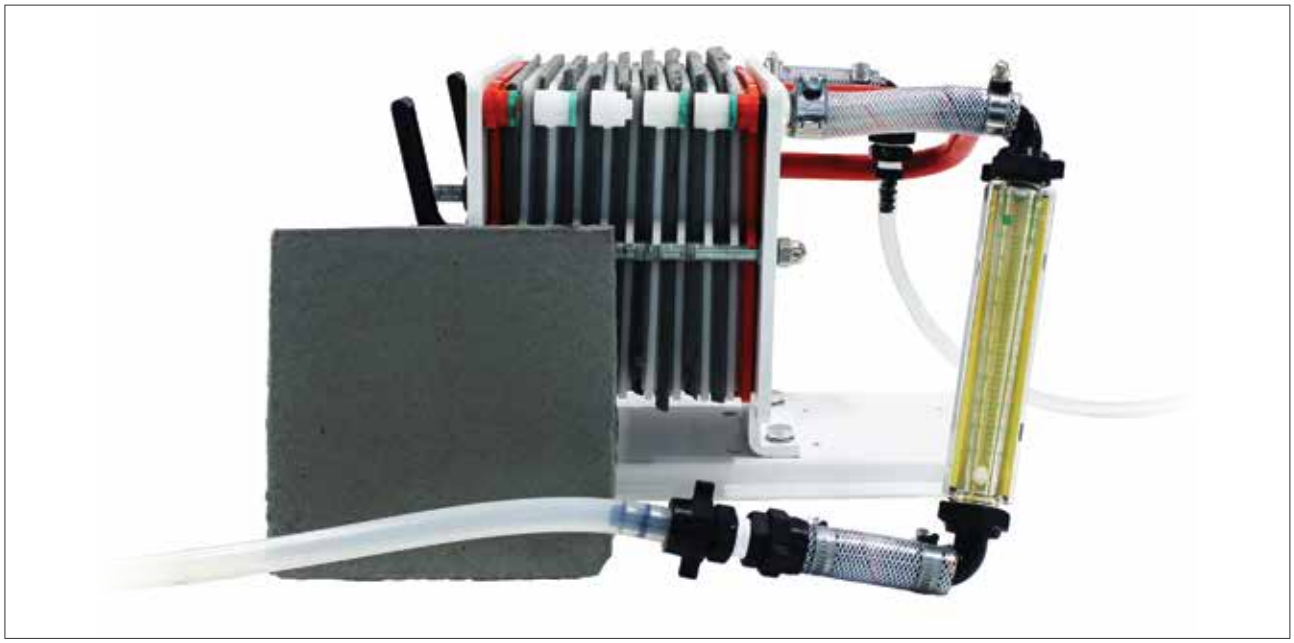
Funder
Strategic Science Investment Fund

Collaborator
Ligar

"Our product development team was looking for a novel way of using imprinted polymers within filtration systems and one of the options was to incorporate them into filter plates. Bringing their expertise in papermaking and fibres, the Scion team worked closely with ours to develop novel and scalable methods to make the plates, with the critical factors being even dispersion of polymer within a structurally sound material, the use of food-safe ingredients and the avoidance of any impact on flavour. The collaboration worked very well, beginning with making papers that could be tested for performance before moving onto plates. Our team appreciated the knowledge and capabilities of the Scion team, along with the flexibility to adapt to challenges throughout the process."

Nigel Slaughter, Chief Exploration Officer, Ligar

To read a fuller story on this research, visit www.scionresearch.com/ar21ligar



The filters are embedded with MIPs and designed to fit in industry-standard plate and frame filter systems.

Delivering FORESTS TO BIOBASED PRODUCTS

Sustainable aviation fuel for New Zealand

Biofuels are the only viable option for sustainable long-haul aviation as electric- and hydrogen- powered options are currently impractical.

The aviation sector was identified as a target in Scion's 2018 NZ Biofuels Roadmap. Since then, Scion has been working with Air New Zealand, Z Energy and LanzaTech to develop a viable pathway from woody biomass to aviation fuels in New Zealand.

A pathway for production of sustainable aviation fuels (SAF) out to 2050 has been described. The development of a policy framework to support biofuel implementation has begun. However, it will take time to produce SAF in New Zealand.

This initiative will help New Zealand to reduce our domestic GHG emissions and meet international commitments around SAF. A local SAF industry could lead to an estimated 6,400 infrastructure development jobs and a similar number of direct and indirect permanent jobs.

Funder
Strategic Science Investment Fund

Collaborators
Air New Zealand, Z Energy, LanzaTech, LanzaJet, Refining NZ and Auckland Airport

"The collaboration, insights and advice provided over several years by Scion were critical to establishing a sustainable aviation fuel pathway that has the potential to deliver material GHG emission reductions within the aviation sector."

Eddie Rutgers, Senior Manager Procurement Operations, Air New Zealand

"Aviation is one of the hardest to decarbonise sectors, but we need to address it if we are to achieve a net zero 2050 and remain a desirable trading partner and tourism destination. Z has been appreciative of the wealth of knowledge, expertise and drive that Scion has brought to the sustainable aviation fuel (SAF) initiatives that we have collaborated on. We would not have been able to form such a comprehensive view of the potential for SAF production in New Zealand without the team at Scion."

Sheena Thomas, Strategy Lead, Z Energy NZ

To read a fuller story on this research, visit www.scionresearch.com/ar21biofuels

Covid-beating vaccine 'beads'

Scion is contributing to the fight against SARS-CoV-2 by helping develop and manufacture an experimental COVID-19 vaccine.

CVC (COVID-19 Vaccine Corporation Ltd), formed by New Zealand experts in vaccine development and biotechnology, is working on a vaccine against SARS-CoV-2, which causes COVID-19.

Scion's biotechnology group has worked with CVC's scientists to fast-track the manufacture of two vaccine prototypes that CVC has taken into pre-clinical testing. Scion's expertise, resources and ability to work flexibly in the face of a global health challenge, have been essential to facilitating the CVC vaccine project.

CVC's vaccine is one of the few designs created specifically to provide cell-mediated immunity: it would be used in conjunction with the COVID-19 vaccines currently being administered to provide broader protection against current and future variants.

Funders
COVID-19 Vaccine Corporation Ltd (who received funding from Ministry of Business, Innovation and Employment and Callaghan Innovation)

Collaborators
COVID-19 Vaccine Corporation Ltd, Callaghan Innovation, University of Auckland

"It has only been through the excellence of Scion's response to CVC's need for quick and comprehensive support that we have been able to make and test a vaccine with potential to help in the global fight against COVID19. We could not have done it without you."

Dr Andy Herbert PhD, CSO/COO, CVC

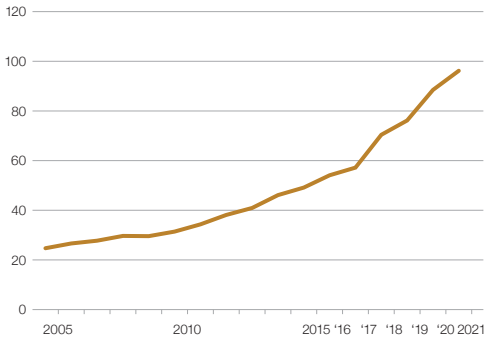
To read a fuller story on this research, visit www.scionresearch.com/ar21vaccine

Sharing

Science papers

144 Refereed papers published

96.56 Rolling 5-year weighted average H-index



Collaborations

62 Publication collaborations with international research institutions

26 Publication collaborations with other New Zealand institutions

13 Partnerships with Māori

6 National Science Challenges

Tech transfer

5,051 Research-specific website visitors

262 Commissioned reports

140 Publications on technical information and research results

189 Popular articles and videos

22 Presentations on technical information and research results

Communication

234 Media mentions

1,519 Subscribers to *Scion Connections*

2,556 Twitter followers

8,113 LinkedIn followers

16,175 Views of Scion YouTube videos

67,762 New visitors to the Scion website

Excelling

From left: *Drs Kelly Wade, Grant Pearse and Mike Watt (Grant and Mike representing the Geomatics Team), Greg Steward and Scion CE Dr Julian Elder.*

Science New Zealand National Awards

These awards highlight the cutting-edge work of New Zealand's government-owned science and research organisations. At the ceremony in December 2020 awards were given in three categories. Scion awardees were:

Greg Steward - Lifetime Achievement Award. Greg was acknowledged for his career in indigenous forestry research. He started as a woodsman trainee with the NZ Forest Service and became the driving force for indigenous forestry at Scion for 44 years.

Greg has authored many papers on indigenous tree species with specific emphasis on managing kauri, tōtara and indigenous hardwoods in plantations. His research on the growth and yield of New Zealand kauri showed that planted kauri stands aged 20 to 60 years were 20 times more productive than natural stands. His work has blown the estimated kauri crop rotations of hundreds of years out of the water.

Greg is acknowledged by his colleagues, industry and Māori partners for his patient wisdom, expertise and willingness to mentor others.

Dr Kelly Wade - Early Career Researcher Award. Kelly has brought a fresh perspective to packaging innovation by applying his knowledge of biomechanics to packaging materials. This novel approach has also been recognised by the Australian Institute of Packaging when Kelly was named the 2020 Australasian Young Packaging Professional of the Year.

Kelly runs Scion's internationally unique box testing facility, and he leads a National Science Challenge Science for Technological Innovation project creating biobased materials that can be applied to develop sustainable packaging.

Scion's Geomatics Team – Team Award. Scion's Geomatics Team has significantly developed the use of cutting-edge remote sensing technologies to help foresters improve the health and productivity of their trees. This includes the first known trial of scanning lidar from beneath the forest canopy using a self-guiding Hovermap SLAM laser scanner.

Team members – Dr Mike Watt, Dr Grant Pearse, Robin Hartley, Dr David Palmer, Honey Jane Estarija, Ellen Mae Leonardo, Peter Massam, Dr David Pont and Liam Wright.

2021 Primary Industries New Zealand Awards

Two Scion partnerships were shortlisted as finalists for the Primary Industries New Zealand Innovation & Collaboration Award:

- Cellulose nanocrystals from New Zealand seaweeds
- Tōtara Industry Pilot.

The Tōtara Industry Pilot was honoured to receive a 'Special recognition for outstanding cultural collaboration' at the awards ceremony in July 2021. The judges and the sponsor made this special award for demonstrating a primary industries partnership committed to Māori co-governance and outcomes.

2020 Scion Employee Recognition Awards

Dr Steve A Wakelin.

Roger Newman Award for Science or Engineering - Dr Steve A. Wakelin

Customer Engagement Award - Roanne Sutherland and Dr Miruna Petcu

Innovation Jumpstart Programme - Marc Gaugler and Dr Christophe Collet

Enabling Science Award - Ian McElroy

Recognition of Contribution to Māori Award - Ramona Radford

Te Reo Award - Jo Mackenzie and Toni Sinisa

Recognition of Publication Success Award - Dr Grant Pearse

Stretchy Science/Smart Ideas Award - Dr Qiliang Fu

Scion Values Award - Stephanie Weal

Health and Safety Award - Robin Hartley

Internationally

Dr Paul Bennett was elected Chair of International Energy Agency - Bioenergy (IEA Bioenergy) for two years, from 1 January 2021. It is an honour for Paul to lead the world's most prominent bioenergy scientists and policy makers as they work together to contribute to the international bioenergy agenda.

Paul served as the Vice Chair of IEA Bioenergy for three years prior to his election. Moving into the chair role in the present international context promises a unique challenge, and his focus is maintaining the momentum around bioenergy, "Bioenergy and biofuels can create clean, sustainable solutions to some of the world's greenhouse gas issues. My challenge will be continuing to advocate for these solutions at a time when COVID-19 could create setbacks such as lower overall fuel demand, cheap oil and added economic stress that could delay green transitions."

Dr Qiliang Fu was awarded a Young Scientist Medal by the International Association of Advanced Materials (IAAM) organisation for his contribution to wood technology.

Last year Qiliang, a wood and fibre scientist, received national recognition when he and his colleagues were highly commended for their transparent wood film in the Wood and Fibre Products Technology and Innovation category in the New Zealand Wood - Resene Timber Design Awards 2020.

Achieving

Meeting our science and innovation goals

Impact Area 1

Forests and landscapes
To grow healthy, resilient forests that are planted primarily for their standing-forest benefits.

Key performance indicators	Achievements
By 2020, Scion, in collaboration with key industry, Māori, and government stakeholders will have initiated an R&D portfolio that achieves impact through accelerated propagation from tissue culture and nursery practice, and productivity gain and greater resilience from genetics and tree improvement.	Scion has worked through a One Billion Trees (1BT) project to test and demonstrate application of new propagation options for indigenous forest species. Results showed that for some species it is possible to grow a healthy and vigorous plant in <12 months, and the survival and early growth of these plants can be equal or more successful than the current industry standard. Many solutions found indicate that the cost to establish indigenous forests can be reduced significantly, helping New Zealand meet its goals for a carbon-neutral future. Scion partnered with the Chatham Islands community to propagate both exotic and indigenous plants for a 1BT project restoring forests across the land. Scion propagated many plants, with the first 1000 repatriated and established during 2021. Further plants are expected to be repatriated over the next 3 years.
By 2021, Scion will have a research platform to accelerate the delivery of ecosystem services from production and conservation forests through sustainable vegetation management practices that support continuous licence to operate. We will partner with key stakeholders Te Uru Rākau (TUR), Forest Owners Association (FOA), LandCorp, Māori, Department of Conservation (DOC) and regional councils to enable the success of a range of tree establishment programmes.	The 1BT Native Tree Propagation Project developed novel methods to overcome the slow and expensive production of indigenous nursery plants. This work enables secure establishment of future indigenous forests, both for new timber-based industries and traditional non-timber benefits. Extension of this project focuses on commercially scalable field trials of forestry-grade native seedlings.
By 2021, Scion continues to be recognised as having contributed to New Zealand's ongoing national and international carbon reporting obligations.	Scion completed the analysis of New Zealand's national planted forest inventory to estimate carbon stock and changes used for UNFCCC reporting on New Zealand's greenhouse gas emissions and will inform policy makers about the current and future contribution of our forests as a carbon sink under the Paris Agreement. Working closely with MfE and MPI, Scion contributed to ongoing method improvement for national and international carbon accounting and greenhouse gas reporting and investigated the potential contribution of natural forests and non-forest woody vegetation to New Zealand climate change targets. New Zealand natural forest carbon stocks were published in a peer-reviewed journal for the first time.

	In our forest inventories' quality assurance role, Scion ensured high standards of data collection in our forests as the basis for carbon stock and carbon stock change calculations. With support from the Greenhouse Gas Inventory Research Fund, Scion conducted a preliminary study to determine the potential size of non-forest woody vegetation as a carbon pool across New Zealand to support a future decision to include non-forest vegetation into national and international accounting.
By 2021, Scion in partnership with Māori have co-developed a breeding plan for at least one indigenous forest species.	Repatriation of >4000 kauri trees to their rohe occurred in 2021. Individual hapū are working on their plans and desires towards co-developing a hapū-led breeding programme in coming years
By 2020, Scion has co-developed, in partnership with Māori, a Māori Forestry Roadmap and this is formally acknowledged by government.	The Māori Forestry roadmap was developed, ready to integrate with Scion's Impact Area roadmaps due to be completed by end-2021.
By 2023, the Forest Investment Framework has been implemented to span three dimensions (time, space and risk), integrated with other land use models, and includes at least three new ecosystem services and five new forest productivity surfaces. The framework includes a protocol to integrate Māori cultural values in the decision-making process.	For the first time, the full value of New Zealand's planted forest resource has been quantified, and the results published in an international journal https://doi.org/10.3390/f12060662 The work demonstrated the value of timber, carbon, erosion control and reduction in nitrogen leaching across the national estate and showed that the value of non-timber ecosystem services could be up to four times the timber profit and up to 12 times in forests on highly erodible soils.
By 2021, the impacts of insect pests and pathogens on tree species grown for their standing benefits have been evaluated and research programmes to mitigate those effects have been started.	Scion assessed the feasibility of using international border interceptions of insects and global invasions to predict the likelihood of insect pests arriving and establishing in New Zealand. This information is useful for risk assessments to target biosecurity measures, including surveillance, to prevent future establishment of high-impact pests in New Zealand.
By 2021, Scion will have developed new methods and technology to accurately phenotype, identify and classify individual trees.	Methods were developed and demonstrated for individual-stem identification and delineation within a multi-age and diverse indigenous forest. These methods will be useful for tracking and classifying forest types and structure and could be adapted for tracking carbon.
By 2023, Scion has provided the underpinning science to support and enhance licence to operate through environmental certification and to meet regulatory requirements, particularly in relation to Douglas-fir wilding spread and pesticides use.	Scion continued its involvement in developing a joint Australia/New Zealand Sustainable Forestry Standard (AS/NZS4708). Once endorsed by the global Programme for Endorsement of Forest Certification (PEFC), New Zealand forest companies will have access to two independent certification mechanisms: Forest Stewardship Council (FSC) and PEFC. This provides further means to demonstrate sustainability of our forest management, enabling licence to operate.

Impact Area 2

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

Key performance indicators	Achievements
By 2021, new fundamental knowledge is developed around wood natural durability, wood permeability and treatability for both radiata and non-radiata species. This new knowledge will be then be used in targeted wood modification, durability and drying solutions.	Thermal modification of *Cupressus lusitanica* showed promise in increasing the durability of boards containing sapwood without adding chemicals for use in outdoor products such as cladding. Analysis of extractives from tōtara and *Eucalyptus globoidea* heartwood and sapwood found significant differences in extractables composition between old and young trees. Further work will establish how those composition differences may affect wood natural durability. A new method for screening Volatile Organic Compound emissions was developed and validated at Scion and is now available as an in-house tool for commercial and R&D applications. A new method to functionalise the surfaces of radiata pine with nanoparticles was designed and validated and now applied to developing new functionalised wood products.
By 2020, Scion has worked with Māori, and at least one Māori entity is active in building a new vertically integrated high-value wood manufacturing enterprise.	Scion worked with Taitokerau Māori Forests Inc (TMFI) on the Tōtara Industry Pilot to test the opportunity for a new industry based on regenerating tōtara on private land. The project formally ends on 31 August 2021, and TMFI agreed to lead the pre-commercial phase to realise the opportunities identified in the pilot.
By 2021, Scion, with science collaborators, government, and industry partners with non-traditional urban stakeholders, has developed a platform of high-value wood products to provide better performing, higher amenity built-environments in terms of affordability, performance and sustainability, e.g. tall timber buildings, prefabrication etc.	Lab-scale New Zealand-grown radiata pine wood fibre insulation products were developed at Scion and their thermal conductivity performance tested by BRANZ as part of a collaborative project. The test on the prototype insulation panels confirmed comparable thermal insulation properties to the ones commercially available with European-made wood fibre insulation products. A method to account for the climate change mitigation benefits of storing carbon in wood products was developed and is being validated. The method uses a single-product perspective and relates the storage benefits to the longevity of the product-storage with a specific time horizon, which enables correlation with deadlines for achieving international climate change mitigation targets. Scion's new Te Whare Nui o Tuteata building attracted visits from science collaborators, government, industry partners, the design and construction sector and the wider community. This timber building showcases that a low-carbon future built with sustainable timber is both possible and desirable.

By 2023, tools, novel forest management approaches and new plant material will be embedded into New Zealand's forests and forestry practices to support the industry's target to increase radiata pine MAI from an average of 20 m^3 ha-1 yr to 35 m^3 ha-1 yr and in a way that enhances the sustainability of forest growing in New Zealand.

Scion and inFact developed FlowLab dataloggers for the Forest Flows Programme. A first of its kind, FlowLab enables continuous collection of big data from instruments at multiple locations throughout remote and steep forest, providing new insights in forest growth, management and genetics x site x environment interactions. The combination of low cost, high operational reliability in a hostile forest environment and the flexibility to run different types of sensors, means this technology is world leading and has attracted overseas interest.

Scion developed a big data cloud platform that handles the streaming and storage of 300,000 observations every 24 hours. This cloud platform can connect with Forest Flow collaborators and provide real time, continuous analysis from multiple data sources. It provides an exemplar for data sharing across CRIs for the proposed pan-CRI National Environmental Database (NED).

Use of NuBalM for predicting crop nutrient and fertiliser demands shows increasingly that the gap between new target productivity levels and fertiliser recommendations are encouragingly smaller than industry has conventionally applied.

Modelling a productivity target based on NuBalM and starting to understand the nutrient gap has led to fertilisation for more than just deficiency mitigations. Several industry partners are trialling a balanced nutrient approach to address multiple limits at a single application.

Micro-respiration is a novel tool being developed for forestry soil screening. Micronutrients at different rates are easily tested for changes in soil activity using this new-to-forestry method.

A forest management company on the East Coast is supporting the development and implementation of precision nutrient modelling for better crop management and future decision making at smaller scales.

By 2023, the forestry industry, land owners, and central and regional government have adopted new tools, approaches and technologies developed to mitigate impacts from the increasing risk to New Zealand's forests from pests (insects, pathogens, weeds), fire and wind in our changing environment (climate, trade and tourism), and to mitigate risks and take advantages of opportunities from climate change.

Find-A-Pest smartphone app was delivered in 2020 to help early detection of pests and increase the reach of surveillance methods. In 2021, after successful roll out with multiple primary sectors and regional councils, the application was updated to include image recognition.

A Scion-led study found that invasive insects and smoke (a potential carrier of biosecurity threats) are transported within atmospheric coherent structures across the Tasman Sea from Australia to New Zealand. A model was developed to forecast the occurrence and movement of atmospheric coherent structures and will be tested in 2021-22.

The automated fire growth and smoke modelling system web-tool went live, and discussions are underway with Fire and Emergency New Zealand (FENZ) on operational implementation of the system. The prototype was successfully used during the Pukaki and Lake Ohau wildfires in 2020 and for fire events. Updated projections of fire risk with climate change were produced and results communicated to MPI, FENZ and other government agencies.

By 2023, Scion has provided tools, new biotech and genetic solutions, new plant material (e.g. germplasm) and competitive niche wood products that will increase the confidence of growers of Douglas-fir, eucalypts, cypresses, redwoods and indigenous species to increase plantings of these species by at least 50 per cent over 2018 plantings.	Using a protocol developed for *Pinus radiata*, gene editing of Douglas-fir was developed and proof-of-concept of applicability obtained through editing genes involved in reproduction. A population of *Eadya daenerys* was successfully imported from Tasmania and approved for release. Once successfully established this parasitoid wasp will sustainably control the Eucalyptus tortoise beetle protecting Symphyomyrtus species both durable (e.g. *Eucalyptus bosistoana* or non-durable species (*E. nitens*). Maximising the health and growth of Symphyomyrtus species of eucalypt forms a vital component of our growing eucalyptus industry. New DNA data collected from Douglas-fir progeny trials and seed orchards was successfully combined with trial data for Swiss needle cast (*Phaeocryptopus gaeumannii*). Genomic predictions of tolerance to Swiss needle cast have been made for all seed orchard parents allowing removal of poor performers and increased confidence to plant Douglas-fir.
Ongoing: New technologies such as automation, robotics, sensors, new digital technology have been implemented in the cities/buildings/products/processing and forest growing value chains, demonstrating improved efficiency, cost reduction, improved safety, and better living and working environments.	A revised redwood growth model was developed and uploaded onto the Forest Growers Research (FGR) website. Radiata pine and redwood 300 Index productivity surfaces were developed for the FGR Tree Farmer application. An augmented reality servicing tool was developed, with StaplesVR and Waratah, which provides a detailed 'walk around' view of the head. The user is guided through safety information, fault reporting, training, maintenance and service tasks. A prototype proximity detection system was developed to alert machine operators to the presence of other people and machines nearby without overloading the usual senses.
Ongoing: Support forest growing, wood products and building industries to grow and develop by addressing domestic/international standards, regulations and market specifications.	Our commercial testing services on timber-engineering and wood-protection exceeded our commercial target by approximately 17 per cent and provided significant benefit to the forest growing, wood products and building sectors. Scion helped revise three New Zealand timber building standards and two joint Australia/New Zealand standards. In the joint standards, a major revision and completion of merging all five parts of AS/NZS 1604 and four parts of AS/NZS 1605 into a mega document of three parts was completed and is now published.

Impact Area 3

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

Key performance indicators	Achievements
By 2021, at least six new polymeric material products with renewable content have been developed to prototype stage using existing (e.g. extrusion, injection moulding) and emerging technologies (e.g. 3D printing or electrospinning), and two of these prototypes have been incorporated into new product offerings by firms.	Scion developed materials with renewable content for aquaculture applications and demonstrated how 3D printing can be used to produce prototypes and short production runs. Scion also developed new temperature-responsive material prototypes based on renewable materials that are currently in commercialisation stage.
By 2020, two different genetically modified biotech tree lines have been developed and existing trees evaluated to determine their viability as alternative feedstocks for producing high-value chemicals and/or processability for fibre or bioenergy.	A field trial was terminated in March-April 2020 when the trees were destroyed owing to COVID-19 disruption and possible cone formation.
By 2021, Scion has identified technology innovations to deliver the Biofuels Roadmap outcomes and has secured funding to progress them.	Scion continued developing a thermal approach to produce a biofuel for ships. Technical and industrial collaborators were formed, and early proof-of-concept experiments performed.
By 2020, Scion and commercial partner(s) have developed a viable and New Zealand-specific biorefinery business case including Scion-developed high-value bioproducts and cost-efficient technology platforms for commodity fibres and bioenergy, including criteria for new short-rotation forest trees systems.	An exemplar biorefinery that integrates into an existing industry using native seaweed was developed for manufacture of high-value nanocellulose. This was trialled at lab and pilot plant scale with a commercial scale plant designed for construction in mid-2021. Nanocellulose can be used in high value products providing a range of benefits such as providing an oxygen barrier.

By 2022, New Zealand has new industries using new high-performance products enabled by Scion-developed technologies (on-demand degradable plastics, green electronics, biobased composites, lignin products and new compounded materials containing biopolymers), using existing (e.g. extrusion and/or injection moulding) and emerging technologies (e.g. 3D printing or electrospinning).	Scion worked closely with New Zealand industry partners to demonstrate what new processes and technologies offer to produce high-performance products. We worked with companies to develop new extrusion processes that convert cellulose-containing textile waste in performance enhancing additives for the construction sector. Scion, together with partners, created a roadmap for New Zealand's plastic industry towards a circular economy for plastics, including an outline of a potential new circular processing technology scenario.
By 2022, Scion has identified commercial opportunities that have led to drop-in replacement of coal with wood residues or wood-based solid fuel products to generate heat in industrial processes. This will help drive a 1 per cent reduction in GHG emissions per annum from the sector, aligned with the New Zealand Energy Efficiency and Conservation target.	Scion developed a solid biofuel from wood that has similar physical characteristics to coal (e.g. energy density, hydrophic, lower ash), and therefore can be burnt in existing coal boilers. Combustion emission tests need to be performed and the route to market explored.
By 2023, Scion has demonstrated the feasibility of converting forest and other biobased materials through distributed and mobile processes into chemicals and biopolymers and has identified a group of interested industrial partners to progress one of the technologies to pilot/demonstration scale.	Scion continued to assess the feasibility of converting biomass resources into platform chemicals. With partners from the primary and manufacturing industry, Scion started feasibility studies of mechanochemical conversion of biomass to chemicals and demonstrated the feasibility of the process on a lab-scale.
By 2023, at least two new growing regimes have been established with the aim of demonstrating how to sustainably grow resilient short-rotation fibre products with either biotech trees or new germplasm with high production of fibres or chemicals.	Scion continued to identify species with high-value chemical potential that can be grown either seasonally, or in few years, and in environments that do not conflict with current land usage. For example, an indigenous species that is often classed as a weed has mātauranga Māori-identified health benefits, and the bioactive compounds have been described in modern literature.
By 2020, Scion has worked with Māori, and at least one Māori entity has included new biobased materials in their product portfolio.	Scion partnered with the Hokotehi Moriori Trust in a Vision Mātauranga Capability Fund project on sustainability and waste reduction on Rēkohu (Chatham Island), which included collaboration with the local industry and communities. Scion worked with Māori partners to develop Māori-inspired renewable composite materials based on indigenous fibres.

	New Zealand's first seaweed-based nanocellulose manufacturing plant was co-developed with Māori family-owned business AgriSea. This technology is additional to their current business and provides high-value materials from industries such as cosmeceuticals.
Continue to demonstrate new biotech solutions to improve productivity and add new traits in modified *Pinus radiata* through the application of gene-editing, and transgenic technology through to field trial.	Experiments did not prove the hypothesis and are likely to end this line of investigation.
Ongoing: Support bioproducts and bioenergy industries to grow and develop by (a) addressing standards that create artificial barriers to products accessing markets or applications, (b) developing technologies and IT systems that allow bioproducts to be traced within the value chains they are transacted in and for their source to be verified, and (c) ensuring environmental compliance for regulators and customers.	Scion contributed to several government consultation documents, including those on process heat and the biofuels mandate.
Ongoing: Quantify risk profiles and mitigation methods for densely stocked forest systems, and delivery of ecosystem services (both positive and negative) for new forest systems to underpin environmental certification and sustainability credentials.	Scion started a project to look at issues associated with energy-specific plantation regions, such as what species, planting density, impact of pests, disease and fire. We are currently assessing what Scion knows and what we need to know to develop a 'how to guide' for energy-dedicated forestry.
Obtain funding to carry out pest risk analysis/risk mitigation research for highly stocked/short rotation and/or GM tree regimes.	Funding not yet obtained.

Financial results summary

	2019 (Restated) Actual	2020 Actual	2021 Budget	2021 Actual
Revenue, $m	55.94	57.88	55.35	61.08
EBIT, $m	1.87	6.02	0.99	6.60
EBIT Margin	3.3%	10.4%	1.8%	10.8%
Reinvestment, $m	1.12	1.99	1.34	2.15
EBIT-R, $m	2.99	8.01	2.33	8.75
EBIT-R Margin	5.3%	13.8%	4.2%	14.3%
Total Assets, $m	55.92	65.07	60.22	70.80
Return on Equity	3.9%	11.8%	1.2%	9.3%
Pre-reinvestment Return on Equity	5.7%	14.7%	3.2%	12.1%
Equity Ratio	73.5%	75.1%	77.8%	74.5%
Dividend, $m	-	-	-	-
Gearing	0.0%	0.0%	0.0%	0.0%

Revenue: Includes science research, contract work for government and commercial clients, royalties and licence fees.

EBIT: Earnings before interest, tax and restructuring costs.

EBIT Margin: EBIT ÷ revenue.

EBIT-R: EBIT before reinvestment where reinvestment are amounts approved by the Minister.

EBIT-R Margin: EBIT-R ÷ revenue.

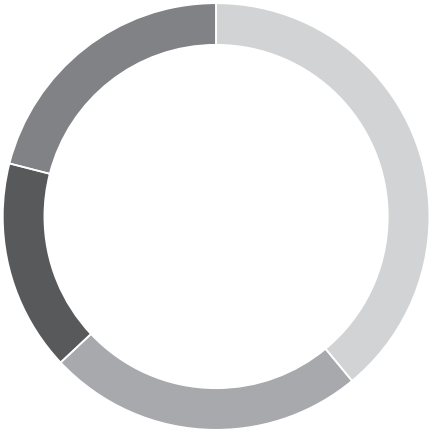
Return on equity: Net profit after tax ÷ average shareholders' funds, expressed as a percentage.

Equity Ratio: Average shareholders' funds ÷ average total assets.

Gearing: Financial debt ÷ financial debt plus shareholders' funds.

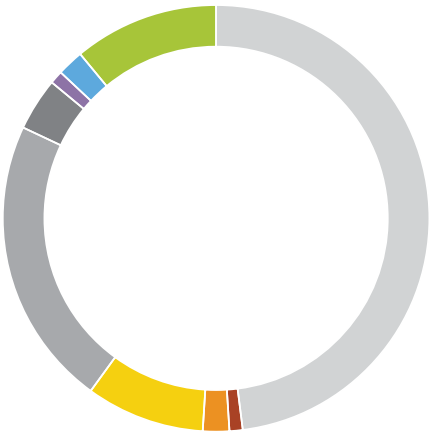
(The Minister of Finance and the Minister of Science and Innovation each hold 50% of the shares on behalf of the public.)

Where our revenue comes from



Ministry of Business, Innovation and Employment (SSIF)	39%
Ministry of Business, Innovation and Employment (Other)	24%
Government departments	16%
Other commercial	21%

How our revenue is spent



Employee remuneration	48%
Training and recruitment	1%
Consumables	2%
Depreciation and amortisation	9%
External services and contractors	22%
Premises costs	4%
Travel	1%
Other operating costs	2%
Non-operating costs	0%
Net profit before tax	11%

Our full Reports and Financial Statements are presented in Part B of the Annual Report. www.scionresearch.com/annual-reports

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