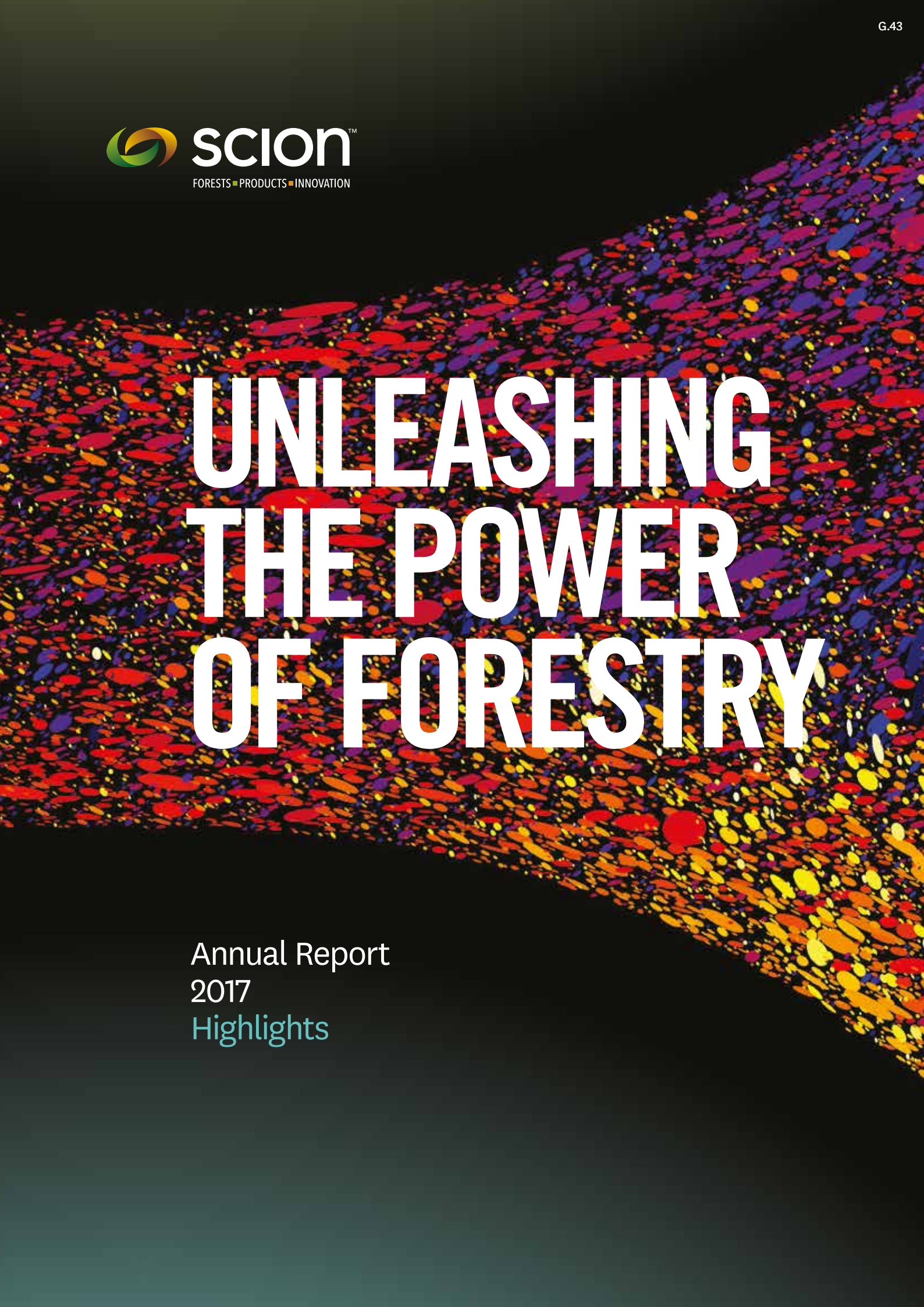


Annual Report
2017
Highlights

# Annual Report 2017
## 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.

The Reports and Financial Statements (Part B) includes the employment and environmental reports, Strategic Science Investment Funding (Core), 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: *Magnified sample of a plastic composite reinforced with Scion's engineered wood fibre (licensed and sold as Woodforce), colour coded for particle orientation to predict product strength.*

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# SCION AT A GLANCE

Operating revenue

**$51.9m**

Last year: $49.6m

Full-time equivalent staff

**293**

**268** Rotorua
**1** Wellington
**23** Christchurch
**1** Dunedin

Total comprehensive income

**$2.3m**

Last year: $1.8m

Published refereed papers

**143**

**56.89** 5-year weighted average H-index

Return on equity

**6.2%**

Last year: 5.2%

**296** Commissioned reports accepted by users

**Ligate™**

Our bioadhesives technology was named NZBIO "Biotechnology of the Year"

April 2017 marked our 70th anniversary

SCION™
FORESTS ■ PRODUCTS ■ INNOVATION

70 years of science

# OUR VISION IS

Prosperity from trees - *Mai i te ngahere oranga*

*Trees are remarkable, renewable resources. Planted as forests they have a powerful potential to be at the heart of a low-carbon, biobased future New Zealand.*

With 70 years' of science and technological innovation backing us, **Scion is uniquely placed to unleash the power of forestry** to build economic value and achieve better environmental and social outcomes for New Zealand.

Our responsibility as a Crown research institute is to work with industry, government and Māori to achieve four national outcomes for New Zealand. These are:

Increase the value and productivity of New Zealand forestry, wood products, wood-derived and other biomaterial sectors

Protect and enhance market access and improve risk

Increase renewable energy production and energy security from forest biomass

Enhance benefits from forestry-based ecosystem services

# CHAIR AND CHIEF EXECUTIVE OVERVIEW

## Forests as powerhouses of our future

As leaders of Scion our role is to keep the institute's vision "Prosperity from trees" front of mind. We believe in our people's passion, dedication and capabilities to get us there. Importantly too, we believe in trees. Indeed, we see the power of trees as a renewable resource that can meet the market needs of a low-carbon biobased economy.

Our long legacy of delivering science impact gives us the confidence to think boldly about the future. Our achievements and those of our predecessors reaching back to the 1920s have built Scion's reputation as a world-leader in forest industry research and technology development. We recognise too that increasingly Māori are playing an important role in shaping the future New Zealand forest industry, and our partnerships with Māori are a valued strategic priority.

Last November our annual strategic review confirmed the increasing demand for wood and wood products driven by the global move to renewable circular economies. Global demand for forest biomass is projected to grow by at least 300 per cent by 2050 as supply chains decarbonise and more wood is used in buildings and other construction.

We are excited by Scion's unique contribution to shaping a truly sustainable future for New Zealand. In this report, we are proud to present some of the past year's achievements that are stepping us towards our vision as we help 'unleash the power of forestry' to deliver prosperity from trees.

A highlight demonstrating this effect was the opening of the Ngāti Whare nursery in Minginui. We worked with Ngāti Whare to support their ambition to build an indigenous commercial nursery, including partnering with them to co-develop our novel propagation technology. This initiative will provide local employment and planting stock to support the 10-year Te Pua O Whirinaki Regeneration Plan. Our partnership aims to licence the propagation technology to other nurseries.

> Our role is to keep our vision "Prosperity from trees" front of mind … we believe in trees. Indeed, we see the power of trees as a renewable resource that can meet the market needs of a low-carbon biobased economy.

We are now seeing the significant progress the Growing Confidence in Forestry's Future programme has made in better understanding the key drivers of forest productivity, with development of management interventions to increase productivity and profitability. The programme has demonstrated that increasing site utilisation by increasing final crop stocking can substantially lift productivity, and many companies are altering their silvicultural regimes to reflect this.

Responding to the forest industry's goal to increase the value of forestry as a land use option, we developed a forest investment framework to assess forest ecosystem services (such as carbon storage, erosion control, water quality, biodiversity and recreation). We are further developing the framework so that we can undertake a national analysis of the full value of New Zealand planted forests, both existing and potential, enabling better representation of the wider benefits provided by forests in land use management, policy and decision making.

An inland container terminal at Kawerau, with a rail link to the Port of Tauranga, is a very likely prospect after a feasibility study we led confirmed such a terminal would be viable, offering considerable benefits to the eastern Bay of Plenty. Establishment of the container terminal is now out for tender.

Ensuring that New Zealand forests are resilient to current and future natural threats is vital for our economy, our environment and our way of life. Media headlines this year warned of the devastating consequences of fire and biosecurity threats. Our forest protection teams have responded swiftly to such threats as they have arisen.

The fire-fighting response to Christchurch's Port Hills fire in February was boosted with our rural fire team mobilised to assist the incident management team to develop fire attack strategies, determine resource needs and ensure fire-fighter and public safety. Post event, the TVNZ One News weather programme used Scion's rural fire risk tool to provide summer fire forecasts. Ironically, February 2017 marked the 25th anniversary of rural fire research in New Zealand, centred at our institute.

Collaborative responses to kauri dieback and myrtle rust have pooled talent from multiple organisations. Scion botanists and pathologists, in the laboratory and field, have played an important part in the overall incursion response, which is ongoing. Our continued investigations into the radiata pine red needle cast disease provided key clues to the disease and its pathway to New Zealand.

This year our bioplastics innovations have reached the hands of thousands.

The biospife, a novel bioplastic based spoon-knife, was officially launched by Zespri at Fieldays 2017, with more than 300,000 produced by Scion and Alto for the global market. For another primary producer, we developed biodegradable bioplastic vineyard net clips containing red grape pomace. The opportunities ahead for bioplastics in the horticulture sector are vast.

Our bioenergy work has sparked the interest of businesses who are invested in their future energy supply. Highly engaged attendance at our 2035 Biofuels Roadmap workshops ensured that the key insights from the work, due to be delivered within the next six months, will be highly relevant to influencers and decision makers.

Deriving value from waste using green technologies is another focus area, and one of our projects has the power to transform lives in developing nations. After successfully completing the first phase of the Bill and Melinda Gates Foundation "Reinvent the toilet challenge" to prove the concept that wet oxidation could treat human waste, we received close to $3 million over two years for phase two, to develop a prototype, simple eco-friendly toilet unit.

Recognition for our clever technologies is highly rewarding. Our environmentally-friendly Ligate™ bioadhesives technology received many accolades in the year. Being named NZBIO Biotechnology of the Year was a welcome surprise and honour, with NZBIO describing the technology as "a game changer for wood panel manufacturers".

Ensuring our people can continue to deliver outstanding work requires an investment in infrastructure and the work environment. In May our Christchurch staff relocated to the NIWA campus from their long-standing home at the University of Canterbury following a very low seismic rating of the building they occupied.

Financially 2016-17 has also been a good year. Revenue has grown 4.6 per cent to $51.9 million (budget $50.3 million) providing a net profit after tax of $2.3 million (budget $1.6 million).

Our main campus in Rotorua also was the matter of serious consideration. In October the Minister of Science and Innovation approved a business case for enhanced science and office facilities and design of an Innovation Hub. Our plans to redevelop 1950s vintage laboratories, co-location opportunities and creation of an Innovation Hub have been well received by industry and other local stakeholders. Including some public access to our science will add an exciting dimension to the project and broaden stakeholder awareness of the important work we do. Starting next year, the three-year development, the largest at Scion for many years, will cost an estimated $18 million.

Financially 2016-17 has also been a good year. Revenue has grown 4.6 per cent to $51.9 million (budget $50.3 million) providing a net profit after tax of $2.3 million (budget $1.6 million). Our cash reserves have increased to $15.5 million (budget $7.3 million) supported by an $8.4 million net cash surplus from operating activities. This positions us well for reinvesting back into the organisation such as through the construction of the Innovation Hub and other significant science and building infrastructure planned over the coming five years.

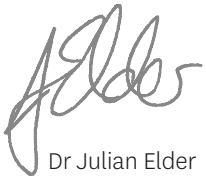
We thank everyone on staff and all our customers and partners who have contributed to our successful year.

We would like to especially acknowledge the contribution of Dr Warren Parker, who retired from Scion during this past year. Under Warren's leadership Scion transformed its strategy, and relationships with the sector, key stakeholders and major international science organisations were considerably strengthened. We thank Warren for his very personal contribution to Scion and the New Zealand forest industry.

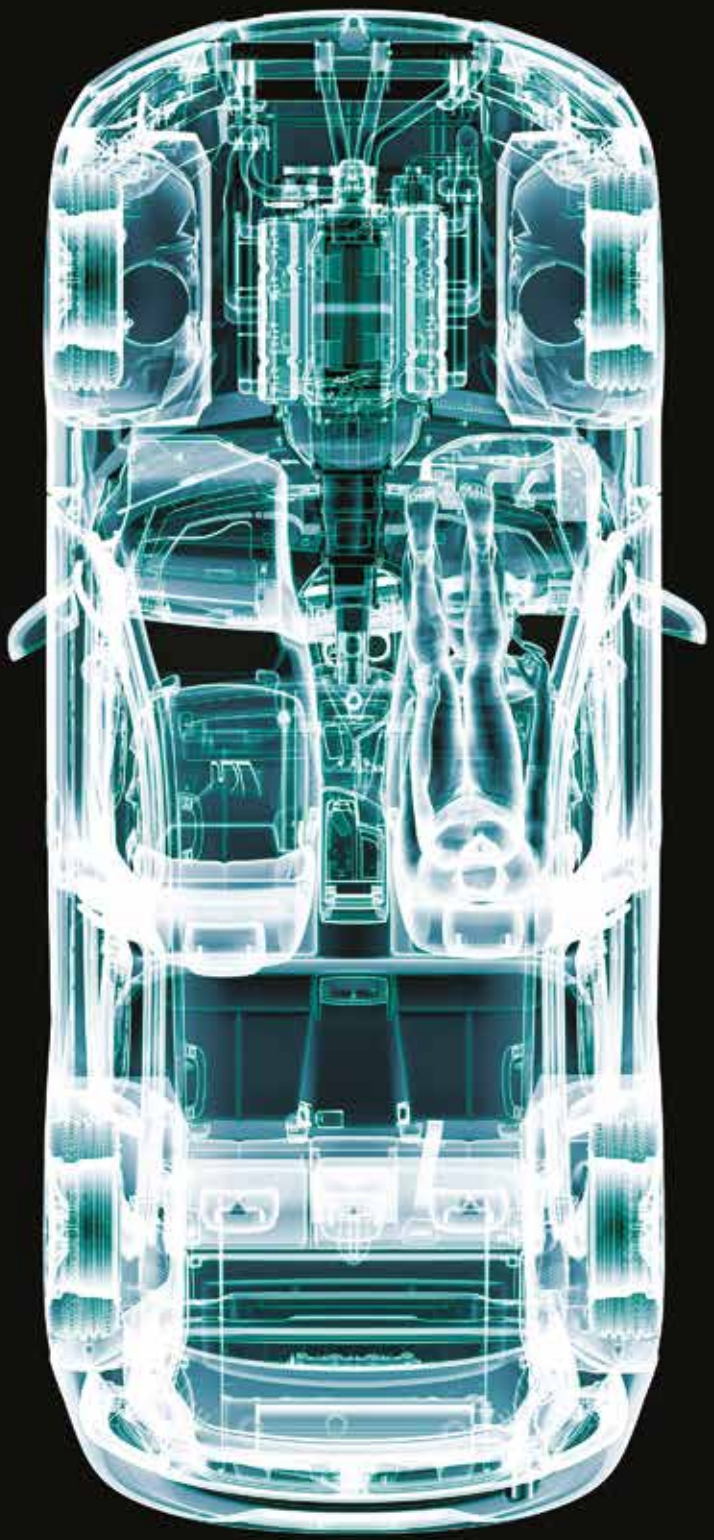
We also acknowledge and thank retiring Directors Judith Stanway and Sheldon Drummond for their services to the Board and for their strong contribution to making Scion the best it can be.

This year we marked our 70th anniversary by launching a series of events through to the end of 2017 to celebrate our science and our people. Now we are poised to look far into the future in our upcoming strategy refresh. We are very excited by the significant opportunity that forestry and manufactured products from forestry have for all New Zealand, regional economies and the Māori economy. We look forward to realising Scion's role in enabling that potential, starting with the year ahead.

Tony Nowell CNZM
*Chair*



Dr Julian Elder
*Chief Executive*



# UNLEASHING THE POWER OF FORESTRY THROUGH SCIENCE AND TECHNOLOGICAL INNOVATION TO MEET CURRENT AND FUTURE MARKET NEEDS OF A STRONG BIOBASED ECONOMY

So, to maximise the value and productivity of New Zealand's commercial forests, we work in close collaboration with the commercial forest growing and management sector;

To improve the competiveness of the solid wood processing industry, we work in partnership with innovative manufacturers and engineering companies; and

To expand opportunities for using wood fibres, biopolymers and biochemicals, we work with a wide range of high-value manufacturers, chemical and industrial biotechnology companies in existing and emerging industries.

Outcome area

**Increase the value and productivity of New Zealand forestry, wood products, wood-derived and other biomaterial sectors**

*Our wood-reinforced plastic is making inroads into automotive manufacturing – future opportunities for new industrial bioproducts from trees are huge.*

# Getting our soil foundations right

Soil is critical to forest productivity, providing the resources that support the growth of trees in nurseries and forests. Scion's soil scientists are using genetic, molecular, and chemical analyses to directly link soil processes to the productivity and sustainability of New Zealand's planted forests. This work is proving that we can use our understanding of soil processes to minimise the use of expensive chemical fertilisers and maximise forest growth.

Research funded by industry through the Forest Growers Levy Trust and Growing Confidence in Forestry's Future programme has resulted in some key findings in soil science. We can now show the importance of nursery conditions in growing trees and how the influence of soil properties in the nursery can effect tree growth and performance for up to six years in the forest. This has created potential for significant improvement in forest volume by management of soil in the nursery.

Dr Simeon Smaill, microbiologist and project leader, says, "The team has developed new treatments that can enhance the activity of soil microbes and benefit tree performance and forest sustainability. For example, continued positive results from a new soil nitrogen treatment has shown that it is possible to reduce chemical inputs without compromising seedling growth and survival."

Scientists at Scion have also continued to develop and improve our Nutrient Balance Model (NuBalM) to predict how nutrients affect growth at the stand level, the effect that management decisions could have, and how to ensure soil quality is maintained to support future rotations. This work has been ongoing for 25 years and data from our long-term site productivity trials has enabled Scion and the forestry sector to improve NuBalM and test its accuracy over multiple locations across the country. It has also been used to prove the value of retaining harvest residue on site for long-term soil fertility.

Major forestry companies are increasingly using Scion's soil-based knowledge and expertise to better manage their forest estates.

Ian Hinton, Technical Manager at Timberlands Limited, says, "The work being carried out by the team at Scion is opening up opportunities we haven't been able to explore in the past. We see real opportunity in the soil management area and with the help of Simeon and others we are now moving quickly from science based trials to large operational trials with the expectation that enhanced soil management will become a key part of our productivity tool box."

The deeper we dig, the more we reveal the untapped potential for managing soil, as an integral and living part of the forest ecosystem, to increase both the productivity and sustainability of New Zealand's forestry estate.

> "The work being carried out by the team at Scion is opening up opportunities we haven't been able to explore in the past. We see real opportunity in the soil management area and … we are now moving quickly from science based trials to large operational trials with the expectation that enhanced soil management will become a key part of our productivity tool box."
>
> Ian Hinton,
> *Technical Manager, Timberlands Limited*

Timberlands, Rayonier

Ministry of Business, Innovation and Employment, Forest Growers Levy Trust

# Precision forestry: easier and more accessible with UAV science

The use of unmanned aerial vehicles (UAVs) and remote sensing in forestry management is helping to usher in a new era of precision forest management. Scion science is helping to realise the potential benefits these tools can provide, and make them more accessible to forest managers than ever before.

As certified operators (Part 102) under the Civil Aviation Act, our UAV team is able to undertake more complex operations leading to new developments over the wide spectrum of research areas we are pursuing. The work has included a project to identify new ways that industry can use UAV data including applications as varied as post planting survival assessment, mapping wind damage and post-harvest residue assessments.

The UAV research programme has been working with forestry technical managers, like Aaron Gunn at Port Blakely NZ, and other partners to undertake field trials of the work.

Aaron, who is also on the Growing Confidence in Forestry's Future technical steering team for this research, says,

> "The remote sensing and UAV research carried out by Scion in our Matakana estate is cutting-edge and is helping to provide a new perspective on the management of our forests. The innovative new tools and techniques they are developing will provide real value to the industry for years to come."
>
> Aaron Gunn,
> *Port Blakely NZ*

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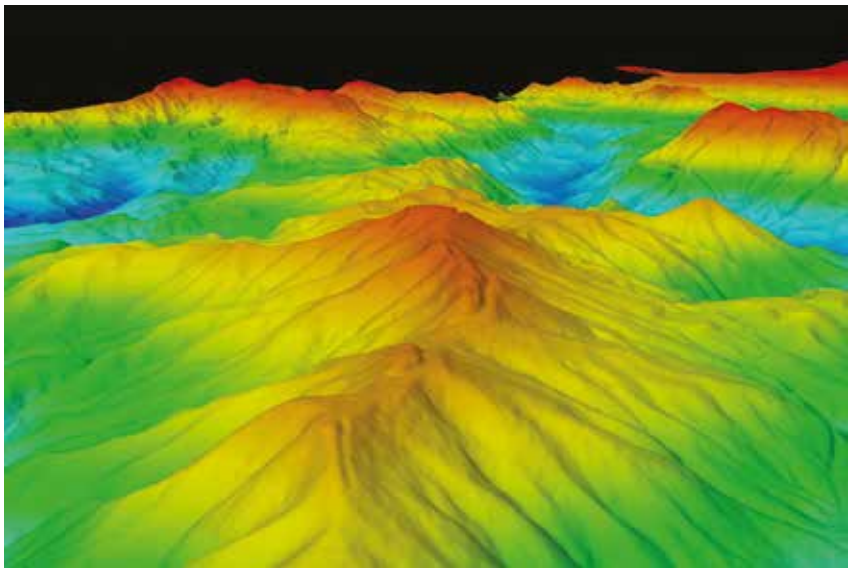


This year, our research team has developed methods for monitoring disease expression in plantation trees. Through carefully designed trials we have defined suitable data collection hardware and procedures using very high resolution multi-spectral imagery. Now, for the first time, low-cost and highly flexible methods are available for the early detection of needle diseases for planted forests. This enables forest managers to undertake targeted management, reducing disease spread and increasing forest productivity.

Scion has worked with the Ministry for Primary Industries to develop new methods to map tree species in urban areas using UAV imagery. This work will allow better surveillance to protect New Zealand's forests from biosecurity incursions.

Weed (gorse and broom) identification is now also a possibility thanks to Scion's data analysis undertaken in five and eight-year-old *Pinus radiata* stands. In this research UAV data was used to validate predictions made from satellite imagery making use of both technologies for better forest management.

Fire behaviour modelling has also benefitted from our multispectral and LiDAR data, which has been used in a fire prediction model, providing information around fire behavior in controlled burns.

Our work has harnessed the high resolution spatial and temporal data to provide a host of new services to forest growers, including pre-harvest assessments of forest volume, micro-site soil classification, data for tree stocking and restocking based on individual tree health, and animal health monitoring.

Ministry for Primary Industries, University of Tasmania, Imagine UAV, AsureQuality

Forest Growers Levy Trust, NZ Farm Forestry Association, AGMARDT, Neil Barr Foundation, Strategic Science Investment Funding

# Bringing Bay of Plenty businesses together

Industrial Symbiosis Kawerau is bringing together manufacturers and exporters in the eastern Bay of Plenty (EBoP) to save the region millions in transport costs, and Scion is helping to make it happen.

> "... the terminal is regarded as being a significant asset that will benefit the entire region and the Scion research team has been pivotal in helping us progress this towards becoming a reality."
>
> David Turner, *Chair of Industrial Symbiosis Kawerau*

Scion's recent survey estimates that approximately 50,000 20-foot equivalent containers are filled with goods from exporters and manufacturers in the EBoP each year. Most of the cargo will make its way on trucks to Sulphur Point in Tauranga. Each truck carrying cargo passes the underutilised, but capable East Coast Trunk railway line. This will not be the case for much longer thanks to the initiative led by Industrial Symbiosis Kawerau and supported by a feasibility study by value chain optimisation researcher, Ginny Christians.

The feasibility study revealed that although no single exporter is large enough to commission a freight train service, collectively, exporters operating across the EBoP dispatch enough cargo to the port to justify a daily freight train.

Ginny says, "Although the solution was obvious from a global perspective, individual businesses in the region simply didn't have the mandate to assess regional-scale solutions. We were able to get the right people in the room to have the right discussion."

Ginny's report concluded that a container terminal facility at Kawerau would be the ideal solution. Local companies have seen the merit in the concept and have expressed interest in investing in the container terminal.

David Turner, Chair of Industrial Symbiosis Kawerau, who initiated the project said that "A vital point regarding the container terminal is that principally, it is about eliminating supply chain waste for value-add businesses in the EBoP – so those businesses can access global markets more efficiently. This way our communities have more opportunities to add value – because the only way individuals can become more valuable, is by adding more value. Consequently, the terminal is regarded as being a significant asset that will benefit the entire region and the Scion research team has been pivotal in helping us progress this towards becoming a reality."

A total annual saving of approximately $4 million in avoided transport costs is expected once the container terminal is fully operational, in addition to a net reduction in vehicle emissions and decreased congestion on the roads.

This initiative is part of the Toi Moana Bay of Plenty Regional Growth Strategy.

Eastern Bay of Plenty exporters, Opotiki District Council

Kawerau Industrial Symbiosis, Kawerau and Whakatāne District Councils, Bay of Plenty Regional Council and Ministry of Business, Innovation and Employment


PHOTO: NZRAILPHOTOS.CO.NZ

# Biospife provides global kiwifruit marketer with an environmentally-friendly solution

Zespri's kiwifruit spife (spoon-knife) can be used for cutting, scooping and now composting, thanks to Scion innovation.

It was Zespri's determination to explore a more environmentally-friendly solution that led to the creation of the biospife. The original version of the spife was made of polystyrene, a plastic that uses non-renewable fossil fuels in its formulation which can take 500 years to break down. The biospife is the solution to all of the polystyrene spife's problems.

Made with PLA (polylactic acid, a plastic from corn) and Scion's kiwifruit compound, the biospife contains renewable materials including kiwifruit skin and is compostable.

Biospife project leader Gildas Lebrun and the team settled on a process called masterbatching. He says, "The 'masterbatch' mixture acts like a concentrate that is added to a compostable bioplastic before being injected into the spife moulds. Getting the mix right was key to making sure the biospife would have the right qualities and meet food safety standards."

The biospife is a 'kiwi' project in many ways. The kiwifruit skins in the biospife are a side product from puree processing in Te Puke. They were shipped to Scion's Rotorua campus to be turned into the masterbatch. After being added to the bioplastic by Alto in Christchurch, the finished biospifes go to Zespri's headquarters in Mount Maunganui. From there, Zespri delivers the biospife to the world, sending them to any of the 53 countries they sell kiwifruit to.

Kiwifruit skins are a biomass side stream of kiwifruit horticulture. If the material can't be reused in a product like the biospife, it is sold as animal food or composted. Adding kiwifruit to the biospifes creates another use and adds value to the by-product before it is composted.

Alto's Engineering Services Manager, Paul Clemence says, "Here at Alto Packaging Limited we are passionate about developing innovative and sustainable products. This is often a difficult process, but when all parties involved have a similar philosophy and are determined to succeed, it makes the challenges a lot easier to overcome. This project was a good example of that."

Zespri's Alice Moore, Global Marketing Manager for Organics, says, "Scion and Alto's innovative work has created an excellent, more environmentally-friendly product.

"It is great to be able to offer an alternative bio-degradable spife and we're looking forward to engaging consumers and telling them about the science behind it as they cut, scoop and eat our kiwifruit."

After the initial production run of biospife using the optimised masterbatch, Zespri ordered a new batch of biospifes and launched the product in New Zealand at Fieldays in June 2017.

Zespri

http://bit.ly/2tIpEAX

> "Scion and Alto's innovative work has created an excellent, more environmentally-friendly product. It is great to be able to offer an alternative bio-degradable spife and we're looking forward to engaging consumers and telling them about the science behind it as they cut, scoop and eat our kiwifruit."
>
> Alice Moore,
> *Global Marketing Manager for Organics, Zespri*

# Huge opportunity for plant-based bioadhesives

Engineered wood products made with adhesives from fossil fuels that contain formaldehyde are common place in our homes, but some can release compounds into the air that contribute to poor indoor air quality and pose health risks.

In a world first, the Scion bioadhesives team has developed 100 per cent biobased-adhesives and resins that could replace formaldehyde-emitting adhesives. With an increasing interest in sustainable alternatives in the global wood adhesives market, estimated to be more than US$4 billion, the opportunity for this environmentally-friendly glue to become commercially successful is very promising.

Made from natural sources, including forestry and agricultural waste, the Scion-made bioadhesives and resins are petrochemical-free, have very low formaldehyde emissions and can be made and used in existing manufacturing operations.

> “The technology is a game changer for wood panel manufacturers.”
>
> Dr Will Barker,
> *Chief Executive, NZBIO*

The technology, which has been developed over seven years, has been patented and trademarked as ‘Ligate’. The ‘green’ credentials of Ligate™ products will provide manufacturers with a competitive advantage over wood panel processors using conventional petrochemical-based adhesives and resins.

"Adhesives and resins made from natural sources have a lower environmental footprint and are considered more socially acceptable than their traditional formaldehyde-based counterparts," says Dr Warren Grigsby, the driving force behind Ligate™.

Ligate™ has earnt a number of accolades since it was trademarked in 2016. In September this technology was named 2016 Biotechnology of the Year by NZBIO, was awarded a judges' commendation for renewable innovation at the NZ Sustainable Business Network Awards and was a finalist for the Innovation in Sustainability and Clean-Tech category at the NZ Innovation Awards.

Chief Executive of NZBIO Dr Will Barker said, "The technology is a game changer for wood panel manufacturers".

"We've spent years mixing and matching assorted ingredients to come up with the right recipe. This is the icing on the cake for our bioadhesives team," says Warren.

The technology has been manufactured to mill scale and the first phase attracted significant international interest. Warren has spent considerable time in New Zealand and Europe profiling Ligate™ with manufacturers.

Ministry of Business, Innovation and Employment

http://bit.ly/2aiSvyk

# Reusing rubber – the road from tyre to timber

Around five million tyres are disposed of each year in New Zealand. Some 30 per cent of these end-of-life tyres (ELT) are recycled, but 70 per cent end up in our landfills or are illegally dumped. In addition to the enormous pressure placed on landfill space, getting rid of waste tyres is costly, and stockpiles of tyres are a fire hazard.

Finding solutions to this environmental challenge is the focus of a two-phase research and product development project led by Scion's Dr Grant Emms and Asona (a specialist New Zealand manufacturer, distributor and installer of acoustic decorative ceiling and wall finishes serving the commercial interior market). Together, we have been investigating the creation of a New Zealand based ELT rubber and processing facility to recycle crumbed rubber into high-value acoustic building products such as flooring.

Grant says, "We've created a number of small scale samples with Asona, so we've proven we can do it."

> Around three and a half million tyres end up in New Zealand landfills each year or are illegally dumped. Finding sustainable solutions to end-of-life tyre problems are a challenge tackled by Scion.

This project is one of three rubber recycling projects funded through the Ministry for the Environment's Waste Minimisation 2015 funding round.

One project is undoing the vulcanisation process that converts raw rubber into hard, durable tyres. Scion is developing an underpinning extrusion process, based on equipment currently available, to revert the cross-linked structure of tyre rubber, and produce the devulcanised, crumbed rubber for use as a high-performance binder for New Zealand's roads.

The final project is adding recycled rubber into manufactured wood panels for acoustic and vibration damping properties. Dr Warren Grigsby is behind this project, which he says has a lot of potential. "The success of this project would create a win-win for New Zealand with fewer tyres sent to landfill and profit from a range of new export products."

Scion is working with commercial partners on all three projects to ensure the work done in the laboratories will be commercially feasible.

Asona, other industry partners

Ministry for the Environment

# Reinventing the water closet

Scion is using waste water treatment science from the pulp and paper industry in an aid assistance project to help solve the world's sanitation problems by reinventing the toilet.

There are 2.5 billion people worldwide[1] living without adequate access to safe and affordable sanitation. While the implications on human and environmental health are enormous, the toilet as we know it is not an option for many of the regions that need sanitation the most. A new solution to treat human waste is needed, and the Bill and Melinda Gates Foundation is working with scientists from Scion, and all over the world, to make it happen.

The challenge to reinvent the toilet was started by the foundation in 2011. The foundation's aim is to remove the barriers to safe sanitation by funding work to create a toilet that is safe for humans and the environment, is sustainable, cheap to use (less than US$0.05 per user per day) and works 'off the grid'.

Scion came to the project in 2015, when the foundation awarded our research team a grant to create a proof of concept – showing that our wet oxidation technology could be an effective way to treat human waste. In 2016, the initial results prompted the foundation to award our team a further grant to create a full-scale working prototype in the next two years. Scion has also been given funding to work to apply extrusion technology to the dewatering of pit latrines and has delivered a highly successful proof of concept.

Research Leader Dr Daniel Gapes says the real winners of this challenge will be the 2.5 billion people who will benefit from the technology. "That number keeps us motivated, it's been key to our success. We're just one of many teams around the world working on a solution to this problem, but we're all sharing information and working together."

To help reduce the organic load of the effluent coming from the wet oxidation process, the Scion team has begun a collaboration with the University of West England (UWE). Ioannis Ieropoulos, Professor of Bioenergy and Self-Sustainable Systems, from UWE says, "This is a wonderful opportunity to bring together multiple technologies (Scion, Swansea and UWE) and collectively try to solve some of the world's sanitation problems. The collaboration with Scion allows us, for the first time, to trial our Microbial Fuel Cells in line with the wet oxidation process; this is novel in its own right and together may give us an outcome, which is more than the sum of the different components coming together."

Scion has a lot of experience in waste treatment, arising from a long-term focus on the pulp and paper industry and over a decade developing the TERAX® technology. Daniel says, "This work arose from our forestry waste research, and the things we learn from it, such as creating new reactors to process chemicals, are applicable across a variety of fields and places."

Swansea University (Wales), University of West England

The Bill and Melinda Gates Foundation

http://bit.ly/2tEkAcM
http://bit.ly/2wjeqCD

> "This is a wonderful opportunity to bring together multiple technologies (Scion, Swansea and UWE) and collectively try to solve some of the world's sanitation problems."
>
> Ioannis Ieropoulos
> *Professor of Bioenergy and Self-Sustainable Systems, University of West England*

[1] See http://www.gatesfoundation.org/What-We-Do/Global-Development/Reinvent-the-Toilet-Challenge

# UNLEASHING THE POWER OF FORESTRY MEANS THAT FORESTS MUST BE RESILIENT TO CURRENT AND FUTURE NATURAL THREATS AND INDUSTRY HAS FREEDOM TO OPERATE

So, to improve New Zealand's ability to manage risks associated with biosecurity, fire and climate change, we work with government agencies, forest growers and research collaborators both nationally and internationally.

And, to sustain New Zealand forestry industry's licence to operate both domestically and internationally we are engaged with many stakeholders in developing and providing tools, technologies and input to regulatory compliance frameworks.

Outcome area

**Protect and enhance market access and improve risk management in the forest industry**

# Rural fire research at the ready: Port Hills fire

Authorities are estimating that it cost over $8 million to put out the fires that claimed over 2000 hectares of Christchurch's Port Hills[1]. But this number, which is predicted to rise as final costs come in, could have been a lot larger if not for the expertise of Scion's rural fire research team who worked 180 hours over two weeks supporting the fire response.

The team's work is helping to make fire suppression safer and more cost efficient while also improving protection of people and property. Rural fire researchers Grant Pearce, Veronica Clifford and Dr Tara Strand assisted the fire incident management teams throughout the Port Hills fire and the multiple Hawke's Bay fires.

Grant says, "We were able to provide accurate predictions of fire intensity, where it would spread and how fast. After the fire was contained, we continued to use modelling to monitor potential break outs from smouldering hotspots."

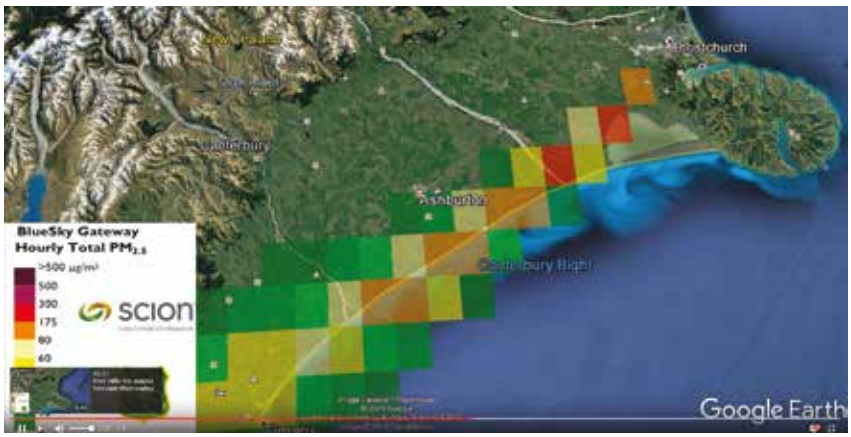
> "Scion's assistance with fire intensity prediction and modelling of fire perimeter growth greatly aided the suppression efforts on this highly complex fire ground."
>
> Richard McNamara,
> *Fire and Emergency New Zealand Regional Manager Rural*

[1] http://www.radionz.co.nz/news/national/334606/port-hills-fire-bill-reaches-7-point-9m

Scion staff were not the only team using our science to help manage the fire response. Rotorua-based company Interpine used techniques developed by Scion for UAVs with infrared cameras to identify and map hotspots that had the potential to flare up and cause the fire to spread again. This is the first time the approach had been applied operationally at a major wildfire in New Zealand.

Fire and Emergency New Zealand Regional Manager Rural, Richard McNamara, was an Incident Controller in the Port Hills fire response. He says, "Scion's assistance with fire intensity prediction and modelling of fire perimeter growth greatly aided the suppression efforts on this highly complex fire ground. By using the best of wildfire science in both real time and scenario planning, the incident management team was able to finally get ahead of the fire development and put in place suppression tactics which fire crews, heavy machinery and air attack used to finally control this massive blaze."

Beyond the fire front, Dr Tara Strand created smoke dispersion models to inform the wider public of likely smoke spread over a 72-hour period. Smoke from wildfires can have a serious health impact for some people, even if they




are far from the flames. Her smoke forecasts were able to help vulnerable people and those with respiratory problems to avoid smoke and prevent health problems such as asthma attacks.

Following the fire, Scion has continued to provide advice to Fire and Emergency New Zealand, councils and communities about recovery and ecological planning to assist with the rehabilitation.

Interpine, Fire and Emergency New Zealand

Ministry of Business, Innovation and Employment and Rural Fire Stakeholder co-funding


## 25 years of rural fire research

February 2017 marked 25 years of rural fire research in New Zealand. In 1990 the National Rural Fire Authority (NRFA) was established and one of its responsibilities was to coordinate research into forest and rural fire management. Along with the Department of Conservation, New Zealand Forest Owners Association and local government, the NRFA worked to establish a research programme at Scion (then the Forest Research Institute). Since the fire research capability was established in 1992, science has been used to improve the art of fire management.

Employed as New Zealand's first full time fire research scientist Grant Pearce (opposite) has been on the scene since then. He says, "Our research has focussed on reducing fire risk, being ready to fight it, responding to fire and recovering from it. Now we are preparing for a future with more extreme fires. We can't stop nature, but we can take precautions and be prepared based on the best science possible."

http://bit.ly/2w58paX

# Understanding kauri whakapapa in fight against dieback disease

Kauri dieback disease is wreaking havoc on our northern kauri forests, and without intervention, this prolific wasting disease will continue to spread, choking kauri to death from their roots. To date, there are limited options for managing kauri dieback after it has become established and given the slow regeneration time of kauri, this insidious disease is a cause of major concern. Kauri's best chance for survival long-term is to find kauri plants with inherent resistance to the disease.

Looking for resistant strains of kauri to breed from is a major focus of the Scion-led Healthy Trees, Healthy Future (HTHF) collaborative research programme. Kauri dieback is caused by the soil-borne fungus-like organism *Phytophthora agathidicida*, and the HTHF programme aims to identify markers and establish screening methods to assess any natural disease resistance.

The team, led by Dr Nari Williams, is working with regional mana whenua groups to screen kauri sourced from within their rohe. Nari and the team have established partnership agreements with mana whenua from Northland, Auckland and the Waikato regions and have undertaken two seed collections for growing kauri in the newly installed *P. agathidicida*-free growing facilities at Scion.

> "I'm optimistic that the investment from both Māori and agencies in looking for naturally occurring resistance could present a solution that will ensure the existence of kauri for future generations."
>
> Waitangi Wood, *Tāngata Whenua Roopū member*

This year, the team has successfully raised 12,000 kauri and will use them to test the susceptibility of kauri siblings from the same mother tree and identify families with potential dieback resistance.

Nari explains, "The seed we collect from a single mother tree has been pollinated by a pollen donor somewhere upwind. If one seedling proves to be resistant, there is either a resistant pollen donor in the area, or the mother is resistant. This is where we need to understand the structure of resistance – is it one gene, or a group of genes, and what does the pathogen do when it infects a seedling?

"Early stages of screening have already shown different responses to *Phytophthora* infection across different kauri lines. While promising, there is still a great deal we don't know about how well our various screening assays predict disease susceptibility as trees age and across environments. Kauri are a long-lived tree. We need to understand whether trees showing resistance today are likely to stand up to infection 5, 50 and 500 years from now."

The Tāngata Whenua Roopū (a collective of the mana whenua groups throughout the kauri regions) remain concerned about the resilience and health of kauri forests. Waitangi Wood, a member of Tāngata Whenua Roopū, says, "I'm optimistic that the investment from both Māori and agencies in looking for naturally occurring resistance could present a solution that will ensure the existence of kauri for future generations."

Healthy Trees, Healthy Future research programme (see https://healthytrees.co.nz), iwi

Strategic Science Investment Funding, Ministry of Business, Innovation and Employment, Forest Growers Levy Trust, Ministry for Primary Industries

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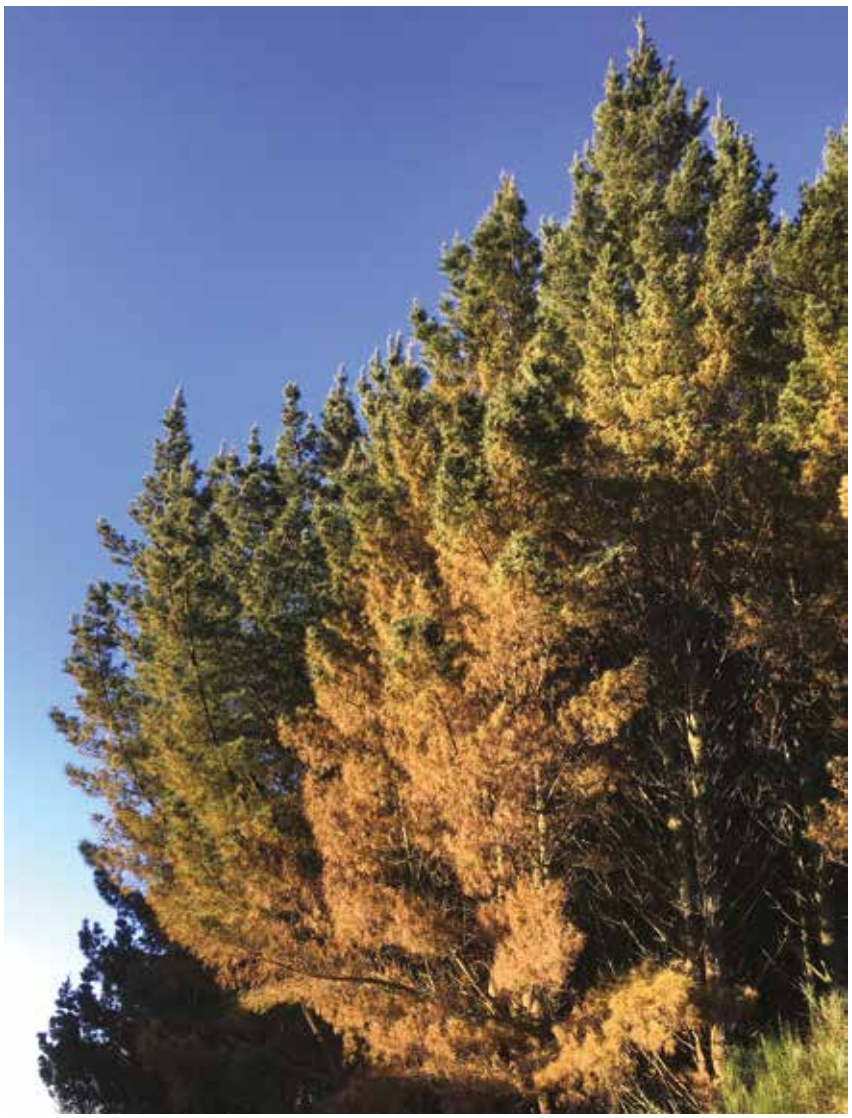


# Controlling red needle cast with copper

Red needle cast (RNC) is a foliage disease that can affect the growth of radiata pine. In certain conditions, the disease causes severe defoliation, reducing growth by about 40 per cent in the following year and potential earnings for the forest owner. While research is underway to identify long-term solutions, Scion has developed a new copper treatment to protect trees that are already planted. We are working alongside industry partners to trial the use of copper on a wide scale, and so far results are very promising.

RNC is caused by *Phytophthora pluvialis*, a pathogen also found in North America.

The chemical typically used to control *Phytophthora* diseases is phosphite, but Scion's research showed mixed results for RNC, where a large volume of chemical was needed to produce a response. Copper is an excellent alternative because it is cheaper than phosphite and is already applied routinely to control dothistroma needle blight. As it is already in use, the application methods and logistics have been determined.

Scion worked with industry to undertake a major field spray trial in February, comparing copper and phosphite as management tools. Forest Protection Science Leader Lindsay Bulman says, "The results showed that copper may be the next best tool for reliably managing red needle cast. One month after copper application, needles showed significantly less disease compared with the control and the phosphite treatment."

Dr Wei-Young Wang, Seed and Special Project Manager at PF Olsen Limited, is a member of the Forest Growers Levy Trust team that is steering the research. He says, "Red needle cast has been troubling the forestry industry since 2008. Scion's development of this effective and relatively inexpensive method to control the disease is welcome news to the industry."

Our research indicates that the best time to apply the copper treatment is during late summer and again in autumn. The next steps will be to determine the dosage and precise timing.

Hancock Forestry Management, Dothistroma Control Committee

Strategic Science Investment Funding, Forest Growers Levy Trust

> "Red needle cast has been troubling the forestry industry since 2008. Scion's development of this effective and relatively inexpensive method to control the disease is welcome news to the industry."
>
> Dr Wei-Young Wang,
> *Seed and Special Project Manager, PF Olsen Limited*

# UNLEASHING THE POWER OF FORESTRY TO FUEL NEW ZEALAND FROM RENEWABLE RESOURCES

So, to help increase New Zealand's energy security through expanded utilisation of forest biomass for energy, we are working with government, forest and land owners, industrial manufacturers, wood processors, energy companies and commercial consumers of transport fuels.

Our science focusses on:

- Wood-based replacements for transport biofuels and industrial energy
- Identifying, adopting and adapting the best international technologies and building the capability for large-scale uptake and deployment.

Outcome area

Increase renewable energy production and energy security by growing New Zealand's ability to produce sustainable bioenergy and liquid biofuel products

# Biomass for industrial heat

Using biomass to replace fossil fuels in industrial heating would be a major step towards reducing New Zealand's greenhouse gas (GHG) emissions. Scion is helping to guide the switch from coal and gas to biomass powered heat especially from forestry feedstocks.

Coal and gas fuelled industrial heating (for example, heating for milk processing in dairy factories) makes up a large proportion of New Zealand's energy use, and it has been identified in the New Zealand Energy Efficiency & Conservation Strategy 2017-22 as one of the largest areas where we could reduce our energy-related $CO_2$ emissions (along with transport). The potential for GHG reductions at a national level from substituting wood for coal is estimated to be around 900,000 to 1,000,000 tonnes of $CO_2e$ per annum.

Coal and gas fuelled industrial heating has been identified as one of the largest areas where New Zealand could reduce energy-related $CO_2$ emissions (along with transport). The potential for greenhouse gas reductions at a national level from substituting wood for coal is estimated to be around 900,000 to 1,000,000 tonnes of $CO_2e$ per annum.

Scion is taking a three-fold approach: modelling the potential supply of biomass particularly woody biomass from plantation forests, for example, availability and price at a given location; looking for biomass derived fuels that

can be used in existing coal-fired boilers; and our team is leading a programme and case study with GNS Science and the University of Waikato.

The case study looked at biomass replacing coal at a specific industrial site. It compared the cost of biomass to that of coal or gas. Our results showed that biomass could be competitive over the 20-year lifetime of a boiler while also emitting fewer greenhouse gases.

In the last year, Scion hosted EECA's Large Energy User's Forum with the top 200 or so industrial energy consumers in New Zealand in attendance. The forum is part of EECA's business sector which partners with businesses from across New Zealand that spend $1 million or more annually on energy and have high carbon emissions. We were able to demonstrate what Scion is working on in the bioenergy sector and showcase our pyrolysis plant. The forum was attended by businesses and public sector agencies, including government, hospitals and universities.

Our biofuels team has also undertaken commercial contracts for facilities interested in understanding their biomass availability and price, allowing them to decide if biomass is a feasible option for them. For example, Scion provided a South Island consulting company with an assessment that used our databases on wood processing, forest residues and a GIS-based biomass supply model to determine the potential wood supply for a heat plant located in central Christchurch. We found that there were sufficient wood residues available to meet demand.

Energy Efficiency and Conservation Authority (EECA), local and national government, industry stakeholders

Ministry of Business, Innovation and Employment, Strategic Science Investment Funding, commercial funding

## New Zealand Biofuels Roadmap

New Zealand uses almost 8.5 billion litres of transport fuels every year with less than 0.1 per cent coming from a renewable source. Transport fuels are responsible for 17 per cent of our country's greenhouse gas (GHG) emissions.

Large-scale liquid biofuel use will reduce transport sector GHG emissions, give greater security of fuel supply through reduced reliance on imports, as well as economic and employment growth. However, the pathway to establish this new industry is unclear owing to multiple options available at all points long the value chain and the best fit for New Zealand.

Some 18 months ago, Scion started a project to create a biofuels implementation roadmap that will plot out the optimum courses for large-scale production and use of liquid biofuels in the New Zealand market. Over the last year, interviews and workshops were held with stakeholders representing land owners, feedstock processors, distributors, commercial users, researchers and government.

A key element of the work has been modelling different biofuel scenarios that use variable feedstock, conversion technologies and costs inputs across multiple land classes throughout the entire country.

Clean Technologies Science Leader Dr Paul Bennett says, "At the end of the project we intend to have an evidence-based, stakeholder-agreed direction for New Zealand's biofuels future."

The project will conclude in late 2017 with the public release of recommendations scheduled for early 2018.

http://bit.ly/2vqHsfT
http://bit.ly/2wTUuHn

PHOTO: DESTINATION ROTORUA

# UNLEASHING THE POWER OF FORESTRY TO NOURISH OUR LAND AND PEOPLE WITH BENEFITS BEYOND TIMBER PRODUCTION

Outcome area

Enhance benefits from forestry-based ecosystem services to improve both the global market position of industry and the environmental sustainability of forestry production in New Zealand

So, with our partners we are working towards demonstrating to forest and land owners, Māori, regional councils and policy makers the value of forests in the landscape through economic, environmental and social contributions to regional development and community well-being.

# How much is your forest really worth?

The nation's 1.7 million hectares of planted forests provide a range of benefits, called ecosystem services (which include timber, avoided erosion, recreation, biodiversity conservation, water regulation, carbon sequestration and nutrient regulation). Most of these services have enormous value to the environment and society, but they can be difficult to quantify. Interest in understanding the worth of those services is increasing, and to help to consistently measure said services Scion is further developing and refining a tool called the Forest Investment Framework (FIF).

Over the past 12 months, the FIF has been used in conjunction with economic valuation techniques to assist in better understanding the full value of existing and prospective forests to inform policy and investment decisions. To date, the quantification of forest ecosystem services has contributed to discussions on the National Policy Statement for Freshwater Management, Emissions Trading Scheme, afforestation policies, forest investment, land use management and forest product certification.

A new biodiversity valuation function has also been added to the FIF. This enables forest owners to calculate the private costs and public benefits of conservation programmes in existing planted forests. If the proposed biodiversity programme is to be undertaken in forests close to where people live, the value in the region would likely increase as these residents would benefit from the biodiversity programme. This biodiversity function can be used for valuing biodiversity investment programmes for North Island brown kiwi, karearea, green gecko, kākābeak, giant kōkopu and other native species.

> "We commissioned the ecosystem services report to demonstrate a commitment to quantifying non-timber benefits accruing from our forests."
>
> James McEwan, *Technical Manager, Wenita Forest Products*

FIF was also used to estimate key forest ecosystem service values provided by 20 forest blocks of the Wenita Forest Products Estate, the largest producer of timber in Otago. Estimated values suggest that the combined environmental value of carbon sequestration and avoided erosion can be greater than the timber profits, not including the recreational hunting and biodiversity conservation values.

James McEwan, Technical Manager at Wenita Forest Products, says, "We commissioned the ecosystem services report to demonstrate a commitment to quantifying non-timber benefits accruing from our forests. This is an area that (Principle 5: Benefits from the Forest) is covered in the FSC® Principles and Criteria."

The ecosystem services report produced by Scion provided information for the criteria and indicators that ensure forest products are used efficiently for economic, social and environmental benefits.

At the conclusion of this research in September 2019, the FIF will include timber, carbon, avoided erosion, biodiversity, avoided nitrogen, water yield and recreation functions. As a final stage, the FIF project team will undertake a national analysis of the full value of New Zealand planted forests, both existing and potential, enabling better representation of the wider benefits provided by forests in land use management, policy and decision making.

Wenita Forest Products, Marlborough District Council, Ministry for Primary Industries

Forest Growers Levy Trust, Ministry of Business, Innovation and Employment

# WORKING IN PARTNERSHIP WITH MĀORI

Māori own some 40 per cent of New Zealand's land in commercial forests, making them one of our most important stakeholders.

This year we celebrated milestones in three projects with our Māori partners and began one new project.

## Northland tōtara

The Northland tōtara project is a long-term and in-depth look at the possibilities for using tōtara growing on private farmland in Northland. The potential in this area was identified in the 1980s. Now, we are looking at how these trees could be turned from a paddock nuisance into a valuable, sustainable forest resource that benefits the whole region.

Māori and their access to this important resource has long been a consideration, and we are working closely with Taitokerau Māori Forestry Collective, a collective of nine Māori land trusts, and Northland Tōtara Working Group and central and local government to make this aspiration a reality. Together, our aim is to realise the value of this potential new industry in the fullest way possible, including social, economic and cultural benefits.

This year we initiated a small pilot study, harvesting 40m³ of tōtara. The harvested wood was used to conduct initial tests that will help us to better understand the characteristics and properties of this species. This timber will be taken through the full value chain and converted into products.

## Minginui nursery

Ngāti Whare are the proud owners of a brand new, state-of-the-art nursery at Minginui. Thanks to their ongoing partnership with Scion, they also have access to new cutting-edge propagation technology that will allow them to produce native seedlings, specifically – tōtara, rimu, kahikatea and miro – with the potential to expand indigenous forestry in New Zealand.

The Ngāti Whare nursery at Minginui, on the edge of the Whirinaki Forest, is using a technique, newly developed by Scion to grow trees from cuttings. This process enables the seedlings to grow faster and in larger numbers, and overcomes the difficulty of sourcing viable seed and unreliable germination of that seed. The novel technology will enable the mass production of four indigenous podocarps on a large commercial scale with assurance as to their whakapapa and their genetic attributes.

Our partnership aims to further develop the propagation approach and expand its application across New Zealand over the next few years.

## Waikura Valley erosion control

The Whangaparaoa 2L Trust are kaitiaki of Mataroa Station - nearly 2,500 hectares of steep, erosion-prone land on the East Coast. The trust's ability to continue farming the station, and to bring its vision of environmental sustainability and community resilience to life, is dependent on stabilising some of the trust's more vulnerable land. Working to this goal, Scion designed a planting trial to address the erosion with plants that retain soil and fit with the Māori land owners preferences for their land.

The trust, together with Scion, secured funding from MPI's Sustainable Farming Fund and erosion control funding programmes to research the survival and benefits of different plant species for erosion management, and to reforest 64 hectares around the trial area.

The project team worked directly with trustees to understand what they wanted planted on their land. Māori landowners practice intergenerational governance, which allows them to consider issues from a long-term perspective and securing the environmental resilience of the land was a key priority for the trust as well as balancing the economic, social and cultural values that underpin trustees' livelihood.

This year, Scion completed the three-year planting trial and presented the results at a hui at Rotorua in April. The results were published in a brochure and are available here: http://bit.ly/2vPXsNe

## Te Pakarito - Ngāti Whakaue kete collaboration

Weaving the old with the new was the main theme of our newest collaboration, partnering with Te Taumata o Ngāti Whakaue Iho Ake (Te Taumata). The project was initiated by Te Taumata, who run Matakōkiri, a science eduation programme for rangatahi (young people) between 7 and 14. Their latest project was to build kete (baskets) to store their six new bilingual science kits.

Te Taumata project leaders and the Scion team created a project where Te Arawa weavers and local scientists would work with Ngāti Whakaue rangatahi to create kete that combined the traditional weaving material – harakeke (flax) with a biobased biodegradable plastic (polylactic acid, plastic derived from corn).

Funded through an MBIE Curious Minds grant, they used three different manufacturing technologies to build three very different harakeke kete – using computer based CAD modelling and 3D printing; raw harakeke fibre set in resin; and sheets of harakeke bioplastic cut into strips and woven like traditional kete.


Starting at Tunohopu marae in Ohinemutu, rangatahi spent time with their whānau (family) learning about traditional ways to work with harakeke. From there they spent several sessions at Scion, working on their three kete prototypes. In between kete design and build, staff demonstrated how extrusion was used to make sheets for weaving and the 3D printing filament, and also showcased material characterisation methods using microscopy and tensile testing.

Rangatahi returned to Tunohopu on 25 May to showcase the kete to their Ngāti Whakaue whānau, peers and the Scion team.

http://bit.ly/2vkCjtn

# UNLEASHING THE POWER OF FORESTRY THROUGH COLLABORATING WITH TOP TEAMS

*Dr Heidi Dungey, convenor of the 2016 IUFRO Division 2 conference hosted by Scion in Rotorua.*

## Being part of a 125-year-old global forest science network

Scion's ties with the International Union of Forest Research Organizations (IUFRO) stretch back to the 1970s. Today, Scion scientists participate at division and task force level, and Principal Scientist and entomologist Dr Ecki Brockerhoff sits on the IUFRO Board.

IUFRO is a voluntary, global network for forest science cooperation, uniting more than 15,000 scientists in almost 700 member organisations in over 110 countries. IUFRO's goal is to advance research and knowledge sharing, and to foster the development of science-based solutions to forest-related challenges for the benefit of forests and people worldwide.

Nine divisions cover IUFRO's activity in key forestry research fields supporting collaborative work and linking research groups. Other IUFRO work is managed by temporary task forces that coordinate cooperation and interdisciplinary research between two or more divisions.

The task forces focus on key emerging issues. For instance, Dr Elspeth MacRae, General Manager Manufacturing and Bioproducts was the deputy task leader for the IUFRO Forest Bioenergy Task Force from 2010 to 2014.

Division 7, Forest Health, focusses on the effects and control of pathogens, insects and pollution. Ecki is division coordinator and is involved with the two task forces Contribution of Biodiversity to Ecosystem Services in Managed Forests, and Forests and Biological Invasions. In the past year, Ecki has co-authored four papers and contributed to special issues of the journals *Biodiversity and Conservation* and *Biological Invasions*.

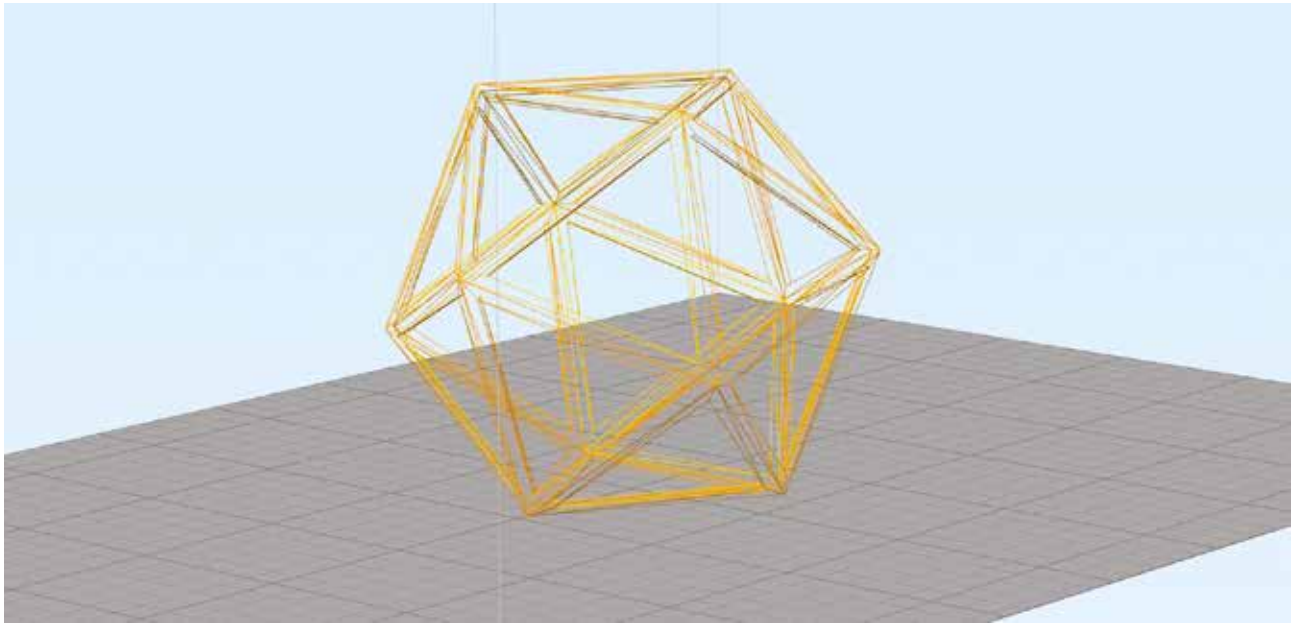
Dr Peter Clinton, Science Leader for Forest Systems, is active in Division 8, Forest Environment, which includes study of forest ecosystems, natural disasters, fire, climate and mitigation measures. Wind damage is one of these risks. Research Leader for Systems Biology and Risk Dr John Moore says collaboration in understanding and developing approaches to manage the wind damage in New Zealand forests has bolstered local industry capability in this area. John also contributes to wood quality interactions within Division 5, Forest Products.

Forest policy and economics is covered in Division 9, with a concentration on forest sector analysis, the social and economic aspects of forestry, policy and governance and environmental legislation. Dr Tim Payn, Research Leader for Enabling Environments, says he values the links to more fundamental science that working with IUFRO brings, and the alternative perspectives that can be gained from working with different forest types and approaches to forest management.

Other Scion staff currently are IUFRO office holders, typically as coordinators and deputies of research units within divisions: Dr Heidi Dungey (within Division 2, Physiology and Genetics), Dr Beccy Ganley (Division 7), and Drs Richard Yao and Peter Edwards (Division 9).

Working with IUFRO gives Scion the opportunity to build on a large foundation of knowledge, benefit from reciprocal sabbaticals, contribute to publications and conferences that influence national and international policy. The result of these collaborative relationships connecting Scion with like researchers around the world is continual innovation across our work.

www.iufro.org



# Working in new ways to create novel products from natural resources

General Manager of Manufacturing and Bioproducts Dr Elspeth MacRae is leading Portfolio 5 – Materials, Manufacturing and Applications – of the Science for Technological Innovation National Science Challenge (NSC).

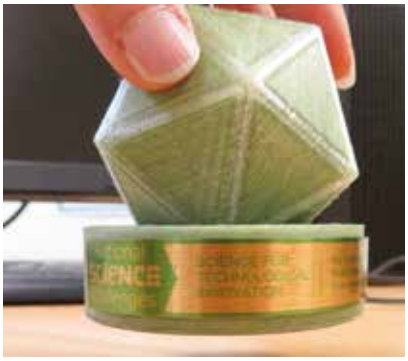
The aim of the NSC is to enhance New Zealand's capacity to use physical sciences and engineering for economic growth. The goal of Portfolio 5 is to see New Zealand selling new materials and products based on the country's biological resources and distributed manufacturing by 2025. Combining biomaterials with additive manufacturing methods such as 3D printing, electrospinning and layering will allow New Zealand to create a diverse range of new products in areas such as furniture, electronics, sensors, marine components, aerospace components, agritech and medical devices.

The spearhead project on 3D printing using New Zealand biomaterials has brought together eight organisations, some of whom have never worked together before. Scion's contribution includes leadership and its capability in manufacturing plastic-biomass composites. Other team members bring expertise in materials and process modelling, materials science, design, engineering, equipment and manufacturing.

The strengths of the collaboration, according to the team, include its cross-disciplinary nature, the opportunities to share equipment, and to maximise investment and funding. Among the benefits are building technical capability and relationships, mixing design and science, and exciting prospects of new science.

A recent outcome is a 3D version of the Science for Technological Innovation (SfTI) 20-sided-solid (icosahedron) logo. The first successful 'print' was presented to Science and Innovation Minister Paul Goldsmith at the All of SfTI Researchers' Workshop in July 2017.

The icosahedron was the product of close collaboration between design, biopolymer and object manufacture, and finishing touches. The development process used a design-led approach starting with an aspirational concept that was used to channel and inspire the science. The final object was manufactured at Scion using a biopolymer/harakeke composite. The creative process was captured on video.



Scion, in collaboration with major research partners, is building a future where wood fibres, cellulose from other plant sources and co-products from primary production can be combined in new plastic-like materials. New Zealand industries, using distributed manufacturing technologies to make new products from these materials, will increasingly become part of the growing local and global circular bioeconomy.

http://bit.ly/2x1CBXo

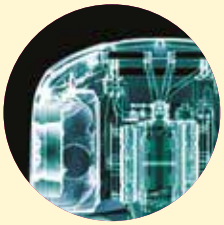
# ACHIEVING OUR SCIENCE GOALS

Meeting our strategic outcomes as set out in our 2016-2021 Statement of Corporate Intent.

| Science outcome 5-15 years | Leading indicators 3-5 years | Achievements in 2016-2017 |
|---|---|---|
| Maximise the value and profitability of commercial forests and their ecosystem services | Sustainably increase the productivity of New Zealand forests  | The Growing Confidence in Forestry's Future (GCFF) programme has made significant progress towards a better understanding of the key drivers of forest productivity and is developing a range of management interventions to increase productivity and profitability. The programme has demonstrated that increasing site utilisation by increasing final crop stocking can substantially lift productivity, and many companies are altering their silvicultural regimes to reflect this. The first application of the phenotyping platform quantified the key environmental factors affecting productivity and how different seedlots perform across these environments.<br><br>The GCFF programme continued to generate better information on the physiological basis of tree growth and how trees respond to different stimuli/stresses. Results from an operational nursery trial demonstrated that seedlings with improved growth and equivalent or improved nutritional status can be produced using a fraction of the chemical inputs conventionally used.<br><br>In simulations on the potential impact that genomics has on the delivery of genetic gain in conifer breeding programmes, genomics was found to increase considerably the genetic gain when the size of the training population was largest or when the heritability was higher. Compared with forward selection, simulations showed that genomic selection had the potential to deliver an increase of up to 24% per generation for wood density and up to 19% for growth.<br><br>Deploying clones of the selected individuals always resulted in higher additional genetic gain than deploying progeny/seedlings.<br><br>Genomic selection was tested for the first time on tree breeding traits. With genomic information used in the breeding analysis, it appears that between 13 and 115% additional genetic gain over traditional breeding will be available to breeders. With clonal propagation, genomics looks like an efficient and effective means to rapidly deliver genetic gain to the forest.<br><br>Accurate, precise and reliable physical description of plants (phenotyping) is vital to determine underlying genetic and environmental influences. Trees are difficult to phenotype because they are large and grow in the forest, unlike agricultural plants where rapid mass phenotyping in glasshouses has reduced breeding cycles and delivered new genotypes for a range of environments.<br><br>Scion has developed a prototype, novel phenotyping platform as the first step towards the use of phenomics in forestry. This platform harnesses new sensor technologies and the use of accurate and reliable geographical information systems to relieve the phenotyping bottle neck and put forestry on the same footing as agriculture. The impact of this platform will be transformational, where outstanding trees and the environments they perform best in will be identified to inform future breeding decisions. |

| Science outcome 5-15 years | Leading indicators 3-5 years | Achievements in 2016-2017 |
|---|---|---|
| | | Newly planted biotech trees (for improved growth and new lines for improved processing) were planted out in the field trial where they are establishing well. The trees will be regularly monitored to follow their growth as the trees develop and in accordance with our field trial approval. |
| | Extract value from forests and dispersed forest holdings  | Scion partnered with ForestX, a New Zealand on-line trading board that lists forests for sale. Scion's wide range of scientific tools are used to provide production expectations for the listed forests. The trading board was launched in August 2016.<br><br>Log price outlooks were disseminated quarterly.<br><br>A feasibility study for an inland container terminal at Kawerau, presented to stakeholders in early 2017, has led to the district council and other parties embarking on the process to establish a container terminal in Kawerau with a rail link to the Port of Tauranga. |
| | Quantify the role of forests in increasing economic, environmental and social outcomes for New Zealand  | Use of Scion's spatial economic modelling system, the Forest Investment Framework (FIF), continued to increase with new projects for a number of regional councils, central government agencies and the forest sector. The first ecosystem services assessment for a major New Zealand company's forest estate showed the significant contribution of ecosystem services (e.g. carbon, erosion control and recreation) to the full value of the estate in addition to timber. Also excellent progress was made on the development of biodiversity, avoided nitrogen leaching and water flow functions, which will add significant functionality to FIF in 2018.<br><br>The sixth annual (and first regional) forest ecosystem services forum held in Havelock, Marlborough, was attended by a wide range of regional and national stakeholders and focussed on new approaches to link ecosystem service flows across land and marine sectors. This was the first stage of a national programme on new economic and spatial approaches to ecosystem service flows and will link land-based primary sectors with marine-based aquaculture.<br><br>Forestry and its multitude of values lends itself to a new national System of Economic-Environmental Accounting approach (i.e. more than just timber), and a quantitative framework (i.e. computable general equilibrium model) was developed to assess the economic impacts from environmental, fiscal and trade policies on various primary industries (including forestry) nationally. The team is working with NZ Forest Owners Association, Ministry for Primary Industries, Treasury and Statistics New Zealand to scope out the opportunities for using an ecosystem services framework as a basis for this approach. |

| Science outcome 5-15 years | Leading indicators 3-5 years | Achievements in 2016-2017 |
|---|---|---|
| Increase the profitability of solid wood processing through customer solutions and supply chain innovations | Facilitate new seed-to-market value chains for specialty wood products  | A forest-to-product study quantified the timber grade recovery that could be obtained from farm tōtara. The study took approximately 40 $m^3$ of logs that were harvested under a sustainable management permit and processed these into appearance grade timber. The properties and the grade of each board were assessed and the results showed good recoveries of high-quality appearance grade material. This work helps to underpin a future industry based on the sustainable use of the farm tōtara resource.<br><br>In partnership with Scion, Ngāti Whare established an indigenous commercial nursery at Minginui to provide employment and planting stock to the 10-year Te Pua O Whirinaki Regeneration Plan. The plan aims to restore the identity of Ngāti Whare and enhance the value of Whirinaki for New Zealand.<br><br>The potential of genomic selection was investigated in an advanced third generation *Eucalyptus nitens* population with the breeding goal for solid wood production.<br><br>Genetic gains using genomics showed that a considerable improvement in tree material towards high-value solid wood production is achievable when certain selection criteria are included in the breeding programme.<br><br>Many high-value international markets demand naturally durable wood. The challenge with such high-value timbers, including many of New Zealand's indigenous species, is drying them in a way that provides high timber recovery and enhances wood material properties such as stability. Building on our experimental knowledge of the effect of supercritical $CO_2$ on key wood/water relationships, and the effect of mechanical stress, we have successfully predicted the softening effect of $CO_2$ on wood material by means of predictive modelling. The results allow us to determine the effect of process parameters on dewatering efficiency, and moisture-related distortion, for a wide range of scenarios, as well as providing an engineering scale-up design tool for larger plants.<br><br>We showed that for a hard-to-dry species the use of supercritical $CO_2$ and a new thermal drying technique can reduce the development of shrinkage and internal checking.<br><br>This work is supported by novel drying research with an industry partnership focussing on eucalypts, Douglas-fir and cypresses. These potential drying solutions could be applicable to some indigenous species, such as tōtara and beech, and is part of a programme with Ministry for Primary Industries, Northland Inc, Tane's Tree Trust and iwi in developing greater economic returns from planted tōtara. |
| | Expand opportunities for wood products and building systems | Scion continued development of high performance wood products (such as very durable and stable wood) with results from scaling up of two technologies using radiata pine. We can now justify moving to commercialisation of these modification technologies, proved to improve the stability and durability while enabling radiata pine natural feature to be expressed in a wide range of colours from natural hues to bright vivid colours. Further novel approaches to protect and enhance a range of wood species are being explored at laboratory-scale, such as thermal modification of non-radiata species. This technique was applied to three species with success. Results indicate that improvements to durability stability have been achieved, and importantly for the species trialled this technique produces new colours with greater uniformity, which should lead to new market opportunities. |

| Science outcome 5-15 years | Leading indicators 3-5 years | Achievements in 2016-2017 |
|---|---|---|
| |  | Scion continued to develop options to address an important market issue, e.g. wood treatment options that avoid the use of highly toxic chemicals such as copper-chrome-arsenic (CCA) formulations. After three years, our biobased chemical durability samples in above-ground trials (decking, flat-panel, joinery and framing) showed no signs of decay. We are now exploring some of the secondary effects that our biobased chemical durability treatment may have on paint and fastener corrosion performance, and a long-term exposure trial was established. In response to increasing demand for non-radiata species we treated a range of house framing and exterior decking applications and established long-term exposure trials.<br><br>Many home and building decisions are made by designers and developers who focus on the cosmetics and functions of houses. This drives a 'code minimum' approach that does not always produce energy efficient and healthy homes. We produced a demo version of a tool that collated a wide range of background material on current building design and built environment planning decision tools, including international research initiatives, existing tools and software. The work supports development of Scion's interface and partnership with the Building Better Homes, Towns and Cities National Science Challenge. With an international secondment we explored the role, the uptake and impact of life cycle analysis and environment product declarations in the New Zealand building sector. Via our work in the built environment we secured a position in the Australian Industrial Transformation Research Hub for Advanced Solutions to Transform Tall Timber Buildings, which aims to grow the role of timber in the medium rise buildings. |
| Expand opportunities in the wood fibre, pulp, biopolymer, packaging and biochemical industries and from their biomass side streams | Develop new industrial bioproducts for existing and emerging manufacturing industries in New Zealand<br><br>  | Success in phase one resulted in follow-on funding for the Bill and Melinda Gates Foundation "Reinvent the toilet" challenge. Good progress was made towards building a prototype. Market analysis was completed of opportunities in the developed world where such a simple eco-friendly toilet could be used.<br><br>The Woodforce licensee in Europe (Sonae-Arauco) continued to work hard at opening the market for Woodforce with good engagement in the automotive sector and small sales volume. Concurrently, Scion is progressing initiatives to understand and open the Asian market for Woodforce.<br><br>Scion filed a patent to protect its novel high-moisture barrier coating that increases the lifetime of paperboard packaging in humid conditions. Discussions with several New Zealand and overseas companies are underway to establish commercial trials of the technology.<br><br>Our formaldehyde free and 100% biobased adhesives technology for use in engineered wood products was named Biotechnology of the Year by NZBIO and received other accolades. The adhesive, named Ligate™, was introduced to targeted global companies resulting in significant interest.<br><br>The biospife – a novel spoon-knife produced through a partnership between Zespri, Alto and Scion – is made from bioplastic material (PLA) that incorporates kiwifruit residues. It is designed to be composted with the skins after the kiwifruit has been eaten. Biospife was officially launched at Fieldays 2017, and >300,000 biospifes were produced by Scion and Alto. |

| Science outcome 5-15 years | Leading indicators 3-5 years | Achievements in 2016-2017 |
|---|---|---|
| | | Scion produced biodegradable bioplastic vineyard net clips containing red grape pomace. Development of the next versions – targeting defined degradation timelines – is underway. The commercial proposition for large-scale manufacture is currently being evaluated. |
| Increase New Zealand's energy security through the use of forest and waste biomass for bioenergy | Accelerate the use of bioenergy and liquid biofuels in New Zealand  | Scion submitted on the draft New Zealand Energy Efficiency and Conservation Strategy, and the new strategy now contains targets for industrial heat and transport.<br><br>Several New Zealand Biofuels Roadmap stakeholder workshops were held and the results of the modelling work was presented to all key stakeholders. Valuable feedback was fed into the next phase of the project.<br><br>The Bioprocessing Alliance Ecostock project aims to develop a cost-effective and sustainable alternative to land filling of pre-consumer food waste through the use of anaerobic digestion technology yielding energy and a nutrient rich digestate as a fertiliser product. The plant commissioning was successfully completed, with consistent operation to date.<br><br>External communication of the findings from the Industrial Symbiosis project resulted in several invitations to speak at conferences. Findings show impact of closer interaction of operating plants on profit, jobs, greenhouse gas emissions and more. |
| Protect and enhance market access and improve risk management in the forest industry including forest health and preparedness for biosecurity incursions, fire and climate change | Ensure New Zealand forests are resilient to current and future natural threats  | Scion's fire behaviour models helped operations staff make decisions on where it was safe to deploy firefighters and what properties and communities were at risk and needed evacuating during the Port Hills fires in Canterbury.<br><br>Breeding for resistance to needle loss caused by *Cyclaneusma minus* has been included in the needle disease strategy of *Pinus radiata* in New Zealand since the late 1970s. Using data from the North Island (New Zealand) and from Tasmania, Australia, we confirmed that resistance to this needle disease is moderately heritable. Using statistics we also determined that considerable genetic gains, up to 30%, could be achieved with further selection.<br><br>Significant research progress was made into chemical control of wildings, including strong engagement with end users.<br><br>Very successful planning workshops and field trips were held with local and international collaborators to firm up the new Extreme Fire programme, with focus on how fire spreads and integrated fire modelling systems and tools.<br><br>Trials showed that copper could provide viable control for red needle cast.<br><br>Resistance to red needle cast was indicated for some industry relevant radiata pine genotypes.<br><br>The Urban Toolkit for Biosecurity progressed by developing an aerial spot spraying system that is a useful method for pest eradication in an urban environment, particularly where aircraft access is challenging.<br><br>Scion developed a risk-based forestry biosecurity surveillance system that should lead to improved early detection and eradication probability when adopted in 2018. |

| Science outcome 5-15 years | Leading indicators 3-5 years | Achievements in 2016-2017 |
|---|---|---|
| | | A keynote presentation at an IUFRO conference in Vietnam on host and geographical range of *Phytophthora* species and their risk of spread to new regions became a key talking point of the conference.<br><br>Collections and molecular reference material from the National Forestry Herbarium assisted the myrtle rust response by helping to identify potential myrtle rust host plants. |
| Ensure the forest industry and bioeconomy businesses' licence to operate | Sustain New Zealand forest industry and bioproduct manufacturers' licence to operate<br><br>  | Working with a range of primary industry stakeholders and research providers (Plant and Food Research, Lincoln University, University of Otago, CSIRO, University of Tasmania) and international experts from Canada and the UK, we identified 'trust' as a major component of social licence to operate and developed a conceptual approach to explore this. We explored a number of elements of social licence through an international virtual symposium and New Zealand workshop. One outcome was the framework for a wide-ranging conceptual paper and future collaboration. We obtained support from the Our Land and Water National Science Challenge for a scoping project on trust and will establish a national primary sector discussion forum on social licence to operate in late 2017 to take the research further.<br><br>Our ongoing research in the detection of wilding conifers resulted in initial successes being able to detect unwanted spread of conifers from plantations with large-scale deployable remote sensing systems, allowing plantation managers to manage their spread more effectively.<br><br>We initiated a successful collaboration to better determine the risk of wilding spread from plantations by wind-modelling.<br><br>Through interactions with schools, the public, government, regional councils and industry players Scion continued to give input into the biotechnology debate occurring in New Zealand. Our contained field trial of biotech trees was maintained and shown to numerous stakeholder groups. Scion is keeping New Zealand informed through membership of international fora such as the EPSO Agricultural Technologies Working Group on regulatory issues with GMOs and new breeding technologies.<br><br>Scion was one of nine New Zealand research organisations participating in the newly formed New Zealand-China Food Protection Network, which aims to enhance communication between research scientists, government organisations and industries here and in China.<br><br>Scion achieved proof of concept that tritium dating could become an additional more precise method of authenticating biobased products. Working with GNS Science and the Energy Research Centre of the Netherlands, Scion validated the idea. If accepted as an international standard, this methodology will add more certainty around the ultimate source of plastic and make it more difficult for counterfeit products to enter the market.<br><br>We were represented on three Standards committees (two New Zealand and one joint Australian/NZ) including chairing of NZS 3602 'Timber and wood-based products for use in building'. |

# UNLEASHING THE POWER OF FORESTRY THROUGH PURSUING EXCELLENCE AND REACHING OUT

## Science papers

www.scionresearch.com/ar17/publications

| | |
|---|---|
| 143 | Refereed papers published |
| 26 | Papers published in Vol 46 of the *New Zealand Journal of Forestry Science* |
| 56.89 | 5-year weighted average H-index |

## Collaborations

| | |
|---|---|
| 68 | Collaborations with universities and research institutions |
| 9 | Formal collaborations with Māori |
| 6 | National Science Challenges |

## Tech translation

| | |
|---|---|
| 326 | Presentations on technical information and research results |
| 296 | Commissioned reports |
| 198 | Publications on technical information and research results |
| 29 | Popular articles and videos |
| 15 | Events sponsored |
| 11 | Programme newsletters |
| 6 | Software/tools |
| 4 | Editions of *Scion Connections* |

## Outreach

| | |
|---|---|
| 39 | Interns and students hosted |
| >550 | Interactions with students at school or on campus |
| 67,405 | Unique visitors to our website (over 11 months) |
| 12,167 | YouTube video views |
| 2275 | Followers on LinkedIn |
| 1259 | Subscribers to *Scion Connections* |
| 765 | Followers on Twitter |

## Awards

www.scionresearch.com/ar17/awards – for more awards

Accolades for our bioadhesives Ligate™ technology

- NZBIO Biotechnology of the Year
- 2016 NZI Sustainable Business Network Awards commendation
- NZ Innovators Awards finalist

# FINANCIAL RESULTS SUMMARY

| | 2015 Actual | 2016 Actual | 2017 Budget | 2017 Actual |
|---|---|---|---|---|
| Revenue, $m | 47.34 | 49.60 | 50.31 | 51.90 |
| EBIT, $m | 3.27 | 2.28 | 2.15 | 3.01 |
| EBIT Margin | 6.9% | 4.6% | 4.3% | 5.8% |
| Reinvestment, $m | 0.80 | 1.35 | 1.47 | 1.37 |
| EBIT-R, $m | 4.07 | 3.63 | 3.62 | 4.38 |
| EBIT-R Margin | 8.6% | 7.3% | 7.2% | 8.4% |
| Total Assets, $m | 46.31 | 48.11 | 50.11 | 54.20 |
| Return on Equity | 7.3% | 5.2% | 4.3% | 6.2% |
| Pre-reinvestment Return on Equity | 8.9% | 7.8% | 7.1% | 8.8% |
| Equity Ratio | 74.1% | 75.1% | 75.3% | 73.5% |
| Dividend, $m | 0 | 0 | 0 | 0 |
| 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.

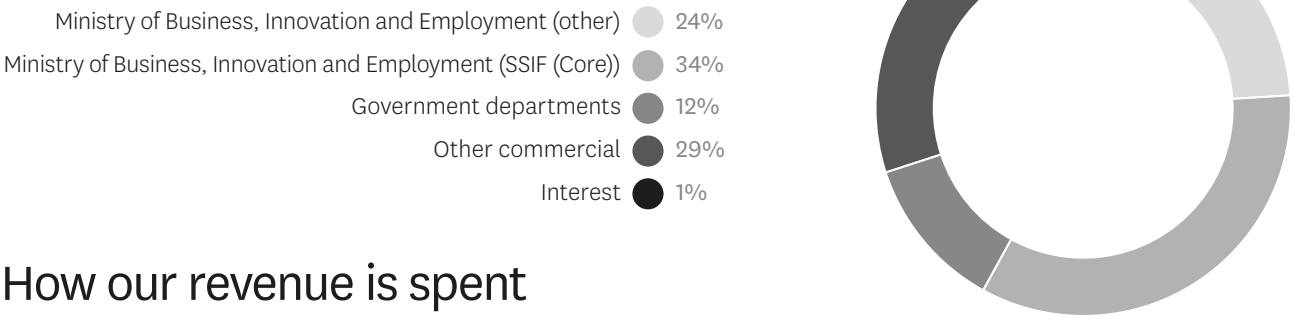
**Return on equity:** Net profit after tax ÷ average shareholders' funds, expressed as a percentage.

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

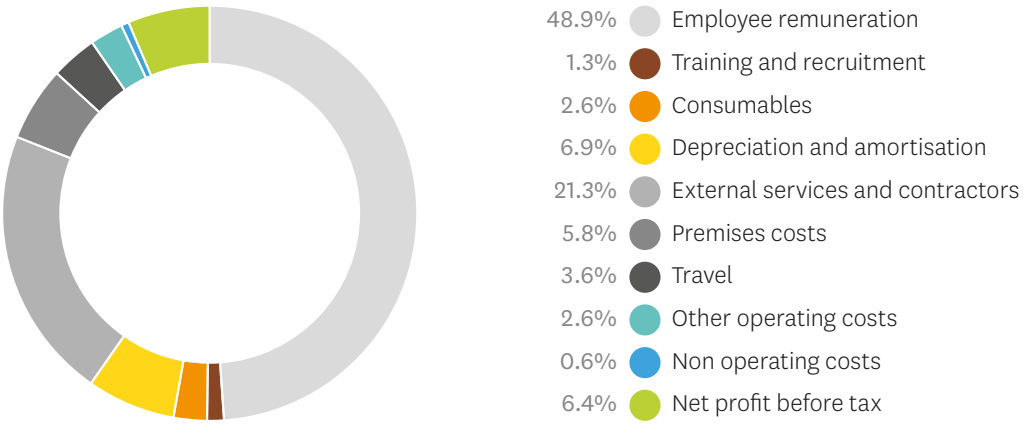
**Gearing:** Financial debt ÷ financial debt plus shareholders' funds.

(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




## How our revenue is spent




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

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Manaaki Whenua
Landcare Research

NIWA
Taihoro Nukurangi

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

SCION
FORESTS PRODUCTS INNOVATION

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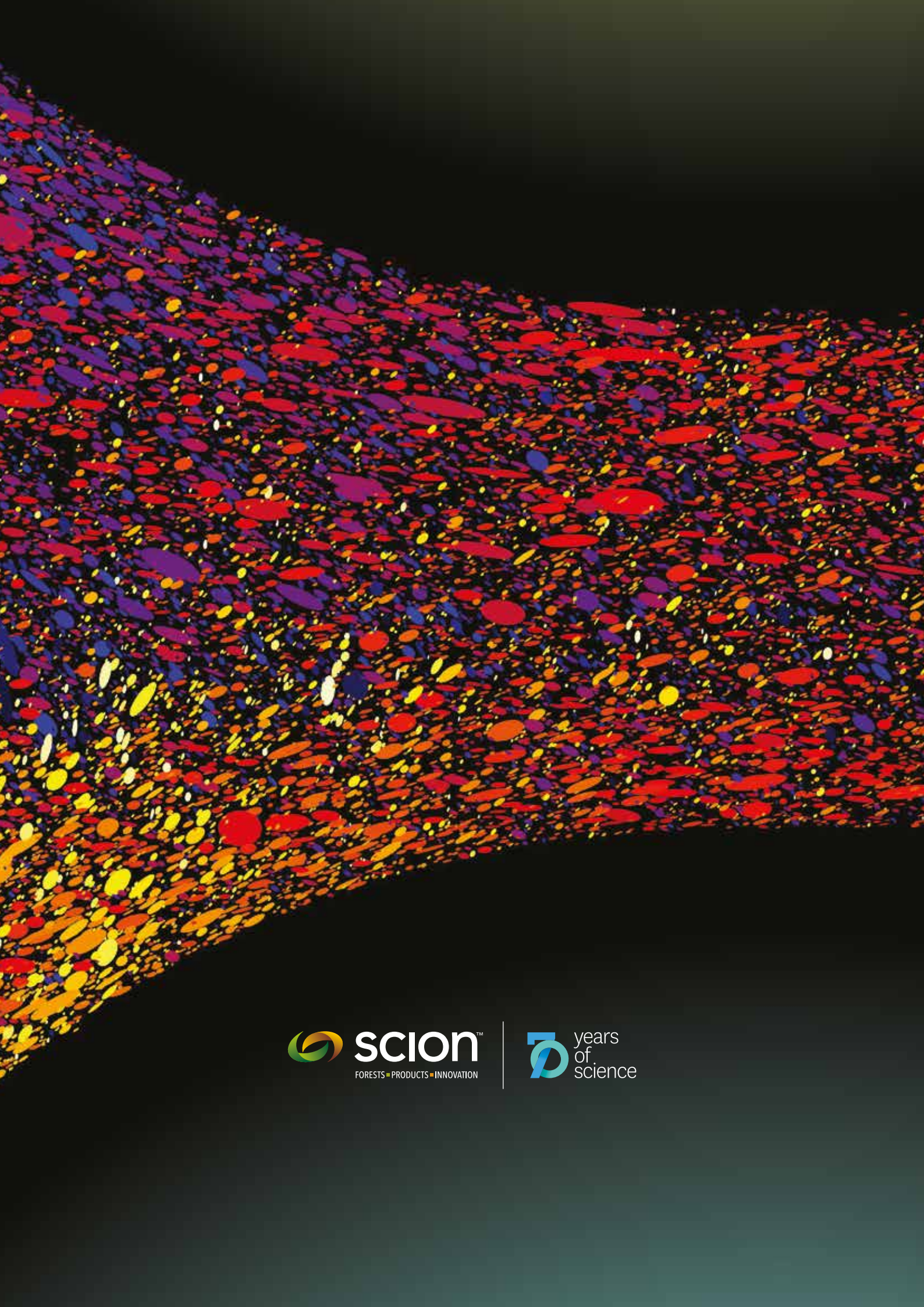
SCION
FORESTS ▪ PRODUCTS ▪ INNOVATION
years
of
science