



SCION 
forests • products • innovation

Annual Report 2014 Highlights

Our vision

Prosperity from trees *Mai i te ngahere oranga*

Scion's purpose is 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.



Investigating surface energy, spreadability and absorption of liquids on packaging materials.



Annual Report 2014 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, core funding investment, directors' report, performance targets and financial statements.

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Scion at a glance



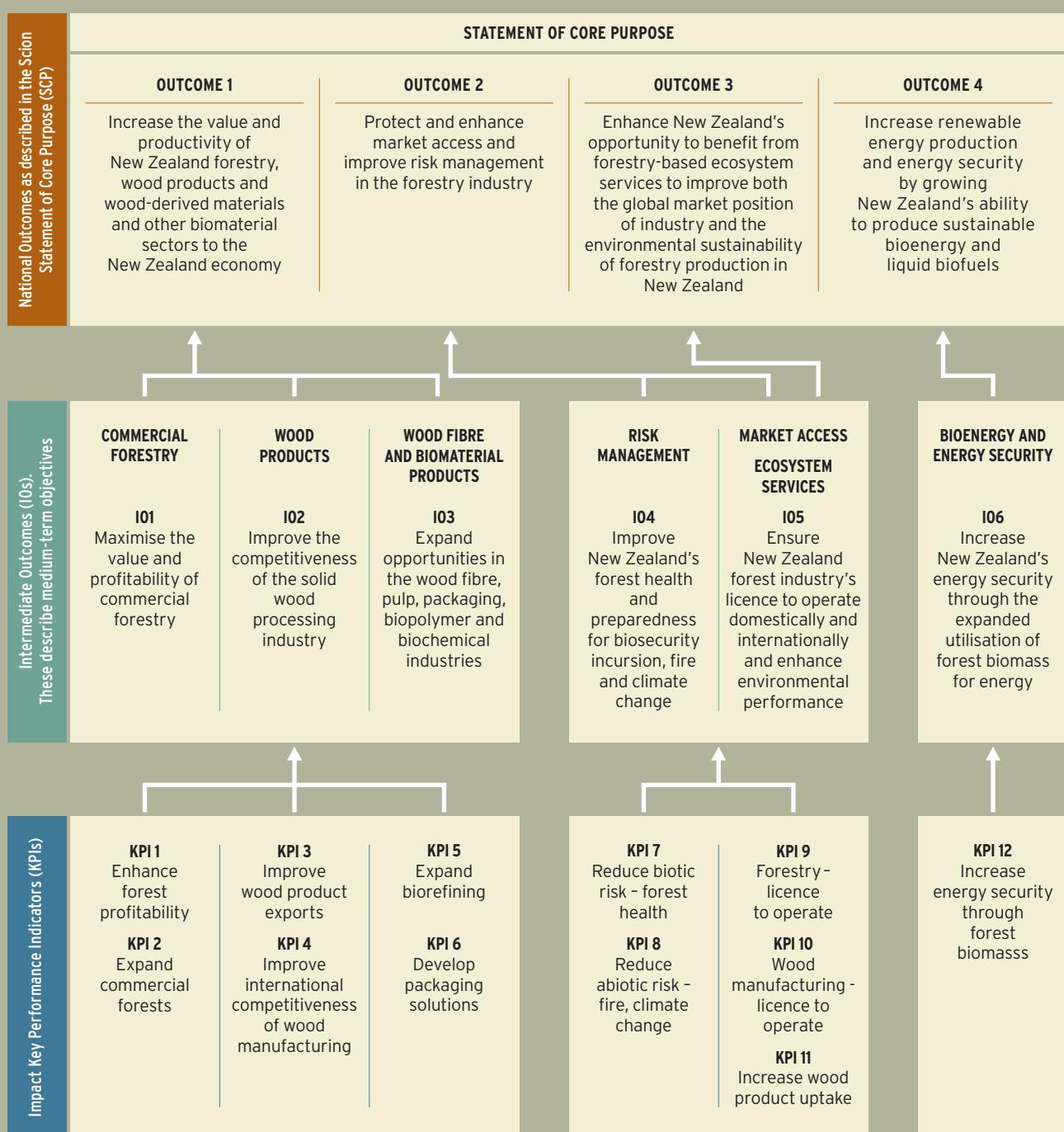
The New Zealand forest industry

- New Zealand's third largest exporter.
- Total export earnings were \$4.5 billion (year ended December 2012).
- Land area in planted forests is 1.7 million hectares.
- The available volume of wood harvested from planted forests has the potential to increase from 25 to 35 million cubic metres per year by 2023.
- The target is to increase exports to \$12 billion by 2022 (from the "New Zealand Forest and Wood Products Industry Strategic Action Plan").

Contents

- 4** Scion's strategic framework
- 5** From the Chairman and Chief Executive
 - Research performance
 - 9** • Commercial forestry
 - 17** • Solid wood processing
 - 21** • Wood fibre, pulp, packaging, biopolymers and biochemicals
 - 25** • Risk and adaptation
 - 31** • Licence to operate
 - 35** • Bioenergy and energy security
- 38** Working in partnership with Maori
- 40** Research collaborations
- 43** Working relationships
- 44** Publications, technology translation and outreach
- 47** Achievements and accolades
- 49** Financial results summary
- 50** Glossary

Measuring and delivering Scion's core purpose*



* This overview indicates how the activities of Scion align to achieving the SCP Outcomes. The above simply shows where the strongest alignment occurs.

From the Chairman and Chief Executive



Tony Nowell CNZM, Chairman (*right*) and Warren Parker, Chief Executive.

The forest industry performed very well too, harvesting a record 29 million m³ of logs and lifting export earnings to a forecasted \$5.111 billion, 19% up on last year.

We are proud to present in this annual report Scion's considerable achievements over the past year. Through working closely with the New Zealand forest industry, manufacturing firms and government agencies, we contributed to increased forest grower returns and reduced their biosecurity risks, developed new bio-based products and facilities for their evaluation, improved our customer's licence to operate in both export and domestic markets, transferred technology to firms, and positioned the forest industry and the high value biomaterials manufacturing sector in four National Science Challenges.

Scion's financial performance reflected this close alignment with customer and sector needs with revenue growing by 5.8% to \$48.137 million (budget of \$47.886 million) and EBIT at \$3.777 million being \$1.676 million ahead of target. The sale of trees contributed to the strong profit result and lifted the post-investment return on equity to 9.4% (budget 5.3%). Capital investment

to new equipment and facilities was \$4.114 million (1.2 times depreciation) consistent with our goal of providing internationally competitive, modern and safe working facilities for our staff.

The forest industry performed very well too, harvesting a record 29 million m³ of logs and lifting export earnings to a forecasted \$5.111 billion, 19% up on last year. This is in line with the New Zealand Wood Council's goal of earning \$12 billion from forestry and wood product exports by 2022. However, lifting the proportion of logs processed onshore, the key driver of this export growth target, from 45-50% currently to 70% remained elusive. Solid wood processors benefited from the steady recovery of housing and construction starts in New Zealand and key export markets, but their margins were squeezed by high log prices and our persistently strong currency. These factors contributed to the closure of several mills.

Overall buoyancy in the wood and wood fibre manufacturing sector lifted as reflected in expenditure on commercial research projects with Scion (14% up on last year). Increasing the productivity and product diversity of wood and wood fibre manufacturing remains a high priority for Scion.

Aligning closely with industry priorities and government agencies ensured our continued progress in fulfilling our Statement of Core Purpose and delivering virtually all of the objectives in our 2013/14 Statement of Corporate Intent. Our key achievements are described on the following pages, but a number of highlights deserve mention here.

Forest growing and forest health:

- Extension of the Maximum Post Fumigation Exposure Period for

methyl bromide from 72 hours to 21 days during winter for all of New Zealand except for Northland; and, in close collaboration with MPI, eradication of the *Eucalyptus* leaf beetle (*Paropsisterna beata*).

- In partnership with Proseed, supported increased planting of a new hybrid pine with improved tolerance to the high-altitude, cold, dry and snow conditions found in southern regions; and confirming significant genetic gains in traits of high importance to the growers of eucalypts, cypresses and Douglas-fir.
- Commercialisation of an innovative hauler vision system (CutoverCam) with Future Forests Research that will improve worker safety and lower log harvest costs.
- Work with Māori in Northland (Te Tai Tokerau), the East Cape (Ngāti Porou), Bay of Plenty (Rotoehu-Tarawera-Whakatane groups and Toitu Te Waonui) and King Country to assist them to realise the economic potential of their land and forest assets and concurrently assist them achieve their social and cultural aspirations.

In close partnership with forest owners, we secured \$30 million of Crown investment over six years to support forest growing and forest health research. The 'Growing confidence in forestry's future' programme goal is to sustainably double the productivity of New Zealand's plantation forests over the next 20 years and the 'Healthy trees, healthy future' programme aims to develop solutions to the growing threat of *Phytophthora* related diseases (see pages 12 and 27 respectively). Both programmes are multi-agency, world-leading and strongly supported by the newly formed Forest Growers Levy Trust. Close work with the Radiata Pine Breeding Company helped develop a new genomic selection approach to radiata pine in order to double the rate of genetic gain in this species and integrate desired traits. This is also supported by MBIE. These investment successes underpin Scion's future capability and direction in the forest growing sector.

Solid wood and wood fibre (including pulp and paper):

- Commissioning a commercial scale coolroom facility for testing packaging under conditions encountered in the chilled supply chain.

- Increased European in-market trials of Woodforce, a Scion-developed wood plastic technology licensed to Sonae Indústria, and assessment of Woodforce and other Scion-developed wood composite technologies with several New Zealand firms.
- Commercial pilot scale evaluation of a new biodegradable polymer packaging product, ZealaFoam™, for the Biopolymer Network Ltd for the airfreight of fish and other foods.
- Successful trials of an athroquinone-free product with a domestic pulp and paper manufacturer to meet new European Union regulations. Athroquinone is a catalyst in wood pulp and paper production and linked with a number of environmental and health concerns.
- Further proving our transformational dewatering technology through a quantitative analysis of the market parameters for its commercialisation, and installation of a new lab scale pilot plant for assessment of more treatment options and scaling up.
- Development of natural bioadhesives and preservatives with commercial firms to meet the growing demand for non-synthetic chemically treated wood products.

Environmental performance and market access:

- Rotorua District Council approval to build the first commercial scale TERAX™ demonstration plant for the treatment of the city's biosolids (sewage).
- Quantification of the ecosystem services generated by plantation forests (recreation, climate change adaption and mitigation, improved water quality, erosion control and flood mitigation) so that the net economic contribution of different land use enterprises and stocks of natural capital can be transparent to the public and decision makers.
- Informing public debate on genetic modification and new non-transgenic techniques.
- The Norske Skog-led Primary Growth Partnership 'Stump to Pump' assessing biofuels options for New Zealand.

Forestry health and safety

During the year, the forestry sector commissioned an independent review of forestry safety. The review's recommendations should indicate where Scion can best contribute to this critical area of industry reputation, licence to operate and operational efficiency. Scion's research capability in human factors (including safety) research has reduced by 75% over recent years. We are hopeful this situation can be reversed with many aspects of our research programmes - automation through robots, remote sensing, harvesting technology, learning for technology uptake - being highly complementary to assuring the safety of forestry workers.

Future outlook and industry developments

The sectors Scion works with are increasingly well positioned to exploit the global shifts to mitigate and adapt to climate change, address resource limits through renewable technologies and capitalise on China's growth. These drivers of technological and supply chain innovation are reflected in Scion's science and investment portfolio and underpinned by growing demand for biomaterials, renewable energy and chemicals, and use of wood in the built environment.

The collection of a forest grower levy from 1 January 2014 ushered in a new organisational arrangement for forest growing research. Future Forests Research Ltd was repurposed for the governance of the Steepland Harvesting Programme, and a Forest Research Committee was installed to oversee the industry's Science and Innovation Plan, priority setting, and managing the growers' investment into research. The Forest Growers Levy Trust Board is serviced through a Secretariat of the New Zealand Forest Owners Association and the Forest Research Committee. These new structures enable better coordination of forest growing research than in the past and provide a relatively stable situation for research planning and delivery over the near term.

The Wood Processors Association and the Pine Manufacturers Association finalised the terms for merging, which will be in place from 1 July 2014. This will boost the 'strength of voice' of solid wood and pulp and paper

processors. We continue to maintain that the processing sector, like forest growers, would benefit from the introduction of a levy to support industry good activities such the modernisation of standards, generic branding for New Zealand wood and wood fibre products (NZ Wood) and shared resourcing of the Woodco strategic action plan.

Other areas of industry development requiring ongoing research include improving the profitability of forestry and its integration with other land uses in order to encourage afforestation and improve water quality; finding viable alternatives to current fumigation methods for export logs; understanding mechanisms to improve the security of log supply to domestic wood processors; and reducing the current over dependence on China through product and market diversification.

National Science Challenges

Scion is aligning core funding to, and actively engaged in, the planning and formation of four National Science Challenges (NSCs): *Resilience to nature's challenges, Our land and water, Science for technological innovation and New Zealand's biological heritage*. The eleventh challenge, *Building better homes, towns and cities*, announced after the end of the financial year, is also highly relevant to Scion's capabilities.

Establishing the NSCs across multiple providers with different cultures, mandates and customers while also ensuring oversight efficiency and investment alignment, is proving to be a very large task. The NSCs add complexity to the New Zealand science system and decision making about science direction and investment, including CRI core funding. We will work to ensure their actions do not compromise Scion's governance or its capacity to fulfil its Core Purpose efficiently.

Achievements and acknowledgements

Scion staff worked extremely hard over the past 12 months and recovered from the setback of reduced MBIE investment at the end of the first quarter to achieve virtually all of this year's performance targets. Executive team member, Dr Trevor Sturridge finished a 20-year career at Scion in June, and we wish him well in his future role as Executive Vice President at FPInnovations in Canada.

Chris Insley completed his sixth and final year as a Scion Director, and we thank him for his many contributions. We are delighted to welcome Colleen Neville to the Board. With the remaining Directors continuing into the new financial year and healthy relationships in place with all key stakeholders, Scion is very well placed to continue its strong contribution to the growth and resilience of the New Zealand economy.



Tony Nowell CNZM
Chair



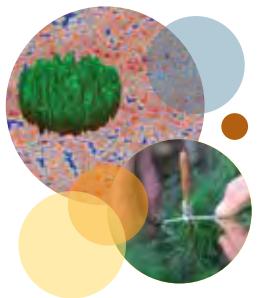
Warren Parker
Chief Executive



Our research on diversified forestry species has focused on making species such as Douglas-fir, eucalypts and some indigenous species viable commercial options.

Commercial forestry

IO1 - Maximise the value and profitability of commercial forestry



Impact KPI 1: Enhance forest profitability. By 2016, the commercial forestry companies will have improved their average profitability by at least 4% compound per annum. This will be achieved by assisting the industry to increase biomass productivity (MAI) to at least their target of 30 m³/ha/annum (currently about 20 m³/ha/annum); reducing supply chain costs from log harvest to customer delivery, and improving log quality and uniformity.

Progress:

- i. The new 'Growing confidence in forestry's future' (GCFF) programme was established, with substantial investment from industry and \$20 million MBIE investment over six years, to support the sector's goal of doubling forest productivity.
- ii. We provided Kaingaroa Timberlands with the confidence to fly the entire Kaingaroa forest with LiDAR to enhance their own management and provide an important data resource for the GCFF programme.
- iii. Phenotyping of three genetics trials was completed for correlation with LiDAR metrics. This research will help to speed-up genetic gains in radiata pine.
- iv. More than 100 participants were involved in two Scion-led wood quality workshops including both forest growers and wood processors in order to show how additional value can be created for both parties.
- v. Rigorous analysis of data from genetic gains trials demonstrated that each unit increase in GFPlus growth rating is associated with a volume gain of 0.33 m³/ha/annum, providing an improvement of \$23/ha in net present value at planting, or an increased stumpage of \$226/ha at harvest based on current prices.
- vi. The Radiata Pine Breeding Company was supported to develop and initiate a genomic selection programme supported by industry and MBIE that has the potential to double the delivery of genetic gain by halving the generation time.
- vii. The first draft sequence of the radiata pine genome was completed to underpin the genomic selection programme and enable increased international collaboration in tree breeding.
- viii. Increases in forest productivity and wood quality through direct biotechnology routes were progressed with plantings of two biotech tree modifications in the field trial site.
- ix. A hauler vision camera system (CutoverCam) was commercialised with the aim of improving worker safety and increasing harvesting efficiency, and first sales were made.
- x. A working prototype of a tree-to-tree robot conceived by Scion and built in partnership with University of Canterbury students jointly won the Institute of Professional Engineers New Zealand Ray Meyer Medal for best final year engineering project. Robot technology could dramatically improve forest harvesting, silviculture and other operations.



Expanding use of LiDAR for forest assessment

Scion's forest management scientists and their collaborators have continued to facilitate the use of LiDAR for forest assessment. Building on the success of a 4,000 hectare LiDAR-based inventory trial completed last year, our researchers have extended the technique to include LiDAR datasets of additional forests with variable conditions and challenging terrain. The results are highly encouraging and indicate that aerial LiDAR data, used with the k-nearest neighbour (k-NN) statistical estimation technique, is robust for a wide range of forest conditions. Log volume estimates that can be derived from aerial LiDAR have also been improved. This is critical information for forest managers and a key component of woodflow planning and forest valuation.

In addition, prediction models for forest productivity using aerial LiDAR data have been developed. The high spatial resolution of aerial LiDAR

means these models can identify the variation in productivity within a stand. This result provides accurate, high resolution information on forest productivity and provides insight into the micro-site scale factors that influence it.

*Investment: FFR, Timberlands Ltd
Collaborators: Interpine Forestry Ltd, Simetra Ltd*

Estimating tree metrics from above

The accuracy of detecting individual trees using aerial LiDAR was put to the test at a forest site with complex terrain and lower LiDAR resolution than previous trials. Results were comparable with earlier results with a good level of accuracy achieved despite the more difficult test conditions, demonstrating that cost-effective LiDAR techniques are applicable over a wide range of terrains.

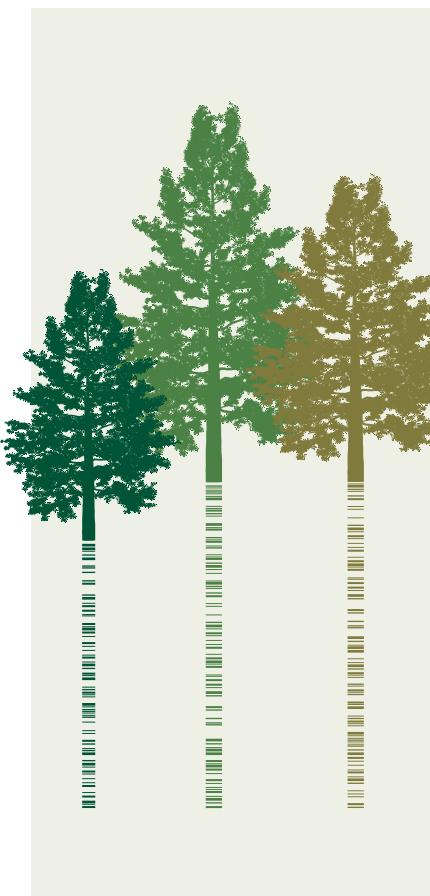
The tree detection techniques were used as the basis of new methods to estimate tree-crown metrics from aerial LiDAR. Initial investigations showed metrics could be used to estimate tree diameter and height as well as outerwood stiffness, a wood quality important for structural timber products.

*Investment: FFR, Matariki Forests - Rayonier
Collaborators: University of Canterbury*

Using satellite imagery to detect red needle cast disease

A study undertaken in the central North Island has shown that red needle cast disease in radiata pine can be detected using RapidEye satellite imagery. This will allow early detection and minimise damage by facilitating earlier, targeted interventions. The study showed that the Enhanced Vegetation Index, which describes the ratio between imagery spectra, could be used to detect red needle cast. Further research will be required to confirm this methodology is robust and repeatable.

*Investment: FFR
Collaborators: Indufor, Hancock Forest Management*



Doubling the genetic gain of radiata pine

Building on our previous work in genomic sequencing, the Genetics Team has identified a vast number of differences that exist in the radiata pine genome. Work is now underway to refine and measure those differences so they can eventually be correlated to physical traits. Mapping the genes responsible for particular traits will have enormous benefits for the forestry industry, fast-tracking breeding by facilitating early selection at the seedling stage and delivering genetic gain to the field in half the time taken when compared with the previous breeding cycle.

Genomic selection involves using genomic markers to select for most of the genetic code controlling a quantitative trait, such as growth, disease resistance and wood quality. It can be implemented from seedling stage before these traits are identifiable, which effectively doubles the delivery of genetic gain by halving the generation time.

Sample genomic measurements have successfully been completed by Rapid Genomics in Florida to test their methodology using radiata pine

genome. Further testing of 1500 samples is underway to optimise the process and begin correlating DNA with breeding values.

*Investment: Scion Core, RPBC, industry shareholders
Collaborators: RPBC, Rapid Genomics*

The value of genetic gain on tree growth and density

Our geneticists have quantified the relationship between genetic gain (GF Plus ratings) and tree growth.

Data from trials established between 1978 and 1994 show the gains made in volume between unimproved (GF Plus 11) genotypes and highly improved (GF Plus 26) genotypes were 10%, 16% and 20% at ages 10, 15 and 20 years respectively. The gains in height for the same ages were 3.9%, 4.2% and 4.4%.

An analysis of wood density using data from 679 families showed that a one unit increase in GF Plus rating for density corresponded to a 1.85 kg/m^3 increase in wood density index; therefore an improvement from 18 to 28 corresponds to a 18.5 kg/m^3 increase.

Both functions have been incorporated into Scion's Forecaster growth and yield simulator to help forest managers calculate the impact of genetic improvement on yield and wood density. This knowledge can help determine the best genetic material to plant on specific sites and silvicultural regimes to optimise the benefits from improved genotypes.

*Investment: FFR, RPBC
Collaborators: RPBC*

Herbicide tolerant pines could eliminate the need for hazardous herbicides

Using environmentally benign herbicides in combination with herbicide tolerant radiata pines could provide an alternative to FSC non-compliant herbicides such as terbutylazine and hexazinone for the forestry industry.

Trials in our outdoor containment facility this year demonstrated that herbicide tolerant pines can be sprayed with herbicides that have a low environmental impact, such as glyphosate, without being damaged.

A business case prepared by Scion indicates that herbicide tolerant trees used in combination with aerially applied low-impact herbicides would provide superior results compared to current practice, from both a financial and ecological perspective.

Investment: Scion Core
Collaborators: Alphametrik



Alternative methods to control wilding conifers

Southern South Island regions are among the best sites in the world to grow Douglas-fir; however, with the cost of managing wilding conifers likely to be transferred to forest growers in the near future, the profitability of growing this high value conifer would be seriously compromised. Non-flowering Douglas-fir may provide the solution.

In a scientific breakthrough, Scion has developed a genetic transformation system for *Pinus densiflora*, which will be used as a model to explore floral control mechanisms in conifers. *Pinus densiflora* was chosen as a model due to its early flowering age and prolific flowering, making scientific observation possible within a short rotation. The next step is to establish propagation protocols for generating whole plants to further develop and test these floral control mechanisms. Methods to control the formation of male and female cones in *P. densiflora* could eventually be transferred to Douglas-fir.

Analysis indicates that eliminating the cost of wilding control for Douglas-fir by planting sterile stock is a financially viable option that can create substantial revenue for growers.

Investment: Scion Core
Collaborators: Alphametrik

In partnership with the University of Canterbury, a quarter-scale prototype of the device has been built to test its feasibility as a means of harvesting trees on steep terrain. The long-term goal is to develop a range of devices that can perform essential forestry tasks such as pruning, measuring or tree felling, removing forestry workers from danger.

Four engineering students from the university were sponsored by Scion to design and build the prototype, and have since been jointly awarded the IPENZ Ray Meyer Medal for best final year project.

Investment: FFR, MPI
Collaborators: FFR, MPI, University of Canterbury

www.scionresearch.com/impact/commercial-forestry/tree-swinging-robot-may-revolutionise-steep-forest-forestry



Tree-to-tree robot improves forest safety

To help improve the safety of steepland forestry, Scion has developed a remote controlled mobility platform that can be manoeuvred through the forest using trees as support, without touching the ground.

Impact KPI 2: Expand commercial forests. By 2016, investment in new forests will have increased through the development of new forest systems (including capturing value from non-timber revenue such as top-soil conservation) that are applicable to a wide group of stakeholders, including Māori and non-industrial private forest owners. Examples will include mixed species stands, alternative silvicultural systems and options for commercial indigenous forestry.

Progress:

- i. A new hybrid pine was released with improved tolerance to the cold, dry, and snow conditions found particularly at higher altitudes, providing a commercial alternative to Douglas-fir in southern high-country areas where wildings are an issue for resource consent.
- ii. A national model of Douglas-fir wood density was completed and incorporated in Forecaster.
- iii. Ongoing genetic gains were achieved and quantified for Douglas-fir, *Eucalyptus regnans* and *E. fastigata*.
- iv. The significant economic opportunity from indigenous forest species, such as kauri and tōtara, in Northland was demonstrated.
- v. Working with Maraeroa C Inc., economic analysis highlighted the potential for increased cashflows from a ginseng understory crop in radiata pine plantations.
- vi. The Waiapu Restoration Partnership on the East Coast received recommendations for building community resilience based on sustainable livelihood options and community assets.



Hybrid pines show good commercial prospects

Hybrid pines promise to play an increasingly important role in commercial forestry. Field trials established by Scion and seed company Proseed in the late 1990s, show *Pinus attenuata* x *P. radiata* hybrids tolerate cold, dry conditions and snow making

them suitable for growing in New Zealand's southern regions and an increasingly inclement climate.

Our tissue culture experts are working with Neiker-Tecnalia in Spain to develop propagation strategies for the drought tolerant *Pinus attenuata* x *P. radiata* var *cedrosensis*. New cell lines of the hybrid have been developed that will eventually be screened for drought resistance *in-vitro* in Spain with the potential to field test these genotypes back in New Zealand. This hybrid offers an alternative to Douglas-fir in southern high-country areas where wildings are an issue for resource consent. There is little risk of the hybrid spreading with both parent species being closed-cone pines.

*Investment: Scion Core, OECD
Collaborators: Neiker-Tecnalia, Proseed*

www.scionresearch.com/impact/commercial-forestry/are-hybrid-pines-the-super-trees-of-the-future

Utilising a ready source of nutrients

Applying nutrients to planted forests in the form of treated effluent may be a cost effective option for improving productivity. Scion recently surveyed the growth, health and nutritional status of trees within Rotorua District Council's land treatment site at Whakarewarewa, to which treated effluent has been regularly applied since 1991. Land application has effectively removed 90% of the phosphorous and 40% of the nitrogen in the treated effluent, greatly improving the quality of water entering nearby lakes.

Effluent application has had mixed results on tree growth and health, resulting in a 10% increase in recoverable volume by age 23 years. However, by modifying the scheduling and application rate, gains of around 20% are possible providing trees are not irrigated from too young an age, are growing in well drained areas, and the amount of treated effluent applied is monitored to prevent overloading the soil to the point that tree health declines.

With the availability of clean water of increasing concern, research is ongoing internationally to improve water quality so it can be reused within defined geographical areas. Future collaborations with US researchers are planned.

Investment: RDC



Building community resilience to climate change

Scion and Ngati Porou researchers have been looking at ways to help rural communities deal with the effects of climate change by developing effective forestry strategies that support environmental restoration, economic development, cultural revitalisation and social prosperity.

Work has focused on the East Coast's Waiapu Catchment. Research on sustainable livelihood options and community assets has recently been presented to the Waiapu Restoration Partnership (Te Runanga O Ngati Porou, Gisborne District Council and MPI), and the partnership has co-developed a 100 year programme to restore the health of the land, people and river.

Restoration of the catchment is widely acknowledged to be a complex and inter-generational process, and Scion's work has fed directly into the partnership's immediate planning horizon for the next ten years.

*Investment: MPI
Collaborators: He Oranga mo Nga Uri Tuku Iho Trust, Tina Porou, Fitzgerald Applied Sociology*

Growing confidence in forestry's future

A multi-disciplinary team of scientists at Scion and other research organisations has embarked on a six year programme to raise the profitability of current and future commercial forestry. 'Growing confidence in forestry's future' is a joint initiative between Scion, the forest growing industry and the Ministry of Business, Innovation and Employment (MBIE) that combines world leading technology with an in-depth knowledge of plant growth science to improve the value of forestry through sustainable intensification.

MBIE has allocated \$3.373 million per annum funding to the project with a further \$1.6 million per annum commitment from the new Forest Growers Levy Trust.

Russell Dale, Research and Development Manager for the NZ Forest Owners Association, says it is one of the most significant initiatives undertaken by the sector. "Our goal

is to improve the value of existing forests and double the productivity of future forests. The industry's target of growing New Zealand's forest exports to \$12 billion by 2022 requires major investment in new processing facilities and a sustainable supply of quality raw materials.

"The industry needs to improve the productivity of each hectare of land through intensification in order to remain competitive with other rural land uses. This intensification must also be within environmental limits to protect our access to international wood markets and for our forests to continue to deliver a variety of environmental benefits."

Through the programme, Scion aims to shift forest management to precision forestry by integrating the latest advances in sensor technology, tree physiology, genetics, forest ecology and complex problem solving. The programme targets intervention points throughout the growing cycle for both current and future forests where

productivity can be improved under intensified management regimes, while maintaining wood quality and the quality of the environment.

Science Leader for the programme, Dr Peter Clinton, says the programme will expand our knowledge of fundamental biological processes within trees. "A greater level of knowledge is required to optimise performance in terms of wood quality and productivity, to match tree genetics and management practices to the environmental conditions, and to guard against unintended consequences."

The programme involves many layers of research, central to which will be the development of a phenotyping platform that will catalogue the performance of different genetic material under a range of environmental conditions. The platform will integrate remote sensing, wood properties, environmental physiology and genetics to identify the drivers of growth and wood quality.

These data will enable trees of interest, particularly those with improved disease resistance, to be identified for future breeding programmes.

'Growing confidence in forestry's future' also links with other programmes supported by forest growers. Two key linkages are the 'Healthy trees, healthy future' programme to combat *Phytophthora* diseases, and the Radiata Pine Breeding Company's genomic selection programme.

Investment: MBIE, FGLT

Collaborators: Landcare Research, University of Auckland, Waipā Institute of Technology, University of Canterbury, Oregon State University, Université Laval (Canada) and CSIRO (Australia)

www.scionresearch.com/gcff

Diverse species

Our research on diversified forestry species has focused on making species such as Douglas-fir, eucalypts, cypresses, redwoods and some indigenous species viable and proven commercial options. Some of our achievements include the development of genetically improved germplasm for a number of species, particularly eucalypts and Douglas-fir, which will help promote the productivity of these species in New Zealand. Online calculators to evaluate silvicultural scenarios for improved wood quality are also available, with new screening methods for wood durability created for redwoods and cypresses.

We have advanced our knowledge on the potential for kauri and tōtara as productive species, and improved growth modelling for kauri.

Work continues on these species with plans to combine our forest growing research with new wood processing technologies to reinforce the connection between markets, product performance, species choice and forest management practices.

Comparing the growth of alternative species with radiata pine

Several species are being grown in New Zealand that offer sound commercial alternatives to radiata pine, but assessing the economics of expanding

New focus for Future Forests Research

In 2007, a new organisation was formed in partnership with Scion to better organise and deliver research to commercial end users. Improving technology transfer and communication to the forest grower sector was a key driver behind the establishment of Future Forests Research Ltd (FFR).

FFR's purpose was to co-ordinate industry input and funding of research programmes relevant to forest growers and promote the uptake of research outcomes.

Research projects were organised under four themes:

- Radiata management
- Environment and social
- Diversified species
- Harvesting and logistics.

As the main research provider to FFR, Scion mirrored this structure in forest science capability to ensure areas of research were well aligned with the needs of forest owners and managers.

By the end of 2013 much of the research was completed. Over that six-year period research results and their application to

industry have been impressive. New tools and technologies have quickly become mainstream, for example, LiDAR use in forest management, models and calculators to forecast and measure growth, quality and productivity across radiata pine and other plantation species. New machines and vision technologies for improving the safety and productivity of harvesting trees on steep terrain were significant highlights.

With the introduction of a forest grower levy from 1 January 2014 a new organisational arrangement for forest growing research and development came into being. In April 2014 a joint FOA/FFA Forest Research Committee became the primary body that sets the research direction and priorities for forest growers, and this committee advises the Forest Growers Levy Trust Board, (via the FOA/FFA secretariat) on the allocation of levy funds to research programmes. FFR now is focused solely on the PGP steepland harvesting research programme.

their planted area has been hampered by the limited growth data currently available.



Detailed comparisons were made between the available growth data for *Eucalyptus fastigata*, *Sequoia sempervirens* and *Cupressus lusitanica* and that for radiata pine to see if existing empirical growth models could be applied to these alternative species. Results show that the productivity of *E. fastigata* is the closest to that for radiata pine, and therefore applying radiata pine growth models to *E. fastigata* would be feasible at a regional level. However, process-based modelling is likely to be required for accurate modelling at the forest estate level.

*Investment: MPI
Collaborators: FOA*



Hybrid cypress bred for New Zealand conditions

Superior lines of *Cupressus macrocarpa* and *C. lusitanica*, and new cypress hybrids are being developed by Scion that will boost productivity of these sought-after durable timbers.

A focused breeding programme has seen the production of new cypress hybrid clones which have been bred for wood durability and canker resistance, and are the best available for New Zealand conditions. These are currently being tested in forests and are ready for semi-commercial plantings.

The best selections from all species have been established in a new cypress breeding orchard. Crossing between the best trees from the different species will provide a new wave of hybrids within the next 10 years, to ensure the long-term success and resilience of cypresses. Testing seed-based deployment of hybrids such as *C. macrocarpa x Chamaecyparis nootkatensis* is also planned. If successful, this pathway will ensure rapid delivery of the new hybrid material to commercial nurseries for planting.

*Investment: Scion Core, FGLT
Collaborators: FFR, Farm Foresters, FGLT*



A new generation of healthy, fast growing eucalypts

Breeding trials and genetic evaluation are helping to expand the commercial potential of *Eucalyptus regnans* in New Zealand.

An analysis of genetic gain across the three generations of breeding trials was recently undertaken by our quantitative geneticists using new selections and an evaluation of realised genetic gain. Considerable genetic improvement has been made across all generations, estimated to be 4% for height and 24% for diameter at breast height. The next generation is expected to improve a total of 9% in height and 31% in diameter. When delivered, this genetic gain could add approximately \$1400 per hectare (on a 25-year rotation length with an 8% discount rate).

Seed orchards are being established to deploy the new generation of healthy fast-growing eucalypts. Seed from the previous generation will be available within two years, and grafts from new selections will be established in seed orchards during 2015/16 with seed available 3-5 years following planting.

*Investment: Scion Core, FFR, FGLT (Emerging Species Sub-committee)
Collaborators: FFR, FGLT*

www.scionresearch.com/impact/commercial-forestry/exciting-new-possibilities-for-eucalypts



Wood density model for Douglas-fir attracts keen interest

Wood density models that describe the variation in density at regional, inter-tree and intra-tree scales for New Zealand grown Douglas-fir are now available to the forestry industry. The models combine data on how wood density characteristics are affected by site, silviculture and genetics.

The models have been incorporated into Scion's Forecaster growth and yield simulator to help forest managers better predict how different combinations of site and silviculture effect wood density and end-product outcome.

The models are already attracting keen interest from forest growers, specifically about the unexpected result that wood density was largely independent of stocking. This is in contrast to most other species where wood density generally increases with stocking.

*Investment: Scion Core, FGLT
Collaborators: Ernslaw One Ltd, Blakely Pacific Ltd, City Forests Ltd*



Taming a wild species – plantation mānuka

Catering to the growing global demand for products made from New Zealand mānuka honey is being hampered by the limited supply of raw honey. Most of the current supply is produced from natural mānuka stands; increasing this supply could boost New Zealand's exports of mānuka honey-based products by an estimated \$1 billion per year.

Scion is looking at ways to achieve this goal by using forestry techniques to establish mānuka plantations on marginal land, and improving the volume and value of honey produced per hectare. To date, 2400 seedlings have been planted in establishment trials across four sites, under varying conditions. A business case has also been completed that identifies research targets that need to be met in order to provide attractive returns to landowners.

Investment: PSAF, confidential industry partners

opportunities for the region. These will be based on exotic and indigenous species that both meet the aspirations of local Māori and deliver high value wood products.

An in-depth analysis has been undertaken of the Te Tai Tokerau region using yield information and Forest Investment Finder (FIF) to consider land use options. Returns from various economic scenarios have been estimated that incorporate five species across 55,600 hectares in six geographical locations. The analysis involved modelling mānuka with honey returns, and timber returns from kauri, tōtara, eucalypt and cypress benchmarked against radiata pine. A number of new scenarios were shown to be economically viable based on conservative yield, cost and price assumptions.

Log processing options for these species will be explored in the future using existing forest infrastructure and facilities to determine if investment in processing is required and at what scale. Implementation studies are also being planned for the planting of new forests to test the recommended species and scenarios.

*Investment: MPI SSF, Iwi partners
Collaborators: Wright Partners Ltd*



Helping build economic resilience in Northland through forestry

Scion is investigating new sustainable forests for Northland that will provide employment and economic

expensive. In partnership with iwi, Scion has overcome this by developing techniques to vegetatively propagate these species. This approach is rapid and reliable and could be scaled up for an industrial sized forest at costs likely to be competitive with current forest establishment costs, and providing an acceptable margin at each step in the value chain.

This is an important step towards providing low-cost quality indigenous species at volume for New Zealand's forest industry, and towards sourcing rōhe-based material for Tangata whenua.

Investment: Scion Core, MBIE, PSAF, Iwi

Collaborators: Iwi



Vegetative propagation of indigenous species

Large scale plantings of indigenous species are commonly being used by forest growers to provide ecosystem services (such as biodiversity restoration, steepland stabilisation, carbon sequestration) or simply return land to its natural state.

Producing trees like tōtara, rimu, kahikatea, miro and silver beech from seed is difficult, seasonal and



Automated
dewatering plant removes
water from raw wood
enabling further
modification.

Solid wood processing

IO2 – Improve the competitiveness of the solid wood processing industry



Impact KPI 3: Improve wood product exports. By 2016, Scion will have supported the industry in achieving its export growth target of a 6% per annum increase over 2012 values and helped implement strategies to maintain this growth rate.

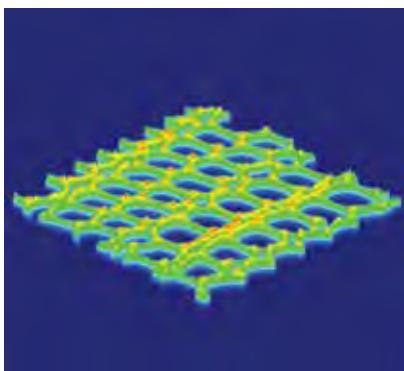
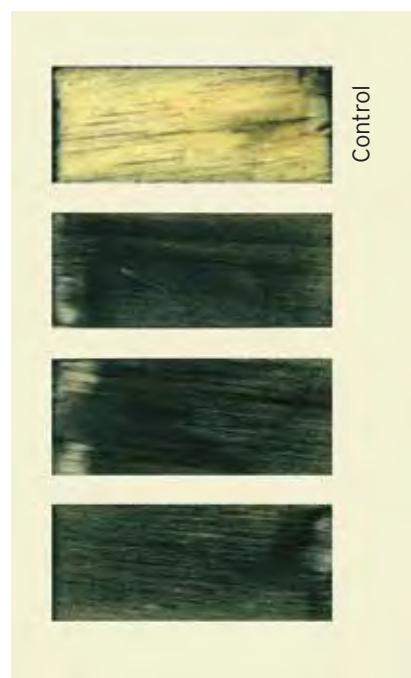
Progress:

We continued to:

- i. Develop the business case and scale-up trials, including new knowledge on the behaviour of water in wood, for a novel high performance and high value wood product using radiata pine.
- ii. Develop to pilot scale a new water-based method to enhance the durability of radiata pine using natural bioactives to address concerns in some markets over some preservatives in timber.
- iii. Support the industry in enhancing Australian and New Zealand standards so that wood products can be readily used for buildings and other purposes.
- iv. Develop and patent bio-derived adhesives for plywood applications to provide alternatives to formaldehyde-based adhesives as a product differentiator.
- v. Support industry in their product development activities through joint projects or through consortia contracts and use of our testing facilities.

been shown to improve the penetration of India ink into kiln dried and dewatered wood.

The enzymes are thought to act by removing or widening pits in the wood that prevent large molecule treatment agents, such as dyes and tannins, from penetrating. The treatment process can be completed within a day when used in combination with vacuum impregnation, and pH and temperature conditions that allow the enzymes to work quickly.



Scion's confocal microscope was used to capture detailed images of cell pores at nanoscale by using carbohydrate probes as markers. Being able to capture this in three dimensional imagery provides vital clues as to the location and size of wood cell pores.

This technique will help our scientists target wood modification agents that can infuse into the wood cells, and to evaluate wood modification processes at micro scale.

Investment: Scion Core

Capturing wood cell pores in 3-D

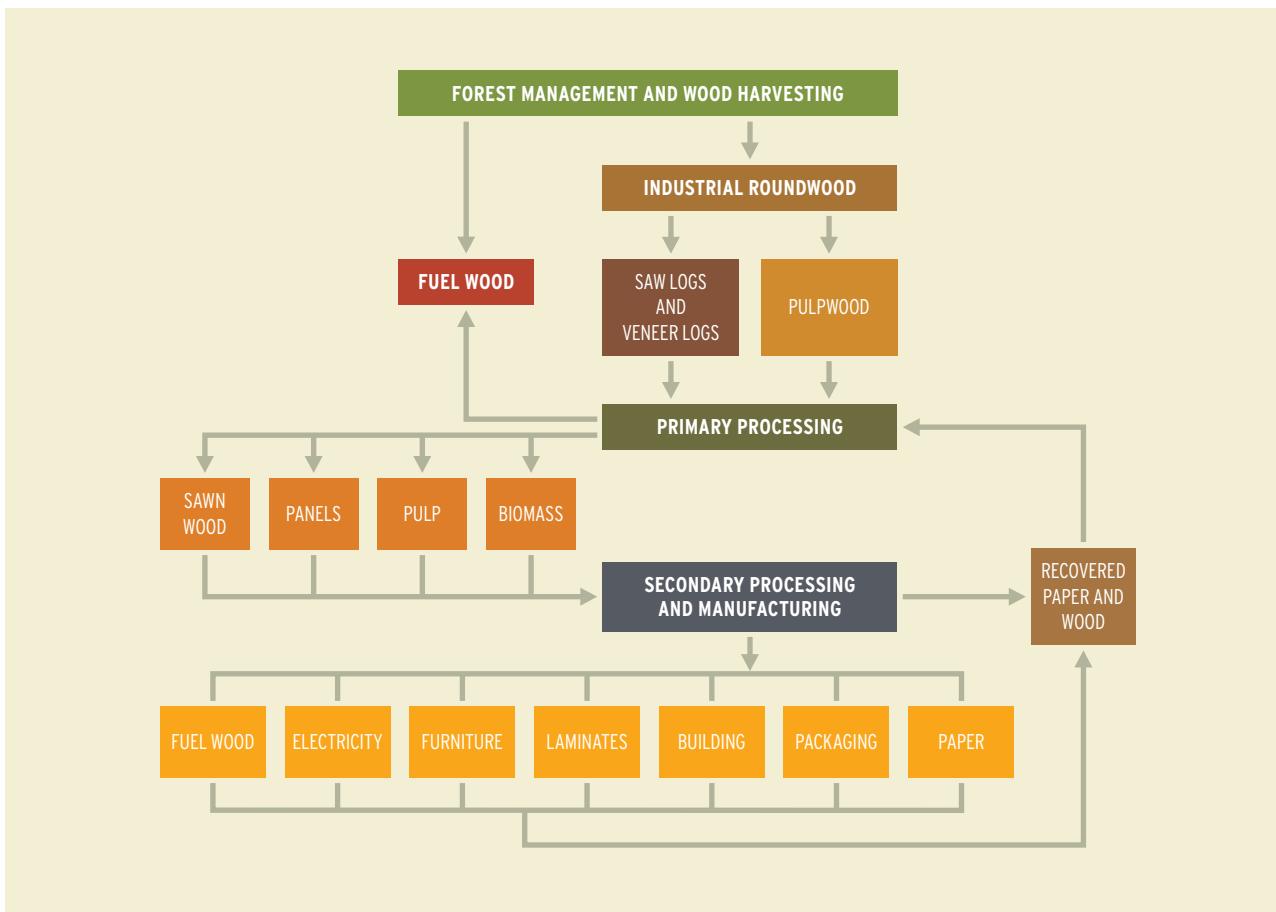
Our wood modification scientists have gained a deeper understanding of wood porosity by developing a novel technique to detect pores in wood cell walls.

Improving the treatability of wood

Our wood modification scientists have discovered two commercially available enzymes that, together or singly, have

Further research is being done to investigate these enzymes as a pre-drying treatment for timbers that are hard (and therefore usually expensive) to dry.

Investment: Scion Core



Mapping the way forward for wood processing

New Zealand's wood harvest is expected to increase by 40% over the next eight years. Along with the recruitment of two supply chain specialists, Scion is developing a technology roadmap to identify the best ways of utilising the additional 10 million m³ of logs to create wealth in the regions and improve export earnings.

The roadmap uses a whole value chain approach to the wood sector that expands on the WoodScape model and integrates with other analysis tools Scion-wide. Factors such as feedstock supply, processing technology, infrastructure, logistics and market demand will be considered on a regional basis, with the roadmap expected to be completed by the end of 2015.

The research programme was launched at a two-day international workshop on Transpacific Value Chain Optimisation. Leading on from this, an industry steering group has been

established, industry 'pain points' identified and comparators established with other sectors and international best practice.

Investment: Scion Core, Grow Rotorua, Industrial Symbiosis, University of Auckland

Collaborators: FPInnovations (Canada), Université Laval (Canada), University of Waikato, University of Auckland

Identifying new opportunities for wood processing in New Zealand

Scion's WoodScape model has helped identify a number of promising investment options for wood processing companies. The model, which is used to analyse and compare new and existing technology options and their sensitivities to key variables, has been expanded to include biofuel technologies and a greater number of variants for existing technologies.

A recent WoodScape analysis of Kawerau's resources and infrastructure has determined the advantages of centralising wood processing in the

area as part of the Kawerau Industrial Symbiosis strategy. Centralisation of materials, technologies and services in proximity to the area's abundant renewable natural resources, will help reduce operating costs and create new business and employment opportunities. For example, being able to access geothermal heat can add up to 6.6% (average 2%) to the return on capital employed in a wood processing plant. Clustered processing options are also being explored for Rotorua District Council as part of its Grow Rotorua strategy.

The WoodScape project is designed to help the wood processing industry meet Woodco's goal of boosting export earnings from wood processing some \$6 billion by 2022 by identifying new high value, export competitive processing opportunities.

Investment: Scion Core, MPI, Woodco, NZTE

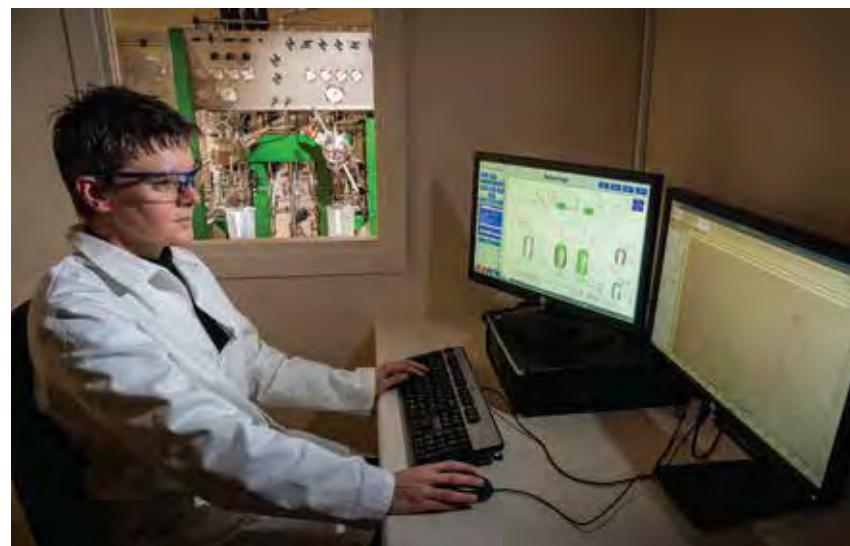
Collaborators: FPInnovations (Canada), Woodco, NZFOA, PMA, WPA, individual wood processing companies

Wood dewatering plant aids technology advancement

Scion's dewatering technology has taken a leap forward with the completion of a new automated laboratory-scale dewatering plant, purpose designed and built in-house. The machine deters raw wood samples allowing further modifications to take place, such as adjustments to stability, colour and durability.

The new plant is fully computerised, providing an accurate control of temperature and pressure and with reliable results that are automatically logged. It also combines the dewatering and wood treatment together into one streamlined process.

Continued use of CT and MRI imaging technology is helping our scientists to assess the moisture gradients that are retained within dewatered wood. These three-dimensional images of moisture patterns will



provide a deeper understanding of the interactions between water and wood and the effect these have on wood performance, particularly stability. This knowledge underpins the development of new wood products,

and new approaches to wood drying and modification.

*Investment: Scion Core
Collaborators: Locus Research,
Lakes Radiology*

Impact KPI 4: Improve international competitiveness of wood manufacturing. By 2016, Scion will have supported wood manufacturing companies to enhance the international competitiveness of their operations by delivering on average a 2.5% savings per annum on operating costs over 2011 values.

Progress:

- i. In association with Solid Wood Innovation, we continued the large-scale trial to develop a tool to segregate logs for wood quality.
- ii. Solid Wood Innovation, of which Scion is a shareholder, was successful in gaining a two year extension to its MBIE contract with log segregation being a key research focus.
- iii. Options were developed for lower quality logs to provide added-value solutions through improved processing.
- iv. Methods were provided to improve detection of flaws in appearance grade products and hence manage them.
- v. Moisture sensors in kilns were improved to progress more cost-effective drying regimes and reduce the variability in wood drying.
- vi. Trouble shooting in individual mills was provided to improve both process efficiency and product performance.

Improving the competitiveness of wood manufacturing

Over 90 commercial projects were carried out this year by our Wood and Fibre Team, helping over 40 Australasian clients achieve commercial success. These projects focused on the evaluation of structural timber products and systems, along with timber durability testing and consultancy.

Our work has been instrumental in the commercialisation of new products, products being extended into new applications, approvals gained, product performance improvements made and new sales opportunities captured.

*Investment: Industry clients
Collaborators: Industry clients*

Thermally modified wood provides natural durability

Our knowledge in timber performance and modification has underscored the development of a new thermally stabilised wood product which is environmentally friendly and does not pose an end-of-life issue.

Our client has invested in a kiln that thermally heats timber to enhance durability. Scion has been able to quantify changes in the mechanical and fastening properties of a new modified wood product and compare them with structural building code requirements. Long term durability trials have also been established to determine its hazard class rating and therefore what applications thermally treated radiata pine can be used in. At this stage the product has a hazard rating of H3.1.

Investment in this new technology has created exciting market opportunities for our client, producing high value timbers that cater specifically to companies requiring sustainable, non-toxic products.

*Investment: Industry client
Collaborators: Industry client*



3-D printing of biopolymers.

Wood fibre, pulp, packaging, biopolymers and biochemicals



IO3 - Expand opportunities in the wood fibre, pulp, packaging, biopolymer and biochemical industries

Impact KPI 5: Expand biorefining. By 2016, Scion will have supported the emerging biorefining industry to grow processing capacity or revenues by at least 10% per annum through development of new products.

Progress:

- i. The Woodforce product using MDF fibre was significantly improved with international partners through development of a Generation 3 product at the lab scale. Uptake in New Zealand is progressing through discussion with plastics processing companies.
- ii. The recyclability of Woodforce products compared to other fibre composite products was demonstrated including its advantages over several cycles of reuse.
- iii. New feedstock options for pulp and paper mills with the potential to create new co-products were successfully explored at lab and pilot scale.
- iv. A partnership with two EU based R&D programmes was progressed to define New Zealand projects to jointly develop standards for bioproducts.
- v. Through clever extrusion technologies and formulations for releasing actives a new animal health product was developed with a commercial partner.
- vi. Novel water dissolvable polymers were successfully extruded and moulded into 3-D printable concept products.
- vii. The Biopolymer Network Ltd was assisted in developing new additives for resin and foam products and commercialising extractives for application in personal care products.
- viii. We continued development of lignin-based products for application in high-value markets, including working with start-up companies on new applications for lignin as a cheap feedstock compared to petroleum-based feedstocks.
- ix. We continued development and patenting of bio-derived adhesives for fibre board applications to provide alternatives to formaldehyde-based adhesives as a product differentiator.
- x. Testing and research facilities were provided to assist industry-based product development options.

Our client is now exporting a much higher value product into Asia and steadily increasing their international market share.

Investment: Industry client

Collaborators: Industry client

Recycling renewable resources

Plastics reinforced with MDF fibre (licensed to Sonae Indústria as Woodforce) can be recycled many times with little change to their mechanical properties. Woodforce is an engineered diced wood fibre pellet developed by Scion that is used to reinforce thermoplastic polymers.

Polypropylene reinforced with MDF, flax and short glass fibres were recycled six times through Scion's extrusion and injection moulding pilot plant, and tested for strength, stiffness and impact strength. The MDF composite fared the best, retaining on average, 87% of its original properties in comparison to flax (72%) and glass (59%). The MDF fibres also retained most of their original fibre length, and therefore strength, whereas flax and glass fibres were more prone to degrading or breaking.

In addition, MDF fibres have a lower density than glass fibres making them an attractive alternative for use in materials where weight is important, such as car parts. Cars in Europe are required to have a reusable end-of-life option by 2015 (Directive 2005/64/EC).

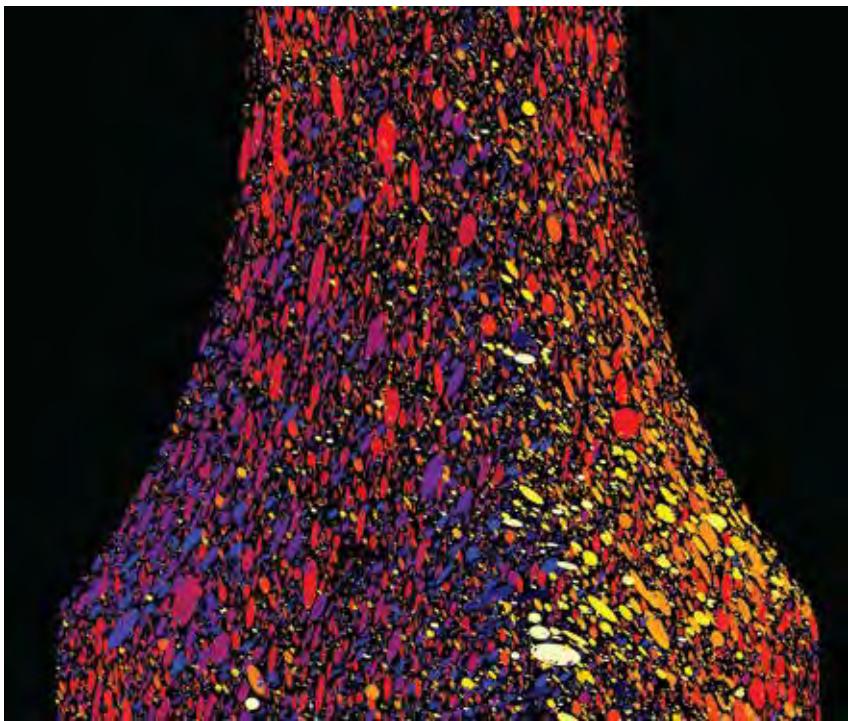
Investment: Scion Core, Sonae Indústria
Collaborators: SCC (France)

www.scionresearch.com/impact/wood-fibre/investment-in-bioplastics-pays-off

Investing in new markets

Scion's expertise in the technical aspects of producing mechanical pulp has helped a leading pulp and paper manufacturer undergo a multi-million dollar upgrade of its thermo-mechanical pulp mill.

The upgrade and the introduction of new processes enables our client to enter a higher value segment of the Asian market. Using Scion's thermo-mechanical refining pilot plant, our client was able to de-risk technical aspects of the new process and ensure the tight product specifications could be met.



Magnified dogbone sample of Woodforce, colour coded for particle orientation.

New technique to measure fibre alignment in wood composites

Scion is looking at ways to predict the strength of wood composites based on the orientation and aspect ratio (length-width) of its wood fibres. Wood fibres may be distorted during extrusion or injection moulding processes, affecting the strength properties of the wood composite product and the product's recyclability.

A combination of microscopic two-dimensional imaging and mechanical modelling is being used to map the correlation between fibre orientation and strength, using polypropylene reinforced with Scion's engineered wood fibre dice (licensed as Woodforce).

The analysis has shown that accepted micromechanical models used to predict behaviour in glass fibres can also be applied to Scion's wood fibres without needing to be modified.

*Investment: Scion Core
Collaborators: E-Xstream (Belgium), University of Otago, University of Göttingen (Germany)*

Extrusion technologies gain momentum

Scion's extrusion research has led to several new product developments for a diverse range of end uses.

We have helped scale-up a new proprietary extrusion technology for producing animal health products, and the associated formulation for releasing actives that improve animal health and well-being.

Novel water dissolvable polymers have been extruded and then moulded or 3-D printed into concept products. Using this experience, we were able to help another New Zealand company set up an extrusion line for their own proprietary water dissolvable products used, for example, in the animal processing sector.

Advancements have been made to the commercial feasibility of extruding wood-plastic composites in New Zealand using novel local feedstocks relevant to New Zealand manufacturers. These new feedstocks will also include nanocellulose reinforcements in the future, and collaboration with Innventia in Sweden has been established to investigate this further. Gaining a better understanding of how extrusion parameters affect the production and performance of various wood-plastic composites has helped several companies develop new production lines or products. Companies are now evaluating commercial options.

*Investment: MBIE
Collaborators: NZ manufacturers, The University of Waikato, University of Auckland, Massey University, AUT, Innventia (Sweden)*

Growing interest in green bioadhesives

Business plans are underway to commercialise Scion's bio-derived adhesive and resin technologies for both structural and non-structural applications. The products are made using agricultural and forestry processing residues such as lignin, providing a green option for New Zealand's wood composite and packaging manufacturers.

This year, significant gains have been made in optimising the technologies' adhesive properties and performance and further proving their low VOC (volatile organic compounds) emissions. A Life Cycle Analysis used to calculate the environmental impact of both petrochemical-derived and bio-based adhesives showed bioadhesives had a 22% lower carbon footprint than their counterparts. This opens the way for new end-of-life and recycling options, bolstering the manufacturing industry's licence to operate.



Manufacturing protocols have also been developed for the use of our bioadhesive and resin technologies in plywood, MDF and particleboard. An industry forum held in August 2013 attracted key New Zealand wood adhesive and panel board manufacturers and end-users interested in using our low VOC adhesive technologies, with international interest also growing.

*Investment: MBIE
Collaborators: New Zealand manufacturers*

www.scionresearch.com/impact/wood-fibre/environmental-impact-of-bioadhesives-encouraging

Impact KPI 6: Packaging solutions. By 2016, Scion will have supported the packaging and composites products industries to grow the value of exports by at least 5% per annum in real terms.

Progress:

- i. We supported the Biopolymer Network Ltd commercialise the ZealaFoam™ bio-based foam packaging product as a sustainable alternative to expanded polystyrene for fish applications.
- ii. An enhanced coating system for packaging was patented and we ran a coating product in scale-up trials at commercial facilities.
- iii. The new biodegradation testing facility was used to test two packaging related products for likely compliance with industrial composting standards.
- iv. We invested in a new state-of-the-art facility to test the performance of packaging in cool stores under different conditions such as those in shipping containers.
- v. Industry members and researchers on packaging attended an open day and workshop at Scion to be updated on our capabilities, equipment, facilities and areas of research.
- vi. The metrics on life cycle analyses were translated as required by the Global Protocol on Packaging Sustainability for New Zealand application.
- vii. The packaging and composites industries received our support through participation in industry events and provision of direct services.

Commercialisation of ZealaFoam™ a step closer

ZealaFoam™, the eco-friendly alternative to expanded polystyrene (EPS), is moving closer to commercial production through a number of industry trials. Sustainably derived and industrially compostable, the bioplastic is attracting keen interest from industries both locally and overseas for use in packaging, sporting goods, furniture and insulation.

Once commercialised, ZealaFoam™ will offer a sustainable packaging alternative for New Zealand companies and the competitive advantage over their competitors, particularly in cool chain exports such as fresh and frozen seafoods. EPS moulders will also have the opportunity to expand their product range and meet new markets, using existing production equipment.

ZealaFoam™ developer, Biopolymer Network Ltd (BPN), won the New Zealand Innovation Award for Innovation Excellence in Research in October 2013. Biopolymer Network Ltd is an incorporated joint venture between Scion, AgResearch and Plant and Food Research.

Investment: BPN collaborators, industry partners

Improved moisture barrier increases life expectancy of packaging

Scion's new barrier coating technology improves the humidity resistance and life expectancy of corrugated paperboard packaging in the chilled supply chain. Multiple thin layers of coating are applied which reduces both the total volume and cost of coating. In addition, packaging converters can apply the coating in-house using an industry-standard flexographic press without the need to invest in new equipment.

The new technology is expected to reduce costs throughout each step of the supply chain. Greater moisture resistance means less paper is required and less waste generated. The coating also provides a high level of gloss and scuff resistance that protects package branding.

The coating technology has been successfully tested at pilot scale at Karlstad University in Sweden, and trialed on a commercial printing press in New Zealand. A larger commercial trial is now being planned.

*Investment: Scion Core
Collaborators: Victoria University, Massey University, Karlstad University (Sweden), New Zealand manufacturer*

Biodegradation facility unique in New Zealand

Scion's new biodegradation testing facility measures the aerobic breakdown of compostable packaging materials to international composting standards. It is the only such facility in New Zealand, making it easier for packaging suppliers and industrial composting operators to have materials tested and certified.

The facility is designed to quantify the biodegradation timeframe of biomaterials under controlled temperature, moisture and air-flow conditions modelled on industrial composting. It can also be modified to measure the breakdown of any material in any medium such as soil or aquatic environments. In the past year, the post testing data work-up has been optimised and eco-toxicity testing has been developed in line with EN 13432.

Investment: Scion Core, BPN

New coolroom helps improve packaging for chilled goods

Scion's purpose-built coolroom is a boon for New Zealand's packaging manufacturers and exporters of chilled goods. The facility makes it possible to reliably predict how packaging performs under fluctuating humidity, and will aid the development of new and improved packaging systems for New Zealand's fresh exports.

The coolroom has a special twin wall designed to keep temperature constant, and accurately cycles relative humidity between 50 - 90% to imitate the conditions products experience in the chilled supply chain.

Compression creep tests can be conducted in the facility to capture the strain profile of a box or measure box lifetime, allowing for comparative testing of new and existing products.

*Investment: Scion Core
Collaborators: AgResearch*

www.scionresearch.com/impact/wood-fibre/protecting-your-product-with-better-packaging



Scion is developing tools to reduce the spread of invasive pests between countries.

Risk and adaptation

IO4 - Improve New Zealand's forest health and preparedness for biosecurity incursions, fire and climate change



Impact KPI 7: Reduce biotic risk. By 2016 increased export earnings from New Zealand's forest resources will be enabled by reducing the risk of new forest pests (insects, diseases, weeds) establishing in New Zealand, and by minimising the impacts of already established pests. This will be achieved by: (i) biosecurity agencies using tools developed to identify and block high risk pathways, and to detect and eradicate new pests; and (ii) providing forestry companies with resistant germplasm and new chemical, biological or silvicultural treatments for effective pest management.

Progress:

- i. The development of a new pest detection tool for MPI continued.
- ii. We demonstrated to MPI that pest risks associated with the wood packaging pathway have been mitigated although further improvements may be necessary.
- iii. New plant identification tools for MPI were developed.
- iv. By enhancing procedures to detect the pathogen *Phytophthora* taxon Agathis in soil we aided DOC and MPI with kauri dieback surveillance.
- v. Collaboration with an overseas risk assessment group was initiated to improve New Zealand's pest detection surveillance systems.
- vi. We showed a chemical has the ability to control red needle cast disease for at least 12 months.
- vii. A spray model that gives insights on how to reduce spray drift and non-target impacts in forestry and other applications was improved.
- viii. *Pinus radiata* clones that show resistance to red needle cast were identified.
- ix. A biological control agent for a significant *Eucalyptus* pest was successfully released and established.
- x. Working with MPI and operational managers, a new Scion aerial spot spray application technology was used in a programme to eradicate a leaf beetle that is a serious threat to eucalypts.
- xi. A new six year MBIE-funded *Phytophthora* programme that targets disease issues in the forest, horticulture and conservation estates was established.

costs and benefits of the policy. An integrated model has also been developed to predict new incursions at a pathway level, rather than for individual pests.



Results show that ISPM15 has reduced pest arrival rates substantially but that some risk associated with wood packaging, remains. Despite this and the ongoing increase in international trade, ISPM15 has considerable cumulative net benefits over the longer term. These studies were published in 2014 in three high impact international journals.

Opportunities to improve ISPM15 and further reduce pathway risks have also been identified.

*Investment: Scion Core
Collaborators: B3; AgResearch; USDA Forest Service; USDA Animal and Plant Health Inspection Service; New England Forestry Foundation; The Nature Conservancy; University of California, Santa Barbara and Davis; University of Maryland, College Park; Columbia University, New York; McGill University, Montreal; NCEAS*

Biosecurity risk associated with wood packaging mitigated

The International Standard for Phytosanitary Treatments of wood packaging materials (ISPM15) is a worldwide policy to reduce the spread of invasive pests between countries via wood packaging, such as pallets.

Completion of the first cost-benefit analysis for ISPM15 has helped confirm the benefits of the policy and quantify the remaining risks posed by wood packaging. A century of data on insect pest invasions and border interceptions have been analysed to estimate the effectiveness, impact on trade, and the direct and indirect



Tiny wasp tackles serious eucalypt problem

The Australian parasitoid wasp *Cotesia urabae* was introduced to New Zealand in 2011 by Scion as a biological control for the gum leaf skeletoniser, *Uraba lugens*. The caterpillar defoliates eucalypts, posing a serious threat to commercial forestry, urban environments and public health. Since becoming established in Auckland in 2001, it has spread to many parts of the North Island and Nelson. Hosts include the commercially grown *Eucalyptus nitens* and *E. fastigata*, and amenity species *E. nicholli* and *Lophostemom confertus*.

Cotesia urabae is a tiny host-specific wasp that lays its eggs inside the gum leaf skeletoniser caterpillar. The larva emerges 14-20 days later to pupate, killing the host. A sample of about 500 gum leaf skeletoniser

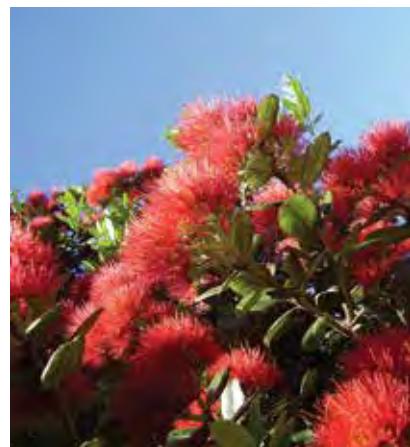
caterpillars collected recently from five sites around Auckland showed 40% of them contained the parasitoid. Four of the five sites were areas where no parasitoids had been released, indicating that the wasps are well established and colonising new sites in the region. This is a promising outcome for the suppression of the gum leaf skeletoniser.



First releases of the wasp were also made in Nelson and Napier in 2014, but establishment in these areas has yet to be confirmed.

Investment: Scion Core, MBIE

Collaborators: University of Auckland, Hawkes Bay Regional Council, Napier City Council, Tasman District Council



DNA barcoding for rapid identification

New Zealand's proximity to Australia makes it likely that the airborne rust fungus, *Puccinia psidii* will cross the Tasman. The pathogen causes myrtle rust, and infects many species of Myrtaceae - a genus containing pohutukawa, rata and mānuka, as well as eucalypts and feijoa.

To prepare for such an incursion, Scion's Herbarium Curator has developed a DNA barcoding library of over 100 species of Myrtaceae in New Zealand, some with known susceptibility to myrtle rust, or that are of economic and cultural significance.

DNA barcoding provides an easy and reliable means of species identification without the presence of multiple characteristics such as flower, seed and fruit. This will improve MPI's preparedness and capability to respond to an incursion and help reduce the risk of the disease spreading.

Investment: Scion Core, MPI

A targeted approach to aerial spraying

A novel method of applying insecticide was used during an eradication programme that aims to eliminate the *Eucalyptus* leaf beetle, *Paropsisterna beata*. The beetle poses

a serious threat to New Zealand's eucalypts, and was discovered in a semi-urban valley bordered by steep terrain near Wellington. MPI approached Scion to assist with an eradication programme due to the complexity of the location.



A unique approach to insecticide application was needed to prevent drift onto nearby houses so our Pest Management Team developed two new aerial spray methods, the spot-gun and spot-boom that target single tree canopies rather than broadcast spray over a wide area. The spot-spray methods use a combination of large drops and helicopter turbulence to push the drops onto the tree-canopy, thus reducing drift and off-target environmental and health impacts. To date, no further trace of the beetles has been found. This response was nominated for the MPI Director General's Award for Excellence.

The spot-gun and spot-boom methods are the first tools in a 'toolkit' of spraying techniques we aim to develop over the next few years.

*Investment: Scion Core, MPI
Collaborators: B3, MPI, Hammond
Resource Management*

Chemical control of red needle cast in radiata pine

Chemical spray trials to identify treatments for red needle cast show phosphite is effective in reducing the number and length of lesions caused by the pathogen *Phytophthora pluvialis*. These effects persist for at least 12 months after application.

This is a positive step in the development of cost-effective control of red needle cast. Scale-up field trials are being planned to determine optimum dosage and timing of phosphite application.

Investment: Scion Core, FOA, FGLT

Healthy trees, healthy future

Scion leading the way in global *Phytophthora* research

Phytophthora are soil or wind borne plant pathogens that pose a major global biosecurity challenge. The pathogens' attraction to a broad range of hosts plus the increasing movement of organic material between countries has escalated the proliferation of *Phytophthora* related diseases.

Protecting our primary industries from new, emerging and established *Phytophthora* diseases is imperative for the country's economy now and into the future. Without intervention, the Government's aim of increasing export earnings to 40% of GDP by 2025 is at risk, along with the health of New Zealand's indigenous and urban forest resources.

Scion has been allocated \$10 million funding from MBIE over the next six years, with significant co-funding from sector groups, to lead a collaborative research programme to address the biosecurity threat of *Phytophthora* species to New Zealand's agri-forestry, horticulture and natural ecosystems. The programme will combine a multi-pathogen-host model with metabolic and genetic analysis to identify hosts that have broad resilience to a number of *Phytophthora* species.

A focus on three *Phytophthora* diseases

There are three major *Phytophthora* diseases currently affecting New Zealand's primary industries and conservation estates.

Red needle cast (caused by *P. pluvialis*) is a new disease of radiata pine which is considered a high priority for the \$4.5 billion a year forestry industry.

Crown and collar rots in apples (*P. cactorum*) may result in up to 20% tree loss during establishment, with ongoing root damage and tree losses under wet conditions.

Kauri dieback (*P. taxon Agathis*, or PTA), poses a serious threat to our indigenous kauri with a wide range of social, aesthetic, cultural and environmental impacts.

Breeding for resistance to a range of pathogens

Scion is taking a genus-wide approach to disease breeding, management and research. The project builds on our existing programmes for red needle cast, kauri dieback and other *Phytophthora* species, using a systems biology approach to detail the host-pathogen interaction. Screening and selection for pathogen resistance will generate detailed genetic data that can be used in breeding programmes to generate germplasm resilient to a broad range of *Phytophthora* species.

Eight *Phytophthora* species have been selected for our multi-pathogen-host model that straddle the forestry and horticulture industries, and natural and urban estates. The three host species targeted are radiata pine, kauri and apples.

The impact of this research on industry is high and far reaching. For the forest industry, the research will actively contribute to lowering disease levels in our plantation forests, and so increase productivity. For MPI, this research is critical for improved prediction of *Phytophthora* impacts on a variety of different sectors or in addressing market access concerns. For the New Zealand population, research that helps protect our iconic kauri is immeasurable.

Early outcomes from the new *Phytophthora* programme

Our understanding of *Phytophthora* pathogens, the diseases they cause and how they are expressed has grown considerably over the last year.

Phytophthora genomes are being sequenced in collaboration with Exeter University. This resource has been used for the MBIE project and to also initiate collaborations with other research parties, such as the Canterbury University and Otago University, and the University of British Columbia in Canada.

A new diagnostic tool developed recently will help with pathogen identification. The high resolution melting (HRM) assay can distinguish several important species of *Phytophthora* associated with trees in New Zealand, allowing for a faster turn-around and diagnosis of samples in both research and diagnostic applications.

Previous work undertaken by our Genetics Team has shown that resistance to red needle cast (RNC) is genetically controlled. 'Elite' clonal material developed by the Radiata Pine Breeding Company is being screened for resistance and as a potential benchmark for future work.

The zoospore inoculum production method for RNC has been improved, allowing more zoospores to be produced more reliably and with less personnel hours involved. This allows

more artificial inoculation experiments to be conducted, directly benefitting the chemical control, genetic breeding and biological control programmes.

Scion was also heavily involved in the successful Kauri Dieback Symposium held in Auckland in November 2013, and another symposium is being planned through the Kauri Dieback Programme partners.

Investment: Scion Core, MBIE, FOA, FGLT, RPBC, Kauri Dieback Programme

National collaborators: Plant and Food Research, Landcare Research, RPBC, local Māori groups, DOC, Kauri Dieback Programme, NZ Genomics Ltd, University of Auckland, AUT and Massey University

International collaborators: The University of Exeter (UK); IFO (France); Murdoch University, Australia; UBC, Canada; Oregon State University, USA; the University of Algarve, Portugal

www.healthytrees.co.nz

Impact KPI 8: Reduce abiotic risk. By 2017, Scion will have protected New Zealand's forest export revenues by improving the resilience of New Zealand forested and rural landscapes. This will be achieved by providing appropriate agencies and companies with tools across the spectrum of reduction, readiness, response and recovery, that help to minimise the impact of abiotic risks (fire, wind, extreme rainfall) in a changing environment (e.g., climate change).

Progress:

- i. Wildfire risk assessment maps were improved.
- ii. New firefighter fitness standards that should improve health and safety were recommended to fire authorities.
- iii. The forest industry began to apply the wind risk decision support tool to minimise the risk of wind damage and subsequent financial loss and disruption.

Mapping wildfire prone areas to protect vulnerable communities

Our Rural Fire Research Team has developed a method to map the risk of wildfire in rural-urban areas where flammable vegetation fuels meet people and property, and public safety may be in jeopardy. This will have enormous benefits for rural fire managers. Data for a range of environmental and social fire risk factors have been overlayed onto maps of the rural-urban interface to identify at-risk areas. The method has been successfully tested in two case studies at Nelson and Rotorua.

Identifying wildfire prone areas will help reduce the number and consequences of wildfires by enabling fire authorities to prioritise activities such as fire prevention, fuel reduction and the promotion of SmartFire communities. The information can also be used by local government and fire agencies to strengthen planning and building regulations for high fire risk areas.

Recommendations from this study have been presented to fire managers and at the NRFA's FireSmart planning workshop. This has progressed the development of a national FireSmart programme for rural communities.

*Investment: NZ Fire Service Commission
Collaborators: Validatus Research, Rotorua District Council, Nelson City Council, Tasman District Council*





Keeping our firefighters fit and well

A review of the National Rural Fire Authority (NRFA) health and fitness guidelines for volunteer firefighters by Scion's rural fire research team has led to recommendations being made for new standards of fitness.

Fighting forest and rural fires is physically demanding and a high level of fitness is required to minimise fatigue and to work competently. The study provides the Fire Service Commission and the NRFA with background information to make decisions on appropriate minimum fitness standards for rural fire personnel. Draft recommendations regarding the need for medical health checks and a tiered approach to fitness standards appropriate for different firefighting tasks have been made following discussion with firefighters and fire agencies, and a review of international approaches.

*Investment: NZ Fire Service Commission
Collaborators: NRFA, Rural Fire Authorities*

New photoguide expands fire behaviour prediction tools

Our new fire fuel photoguide provides images and technical descriptions of fuel types to help fire managers choose the right fire behaviour model in prediction tools such as the Fire Behaviour Field Manual, Toolkit calculator and smart apps. There are currently 18 individual fuel types

recognised in New Zealand, with 18 fuel load and nine rate of spread models available to predict fire behaviour.



Correct identification of fuel types will help fire managers to accurately predict how fast a fire will spread and how best to control it. The guide

provides users with a better understanding of how fire behaviour models differ from one another and which one is the most appropriate to use to inform fire management and safety decisions.

An abbreviated version of the photoguide for field use has also been produced for inclusion in the Fire Behaviour Field Manual, along with an electronic version for addition to the Fire Behaviour Toolkit calculator software.

*Investment: MBIE, NZ rural fire sector
Collaborators: NZ rural fire sector*

Managing for wind risk

Scion's upgraded wind risk management tool helps forest managers schedule production thinning and harvesting activities to minimise the risk of wind damage and subsequent financial loss and disruption.

The tool synthesises knowledge from complex models that predict risk based on the location and structure of a stand, to create a set of simple decision rules managers can use to inform silviculture practice.

Further research has been done on using multiple criteria to assess the risk of wind damage. These include stand density index, slenderness and tree height. Timberlands Ltd is using information on site occupancy, tree height and slenderness to identify stands that can be thinned with minimal risk. Nelson Forests is using information on the effects of stand structure on wind damage risk to guide the development of new silvicultural regimes.

*Investment: Timberlands Ltd
Collaborators: Timberlands Ltd, Nelson Forests*





On-going
environmental research
helps maintain
forestry's licence to
operate.

Licence to operate

I05 - Ensure the New Zealand forestry industry's licence to operate domestically and internationally and enhance environmental performance.



Impact KPI 9: Forestry licence to operate. By 2016 Scion will have provided tools and technologies to New Zealand's forestry growing companies that enable them to keep abreast of, and implement, international protocols for sustainable forest management and environmental certification in order to maintain access to high-value markets, meet best practice for the minimisation of environmental impacts and allow informed choice over the role of genetic engineering.

Progress:

- i. No long-term detrimental impacts on soils and water quality from two herbicides currently used in forestry for weed control were demonstrated.
- ii. MPI was provided with data that allowed the easing of regulations on phytosanitary treatment of export forest products.
- iii. A summary of the state of knowledge on ecosystem services from planted forests was published, and the spatial economic modelling tool Forest Investment Finder (FIF) is being increasingly used by councils, forest companies, MPI and iwi to explore and quantify the environmental value and benefits of our planted forests.
- iv. Workshops were hosted and presentations given to forestry groups, government departments, local government and non-forest industry bodies on the use of biotechnology to enhance forest productivity, sustain competitiveness and assist responses to biosecurity threats.

remains in question. Trial results indicate that acceptable weed control is still achieved when it is used in combination with an alternative to hexazinone. Subject to further testing, this study provides the forest industry with possible options that are compliant with FSC certification criteria should the restriction on terbutylazine be lifted.

Funding: MBIE, SFF, FOA through the FSC Cluster Group

Determining the environmental impact of herbicides

A two year environmental study on herbicides used in planted forests, shows existing weed management practices have no long term detrimental effects to soil and water.

Field trials were conducted to monitor the concentration of terbutylazine and hexazinone in the forest environment before and after application. The highest concentrations of both herbicides in stream water occurred either on the day of spraying or during rainfall seven days afterwards.

In the six months following application, concentrations were low in the stream water, sediment and algae, and quickly degraded in the litter and soil, posing low risk to the environment. Results highlight the importance of forest litter and organic matter in retaining terbutylazine and limiting its movement down the soil profile.



FSC compliant alternatives for weed control

Scion's Pest Management Team is investigating alternative herbicides to terbutylazine and hexazinone for weed control in forests. The first year's results indicate that the best

alternatives to present industry standards include terbutylazine being applied in combination with mesotrione, triclopyr or clopyralid, or a mixture of triclopyr, clopyralid and haloxyfop.

The status of terbutylazine with the Forest Stewardship Council (FSC)



The careful management of forest harvest residues will play a significant role in determining the long-term effects of aerially applied herbicides.

Research continues to support FSC certification and ensure the industry's licence to operate.

Investment: AgResearch through previously contracted "Undermining Weeds" MBIE programme.

Post fumigation exposure periods extended

In June, MPI extended the maximum post-fumigation exposure period for logs during winter from 72 hours to 21 days for all of New Zealand except Northland. This is the period logs can be held after fumigation before having to be re-treated due to the risk of re-infestation. This decision was based on our on-going research into phytosanitary pest behaviour, and has huge economic benefits for the export log industry.

Ports and log marshalling companies will now have greater flexibility to schedule fumigation treatments between periods of bad winter weather. In addition, exporters can largely eliminate the need to fumigate a buffer volume of logs, traditionally up to 5% of the cargo. For a standard vessel with 10,000 JAS of logs, this means about 500m³ would not require re-fumigation if it was not loaded within the designated timeframe. This alone would save the industry up to

\$75,000 per annum in fumigation costs and reduce methyl bromide use by about 3.8 tonnes.

This result is a positive step on a journey towards achieving a treatment free low risk winter period and reduced reliance on methyl bromide as a fumigant.

*Investment: Scion Core, MBIE, PGP, STIMBR
Collaborators: MPI*

Climate cloud provides ready access to climate change resources

Land owners and managers can tap into information on the effects and implications of climate change at a new online library, www.climatecloud.co.nz. Scion's geomatics and bioinformatics scientists worked collaboratively with AgResearch to develop the digital library as part of Government's strategy to build climate change resilience in the primary sector.



To date, access to information about climate change, its risks and implications to primary sector business has been limited, mainly due to information being distributed by many agencies through disparate channels.

The new digital library holds climate change related resources that are authoritative, relevant and well described. Land managers and other professionals can use the information to understand, mitigate and adapt to a changing climate. Resources have been reviewed for applicability and quality, and include fact sheets, reports, case studies, presentations, audio and video.

*Investment: MPI
Collaborators: AgResearch*

A concerted effort to control wilding conifers

Data provided by Scion to MPI and the Wilding Conifer Management Group on the extent and severity of wilding infestations, helps inform the national

strategy on wilding conifer control and contributes to the concerted efforts to reduce wilding spread.

Our researchers have supported a number of trusts to establish monitoring networks which are critical to document their control success. We have also developed a web-based calculator to provide indicative costs of control. Ongoing control and management efforts are underpinned by evidence-based research on more cost effective control methods, better surveillance and monitoring practices, and improving decision support systems based on wilding spread across a range of environments and site conditions.



At the current level of infestation, the cost to remove wildings and restore affected eco- and production systems is estimated to be up to \$0.75 billion. This could be reduced with more effective control and management approaches. Our research is providing land managers with tools to monitor and target wildings more cost effectively, and by doing so, avoid increasing environmental and economic loss.

*Investment: New Zealand Wilding Conifer Management Group
Collaborators: district and regional councils, DOC, MPI, Mid Dome Wilding Trust, Waimakariri Ecological and Landscape Restoration Trusts, forestry companies*

Forest stream recovery after extreme storm

Shortly after an area of planted forest in the eastern Bay of Plenty was harvested in 2011, a major storm caused severe flooding to the area. The combination of harvest and flooding presented an opportunity for our researchers to study the natural

recovery rate of three streams in the area. These streams had been monitored pre-harvest as part of Scion's environmental research, which provided baseline information on riparian vegetation, stream habitat, water temperature, aquatic insects and native fish.

The storm washed away the woody debris, riparian plants, seeds and soils and initially the aquatic insect and fish populations dropped dramatically. Three years later only partial recovery has occurred. Riparian vegetation is slow to recover, but surprisingly the density of aquatic insects and fish increased above the levels present at pre-harvest. Many of the sensitive species are yet to return but with the lack of shade and cover in streams, and high levels of algae, this may require a few more years.

This research will contribute to the development of risk management strategies for forestry that will protect the industry's licence to operate under future climatic conditions.

*Investment: Scion Core, BOPRC, Matariki Forests, PF Olsen Ltd, Hancock Forest Management (in kind)
Collaborators: assistance by Nga Whenua Rahui*

create a barrier to biotechnology advancement for forestry and other sectors.

The Bay of Plenty Regional Council's draft Regional Policy Statement (RPS) initially would have prohibited any activity involving genetic modification research in the region once embodied in District Plans. Through the appeal process, Scion obtained amendments that made it clear that GMO provisions should not be included in District Plans and therefore there would be no duplication of regulation.

This keeps the channels open for ongoing research into the reduction of agri-chemical usage, and the development of beneficial technologies and higher value products that will keep the industry internationally competitive.

Investment: Scion

Keeping the channels open for biotechnology advancement

As a result of an appeal to the Environment Court, Scion has eliminated the requirement that councils introduce duplication of the regulatory processes and costs involved with genetic modification research. Such duplication would

Impact KPI 10: Wood manufacturing licence to operate. By 2016 Scion will have provided tools and technologies that enable New Zealand wood and wood fibre manufacturing companies to meet international environmental performance criteria for BATEA (Best Available Technology - Economically Achievable) and provide economic benefits of at least \$50 million per annum through reductions in water, chemical and energy use.

Progress:

We continued to:

- i. Work with the pulp and paper industry to provide solutions to divert organic wastes from landfills and reduce adverse impacts on receiving water.
- ii. Participate and support development of industry clusters using industrial symbiosis concepts in the Bay of Plenty to maximise use and re-use of waste streams across regional clusters of industries.
- iii. Support the commercial scale-up of the TERAX™ technology to substantially reduce land fill from organic biowastes.
- iv. Develop a new hydrothermal processing platform to aid in waste management.

Milestone reached for TERAX™

A major milestone for the TERAX™ technology this year has been the final approval of the first full-scale plant by Rotorua District Council. This follows a business case review undertaken by the council and further technical validation by Scion. The plant will be built at the council's wastewater treatment plant with construction expected to be completed by the end of 2015.

TERAX™ technology converts sewage sludge into energy and sterile chemical products, reducing the solid organic fraction by over 90%. The technology has the potential to save local authorities millions of dollars in landfill disposal costs and displace imported sludge deconstruction technologies.

Scion has also been looking at ways to expand the technology beyond biosolid feedstocks and reduce the volume of organics going to landfill in New Zealand. Our work this year has provided proof of concept that TERAX™ technology is applicable to food and general household garbage wastes at both laboratory and pilot scale.

*Investment: Scion Core, MfE Waste Minimisation Fund, PSAF, RDC
Collaborators: RDC, WorleyParsons, Mott MacDonald*



Rugs to riches

Six thousand tonnes of wool carpet enter New Zealand landfills every year at a cost to industry of about \$720,000. Synthetic carpets on the other hand, are designed to be recycled and compete strongly with wool products, particularly in the USA and Europe where accreditation is usually required.

Under the Bioresource Processing Alliance and in collaboration with AgResearch, Scion subjected ground wool-based carpet to hydrothermal treatment at a range of temperatures to determine its performance and degradability. Extensive degradation was evident with the treatment, indicating that hydrothermal processing could provide a solution to the resource being sent to landfill.

Wool production in New Zealand is currently 126,000 tonnes per year with a value of \$800 million. About 70% of this is linked to the carpet industry. By providing a more sustainable end-of-life solution, additional carpet sales could provide a boost to the country's economy

Investment: MBIE

Collaborators: AgResearch

Impact KPI 11: Increase wood product uptake. By 2016, Scion will have provided robust technical information to support standards development and systems innovation by the wood- and bio-based product manufacturing sectors that increases acceptability and uptake of New Zealand products in domestic and international markets.

Progress:

- i. Joint work was continued with Australia on preservation standards and protocols to ensure trans-Tasman harmonisation.
- ii. With MBIE and the industry we progressed the review to modernise the timber building standards (3603) in New Zealand.
- iii. We continued to improve the WoodScape model to advise on best options for establishment of new products.
- iv. With GS1 we translated the Global Protocol for Packaging Sustainability into a usable system and initiated assessment from a New Zealand viewpoint.
- v. We participated in workshops with EU programmes on the establishment of bioproduct standards for the future, supported the successful bid by EU researchers and industry to continue a new programme on bioproduct standards and translation to industry, and defined participation by New Zealand in round robin testing.

Kawerau - a study in industrial symbiosis

Industrial symbiosis is a way in which businesses can share resources, by-products, energy and knowledge to reduce costs and achieve greater returns on their investment. Kawerau's existing infrastructure, its location in the heart of the North Island forestry region and proximity to cheap geothermal energy provide a unique opportunity for the region's wood processing industries to adopt this closed-loop approach. This would be a more efficient use of resources, by-products and residuals, with value being added at each step of the process.

An analysis of industries in the region using Scion's WoodScape model has provided detailed metrics for potential investors of new wood processing opportunities in the area, in line with the Woodco strategic action plan. For example, an industrial sawmill, a plywood mill and a biofuel plant working independently of each other, each with a log input of 350,000 m³, achieve a 15.6% return on capital employed (ROCE). By sharing resources and integrating geothermal energy, this could increase by 17% to 18.3% ROCE, bringing additional employment opportunities and boosting the national GDP.

Investment: Scion Core

Collaborators: ISKawerau

Bioenergy and energy security

IO6 - Increase New Zealand's energy security through the expanded utilisation of forest biomass for energy



Impact KPI 12: Bioenergy. By 2014, Scion (in collaboration with appropriate industry and international researchers) will have enabled at least one commercial partner to adapt and test to pilot scale a bioenergy technology concept with a demonstrated commercial niche in New Zealand and supported additional actions to take this technology to commercial readiness.

Progress:

We continued to:

- i. Support Norske Skog and Z Energy following their success in their 'Stump to Pump' initiative to establish commercial bioenergy production in a pulp and paper mill.
- ii. Build international alliances and develop a new capability in thermochemical biofuels production.
- iii. Participate in IEA Bioenergy as an executive committee member and participant in two tasks, Commercialising Biofuels and Biorefining.
- iv. Lead the Advanced Biofuels Research Network bringing together interested groups in alternative bioenergy technologies for New Zealand through a yearly symposium.

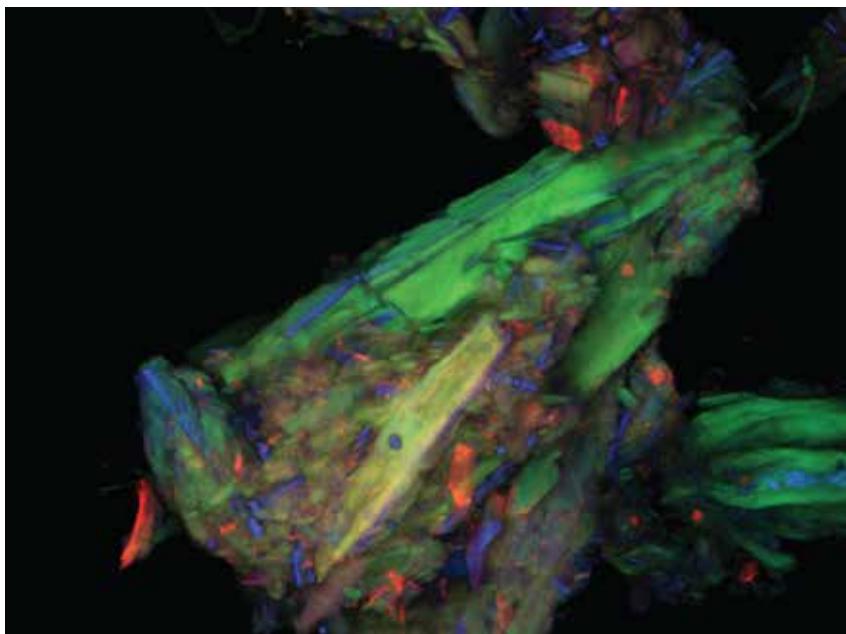
Shedding light on biomass conversion to sugars

Fluorescence imaging and spectroscopy have provided new insights into the molecular interaction that takes place between enzymes and lignin during the conversion of softwood biomass into simple sugars and lignin. Enzymes break down the cellulose and hemicellulose in pre-treated wood into simple sugars, which are then available for conversion into biofuels and biochemicals.

The effectiveness of this process is limited by the enzymes binding unproductively with lignin, but experiments by Scion's bioenergy and biofuels scientists have found this can be improved by adding polyethylene glycol (PEG). Fluorescence imaging shows that PEG binds more strongly with lignin than the enzymes, which increases the availability of the enzymes to bind with the sugars.

Investment: MBIE

Collaborators: INRA (France) (via Dumont d'Urville funding)



Steam exploded wood showing fluorescence of lignin (blue), cellulose (green) and cellulase enzyme (red). Correlations between the three colours show the association between cellulase enzyme and either cellulose or lignin and helps understand resistance in different pre-treatments.

First phase of 'Stump to Pump' nears completion

Creating high value biofuels from forestry and wood processing residuals could have far reaching benefits for the forestry industry and New Zealand's economy. The 'Stump to Pump' programme aims to do just that. In the past year, an assessment was undertaken to determine the technical

and financial feasibility of producing biofuels from forestry waste, and the commercial viability of establishing a modular test plant for the process. This stage of the programme is nearly completed.

The \$13.5 million programme is co-funded by the MPI Primary Growth Partnership, Norske Skog Tasman and Z Energy, with Scion providing research and technology support. If the technology can be commercialised, the estimated economic benefits to New Zealand over the next 20-25 years is an annual increase in GDP of up to \$1 billion.

Investment: MPI, Norske Skog Tasman, Z Energy

Molecular motors may drive energy technologies in the future

Scion's bioenergy and biofuel researchers have developed a physical theory to describe how a biomolecular motor converts energy from one form to another. These nanoscale motors are specialised proteins used by biological systems, including cells, to convert energy from one form to another. Molecular motors operate with efficiencies unrivalled by artificial

devices. Understanding the fundamental physics of how they operate will provide clues for developing new highly efficient industrial energy technologies.

This work has been published by the American Physical Society and supports our goal of providing leadership in bioenergy, biorefining and industrial biotechnology industries.

A research proposal has been submitted to the Marsden Fund to further investigate the theory and to test the validity of the theory against single-molecule experiments at some of the world's leading laboratories.

Investment: Scion Core

[www.scionresearch.com/impact/
bioenergy/molecular-motors-drive-
energy-technologies](http://www.scionresearch.com/impact/bioenergy/molecular-motors-drive-energy-technologies)

Sustainable fuels for schools

Scion's expertise in solid biofuel combustion has salvaged Logan High School's heating system, saving the school from having to invest thousands of dollars in new heating. An original conversion of the school's coal boilers to use wood pellets had been poorly done, resulting in high PM10 emissions

and an explosion that damaged the plant. Based on recommendations made by Scion's bioenergy scientists, modifications have been made to the boilers to improve the safety and efficiencies of the system.



Emissions levels are now below the tight emission requirements for Otago Regional Council and the school has saved an estimated \$400,000 on installing a new non-renewable fuel heating system. These modifications will pave the way for older coal-fired burners to be modified for wood pellet fuel use.

Investment: EECA, Logan Park High School

Collaborators: CRL Energy Ltd



Wood-based biofuel substrate
(600 x magnification).

Working in partnership with Māori

Success for Māori is also success for New Zealand

Scion recognises that success for Māori is also success for New Zealand. This is because decisions made by iwi or iwi groupings over the next few years will have an increasing influence on the nature of forestry and the bio-products value chain in New Zealand. In 2012 we set a target to significantly increase our work with Māori to support them in achieving their aspirations. We have made good progress in attaining this objective and continue to strive to improve our effectiveness in engaging with Māori and working in partnership with them.

In the past year, in conjunction with our Ngā Rangatira Technical Advisory Group and Scion's kaumātua, Scion's Te Papa Tipu Māori Plan was revised to sharpen the focus on two key outcomes, or aspirations. The plan aligns to the He Kai Kei Aku Ringa (The Crown-Māori Economic Growth Partnership) target of supporting "Māori to contribute to the economy at least \$2.6 billion greater than 'business as usual' in 2040". Also through the plan, we aspire "to help enable each Māori landowner to benefit from the economic, environmental and cultural development of their assets".

Our leading indicators of success are:

1. Scion and Māori are actively partnering and investing alongside each other to meet the needs of both partners.
2. Māori and Scion staff are working in each other's organisations and sharing and learning from each other.
3. There is increased investment into Scion research programmes that directly support Māori aspirations.

Scion is working in partnership with several iwi and iwi clusters, and is also a member of Te Ara Putaiao, the CRI Māori managers' group. This



Kawakawa is an indigenous species that is used for culinary, medicinal and cosmetic purposes.

group is committed to developing collaborative approaches to suit Māori business aspirations and leverage the complementary skills of CRIs for this purpose. One such collaborative initiative is the Maniapoto Māori Trust Board's project (see below).

Our work with iwi currently follows the general and highly interconnected themes of extracting greater value from their land, building community resilience by improving the resilience of the land, and protecting tāonga species.

With research showing that indigenous species such as kauri and tōtara may be significantly more productive than expected, interest is increasing in planted indigenous species for commercial aims. We are able to help growers make comparisons with other forest species to support their investment decisions.

Our programmes with iwi include:

- A Bay of Plenty iwi cluster (Ngāti Awa, Ngāti Makino, Ngāti Tu Wharetoa ki Kawerau, Te Pumautanga o Te Arawa) that was formed to evaluate

the potential benefits of changing their business model from being landlords of forested land to direct involvement in the ownership of forests on their land.

- A partnership with NIWA, AgResearch, Plant and Food Research, Landcare Research and GNS to support the Maniapoto Māori Trust Board in their 'Threads of research' programme focusing on land based economic development options for Maniapoto.
- Supporting the Toitu Te Waonui initiative to deliver their vision of underutilised Māori land being used more effectively to create a step change in economic opportunity for Māori across New Zealand.
- Continuing to support Maraeroa C Inc. with its project to develop understorey crops within radiata pine forests and thereby substantially increase the value extracted from their land and promote early cash flow in forests (see story on page 12)
- Supporting the iwi cluster, Te Tai Tokerau Forestry Innovation in Northland to develop a business

case testing in a real world environment, the hypothesis that development of culturally important species such as kauri and tōtara can also create acceptable economic returns.

- An iwi:Scion partnership to commercialise a Scion development enabling some indigenous tree species to be rapidly reproduced in response to increasing demand for large-scale indigenous planting.
- Supporting Ngāti Porou on the East Coast to develop forestry strategies that build community resilience in the fragile environment of the Waiapu Catchment area.
- Working with the Centre of Integrated Biowaste Research collaborators and Te Rūnanga o Kaikōura as part of the ESR-led programme to engage with the community to determine beneficial biosolids reuse options.
- Applying Scion's plant propagation expertise with support from East Coast iwi and DOC to propagate the rare indigenous plant ngutukaka (kakabeak). This is a critical step in bringing this species back from the brink of extinction (see side story).
- Working with trusts and Incorporations to develop cultural indicators for a Māori forestry dashboard to enhance communication and decision making on future forestry and land use options.

www.scionresearch.com/general/publications/scions-maori-plan



Photo: Eric Clinch

Saving the ngutukaka from the brink of extinction

Five hundred indigenous ngutukaka (kakabeak) were returned to the wild thanks to the propagation expertise of Scion's nursery staff. The ngutukaka (*Clanthus maximus*) is at risk of extinction with only 110 of the red flowered variety thought to be naturally occurring in the wild. The white variety has been extinct in the wild since the 1950s.

Scion propagated ngutukaka from the Lake Waikaremoana, Mohaka and East Cape areas to fortify existing populations. Nursery staff were also able to source seed from the white flowered ngutukaka, collected before it

became extinct. Its origin was established using DNA sequencing, and the white flowered ngutukaka is now being propagated at the nursery.

Plans are in place to establish an archive of each population and a seed orchard at Scion to investigate solutions to the species' vulnerability to pests and disease.

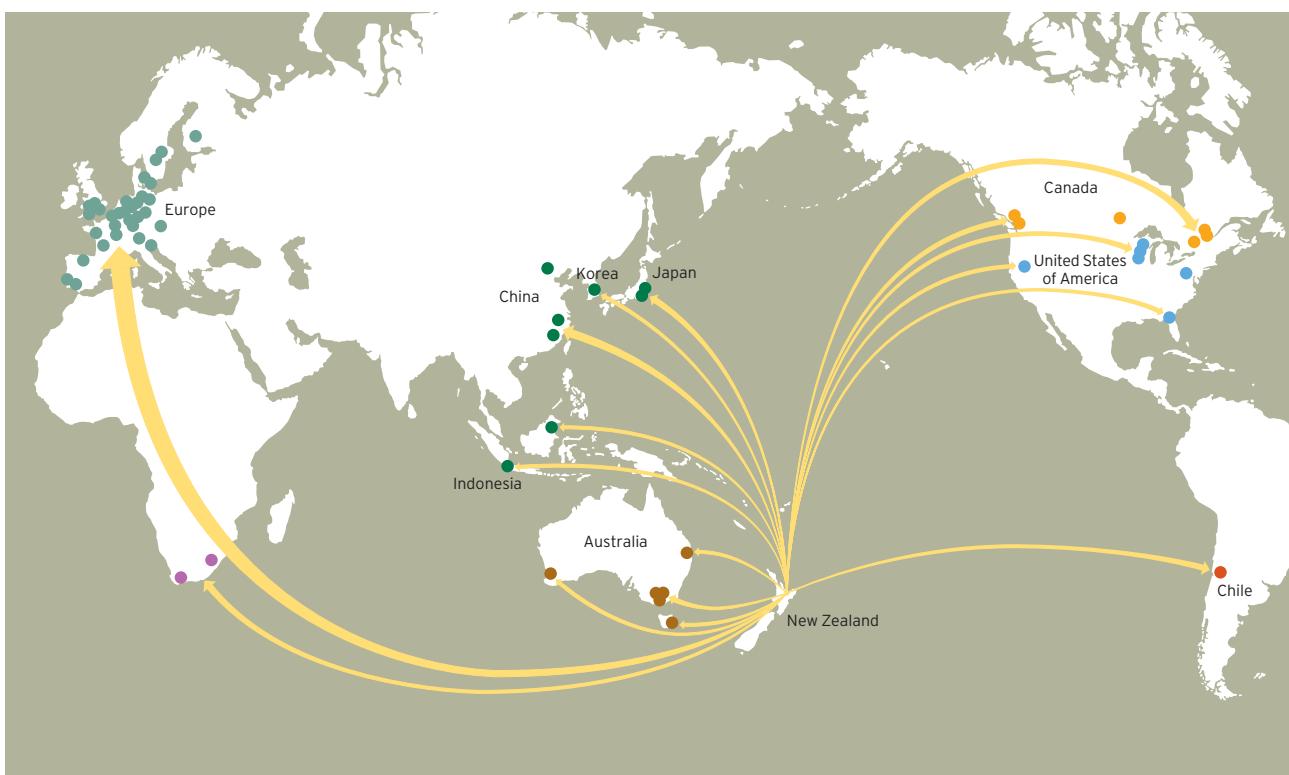
Investment: Scion Core, DOC (in kind)

Collaborators: DOC, Lake Waikaremoana Restoration Trust, LifeForce Restoration Trust, National Ngutukaka Recovery Group

Research collaborations

Assembling multi-disciplinary teams through strong national and international collaborations

INTERNATIONAL RESEARCH COLLABORATIONS



Europe

- Berne University of Applied Sciences, Switzerland
- Bruker Corporation, Germany
- DESY accelerator centre, Germany
- e-Xstream, Belgium
- French Institute of Technology for forest based and furniture sectors (FCBA)
- Forest Research, United Kingdom
- Fraunhofer Institute Würzburg, Germany
- Göttingen University, Germany
- Helmholtz-Zentrum Geesthacht, Germany
- INRA, Bordeaux, France
- International Fruit Obtention, France
- ISA, Technical University of Lisbon, Portugal
- Innventia, Sweden
- Karlstad University, Sweden
- Kew Herbarium, United Kingdom
- Liège University, Belgium
- Mendal University, Czech Republic
- Neiker-Tecnalia, Spain
- Sonae Indústria, Woodforce trials, France and Meppen, Germany

United States of America

- Oregon State University
- SESYNC, University of Maryland
- University of Florida
- University of Wisconsin-Madison
- US Forest Products Laboratory, Madison
- USDA Forest Service (Northern Research Station) West Virginia and Michigan

Asia

- Beijing Forestry University, China
- Chuo University, Japan
- Forestry and Forest Products Research Institute, Japan
- Fujian University, China
- Korea Institute of Energy Research (KIER), Korea
- PT Tamora Stekindo, Indonesia
- Sabah Softwoods Berhad, Malaysia
- Zhejiang A&F University, China

Canada

- Canadian Forest Service, Quebec
- FPInnovations
- Natural Sciences and Engineering Research Council of Canada (NSERC)
- Université Laval
- University of British Columbia
- University of Manitoba

Australia

- CSIRO
- Monash University
- Murdoch University

- RMIT, Melbourne
- University of Tasmania
- University of Queensland

South Africa

- Forestry and Agricultural Biotechnology Institute
- South African National Biodiversity Institute

Chile

- University of Chile

Scion's international reach is wide and deep, and through such collaborations and networks our scientists are constantly 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 global market. Our presence and influence in key networks is well recognised as these three examples show.



VTT. A delegation from VTT Technical Research Centre in Finland visited Scion in February to meet with scientists from our manufacturing and bioproducts teams. The visit was an opportunity to explore a more formal connection between Scion and VTT by way of scientist exchange, sabbaticals and shared post-doctoral research.

VTT is regarded as a globally leading multi-technological research organisation, with about 3000 employees. A collaborative agreement currently exists between both organisations for the research and technology adaptation of novel carbon materials from lignin, biorefineries, nanocellulose applications, pulp, paper and packaging and other global trends.

Finland's forestry industry is similar to New Zealand's. The sector accounts for about a fifth of the country's export revenue and is a major employer. Scion is working with VTT to develop and implement innovative

Montreal Process. Not included in the map is the Montreal Process.

Collaboration is at the heart of the Montreal Process, which is a voluntary intergovernmental response to the need for sustainable forest management. It was formed in Geneva in 1994, and the member countries are Argentina, Australia, Canada, Chile, China, Japan, Korea, Mexico, New Zealand, Russian Federation, United States of America and Uruguay. Scion is deeply involved with the Montreal Process because of forestry's place in our economy, and also through the role held by Principal Scientist Dr Tim Payn who is Convenor of the Technical Advisory Group. This group provides technical and scientific advice to the Montreal Process Working Group.

www.montrealprocess.org

and sustainable technologies and processes that are aimed at better utilising our forestry resources. We are also aiming to aid cross national commercial uptake of novel technologies in both New Zealand and Finland.

KBBE. The Knowledge Based Bio-Economy Forum (KBBE) is a formal cooperation between the European Commission, Canada, Australia and New Zealand to foster international co-operation in four key areas of research - food and health, bio-based industrial products, fisheries and aquaculture, and sustainable agriculture. Each country has a leader for each research theme who co-ordinates and develops collaborative research within that area. New Zealand's leader for bio-based industrial products on the KBBE Forum is Scion's General Manager Manufacturing and Bioproducts, Dr Elspeth MacRae.

The forum is driven by the need to address global challenges. For example, scientists are working together to find ways to help address the security of our food supply in a changing climate, and to investigate new economic opportunities including lignocellulosic biorefineries and bio-based substitutes for petroleum and other declining resources.

Much of the research done at Scion in the manufacturing and bioproducts area fits well with KBBE initiatives. Our work on wood fibres for use in bioplastics, and renewable chemicals used in bio-adhesives and bio-resins, and our licence with Sonae Indústria Group for our wood fibre dice technology, or Woodforce, are good examples.

Unification on standards and protocols for cross-border trade is another important theme, especially with increasing globalisation. For New Zealand, the emphasis is on high performance in thermoplastic

composites - both in wood and non-wood, and the variability in fibre sources. Scion is already doing a lot of work in this area, particularly with composites, biofoams, lignin bioplastics, recyclability and 3-D printing.



KIER. A growing area of research focus around the world is the quest to find commercially viable ways to produce liquid transportation fuels from plant biomass. Many different approaches are being investigated and trialled in this active and rapidly developing area of technology development.

Scion too, is part of the research landscape and is halfway through a three-year joint programme with the Korean Institute for Energy Research (KIER) to develop a technological idea to convert lignocellulosics (plant biomass composed of cellulose) to biofuels. This collaboration exploits the strengths of KIER in rapidly prototyping technology concepts and of Scion in energy systems analysis. Future collaborative opportunities are also being explored to utilise the expertise of Scion and KIER scientists.

Collaborating at home

Extrusion PLUS. One year in, the Scion-led Extrusion PLUS project started trialling development of wood composites / plastics prototypes with

three companies and discussions were well underway with a further seven companies. The project is highly collaborative involving three New Zealand universities, and a diverse mix of manufacturing companies, as well as drawing on links to other world-leading research institutes.

The aim of Extrusion PLUS is to create an enabling technology platform that will allow New Zealand manufacturers with extrusion capabilities to create products with advanced functionalities from locally derived renewable sources to satisfy export markets. Extrusion is widely used in manufacturing with plastics, composites, fibres, adhesives, coatings, laminated structures, metals, as well as in food and pharmaceutical processing.

The benefits of this project include creation of a conservatively estimated minimum of \$45 million per annum new exports in manufactured products containing renewables by 2022. The project began in 2012 with an MBIE investment of \$12.9 million over six years, and a number of companies are also investing cash and in-kind support in the project.

Bioresource Processing Alliance (BPA). A new alliance involving Scion and three other research providers was established during the year to step-up the recovery of high-value co-products from primary industries.

The BPA taps into some of the best technical facilities, research and processing knowledge available in New Zealand through this integration between Scion, AgResearch, Plant and Food Research, and Callaghan Innovation.

The alliance will have wide reaching benefits for the country's economy by adding value to the secondary by-products from forestry, marine, agricultural, horticultural and microbiological sectors. It integrates the research expertise and processing technologies within these separate sectors and provides a single point of engagement for other research collaborators, industry, commercial investors and government agencies.

The BPA is a government-supported initiative, with \$2.5 million per annum available over five years for technical and industry development. Scion's Dr Trevor Sturridge was the General Manager of the BPA until June 2014.

See also 'Rugs to riches' story on page 34 and <http://bioresourceprocessing.co.nz/>

From product acceleration to nutrient science. Drawing on our high-value manufacturing expertise, Scion's participation as a research partner in the New Zealand Product Accelerator was confirmed. The Product Accelerator undertakes research in the manufacturing, materials and design of products for innovative manufacturing companies to enable them to compete and grow their markets. Scion is also involved in Massey University's packaging programme.

Knowledge navigators at Scion and three other CRIs collaborated on a major literature review for the Soil and Land Use Alliance. The result

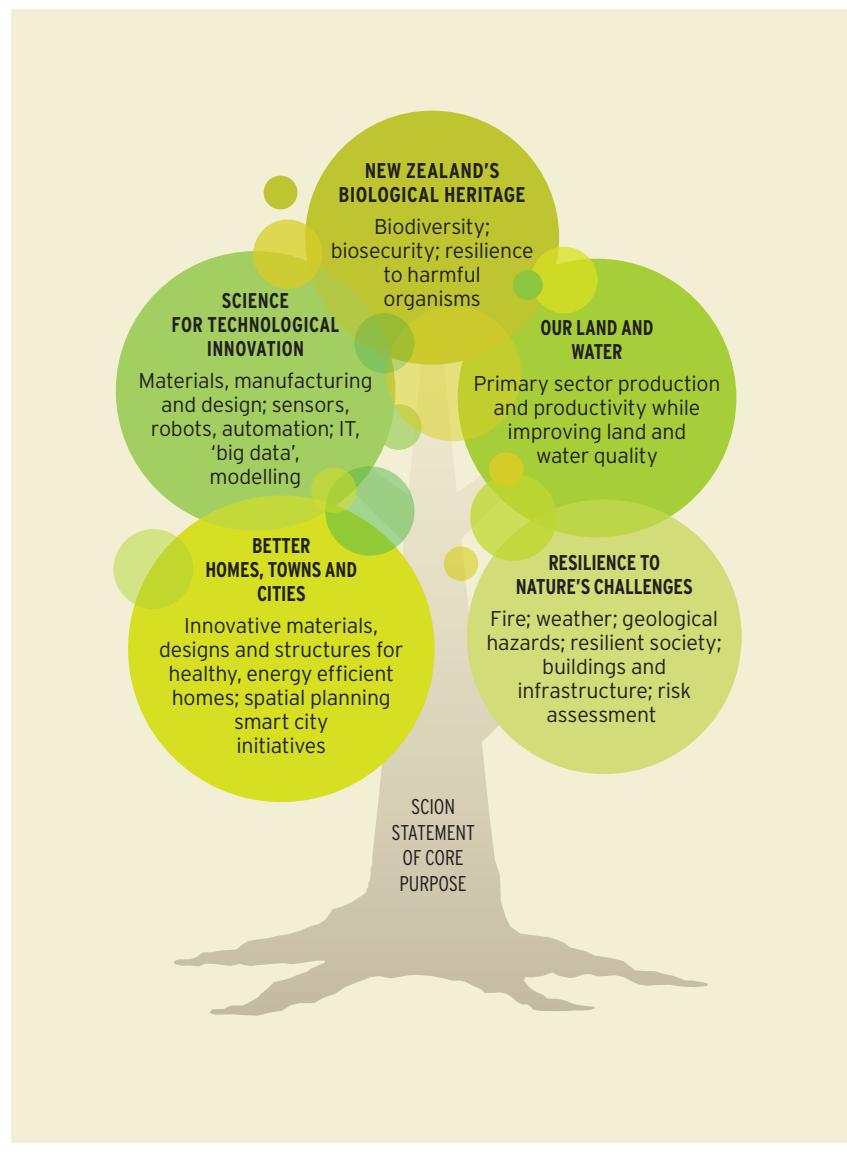
was a library of over 1900 individual references on nutrient management science, and was the first such CRI Knowledge Centre collaboration.

National Science Challenges

Throughout the year Scion's Science General Managers and close to a dozen senior researchers were heavily involved in planning for four of the ten challenges and provided strong input to the development of the final proposals. We also have a strong interest in the eleventh challenge, *Building better homes, towns and cities*, announced after the end of the financial year.

These challenges all align strongly with our core purpose, and are depicted here.

NATIONAL SCIENCE CHALLENGES



Working relationships

Acquiring insights, gaining new experiences and building relationships and reputations

Working alongside industry or policy makers through secondments and placements supported by Scion reinvestment helps to acquire insights, gain new experiences, and build relationships and reputations as these staff discovered.

Sean Taylor - Australian pulp and paper mill. Sean Taylor, from the Wood and Fibre Team, spent a week in Australia in May 2014. There he worked alongside colleague John Lloyd (Chemical Synthesis and Design Team member) troubleshooting the plant's pulp processes.

The technical visit ticked multiple boxes for Sean: he gained a deeper understanding of a unique white water circuit and developed working relationships with mill staff, learnt from John and developed his own problem solving skills.

Joel Gordon - Cucumber Limited. Software engineer Joel Gordon spent a week with web-developers Cucumber Limited in Tauranga. With the increasing use of mobile devices and the expectation that data and applications will be available anywhere and anytime, Joel wanted a better understanding of the key differences between designing desktop and web-based applications.

Apart from offering instant access from home, the field or while travelling, web-based applications can mean reduced investment in hardware and software maintenance. However, developing web applications has its challenges, not least of which is ensuring everything runs smoothly in different web browsers and operating systems.

Particularly struck by the ability web designers have to work directly with clients and make live changes, Joel has been able to incorporate within-browser editing and debugging into his work.

Joel was impressed by the technical experience, speed and efficiency of the Cucumber team and believes that their expertise could be of benefit to Scion in the future.

Heidi Dungey - RPBC. Forest Genetics Science Leader Heidi Dungey's experience breeding commercial forestry species saw her spending half a day a week at the Radiata Pine Breeding Company for a six-month period in 2014. The RPBC focuses on research to improve the genetics of radiata pine and provides superior radiata germplasm to its customers and shareholders Australasia wide.

Providing support for RPBC's CEO John Butcher, Heidi focused on strategic and operational issues and was able to spend some time thinking around the wider picture of tree breeding and ways for RPBC to leverage Scion's knowledge.

Heidi's secondment deepened relationships and strengthened collaborative links between RPBC and Scion. RPBC germplasm materials and their trials are being linked in to the 'Healthy trees, healthy future' and the 'Growing confidence in forestry's future' research programmes. For example, RPBC's elite clones are being screened for resistance to red needle cast.

Working together with RPBC will provide better outcomes for the company's shareholders, Scion and ultimately, New Zealand.

Suren Wijeyekoon - Winstone Pulp. Suren Wijeyekoon swapped his lab coat for 'hi-vis' when he spent three weeks at Winstone Pulp International in May 2014. A chemical engineer expert in the bio treatment of waste water, he helped the company optimise the nutrient flows to their waste water plant.

Waste water is treated using aerobic bacterial digestion but the water does not contain all the nutrients bacteria

need. Supplemental amounts of nitrogen and phosphorus are needed. Fine tuning of the addition rates is vital to ensure the bacteria are healthy enough to do their job, but not overfed and reproducing more than necessary as the waste bacterial sludge must be disposed of (usually burnt) at the end of the process.

Suren's secondment introduced Scion's capabilities and expertise to the company. Post-secondment, strong professional and personal relationships are continuing to develop and Scion is fast becoming the first technical port of call, with bigger projects looking likely in the future.

Brenda Baillie - freshwater management policy. Brenda Baillie's background in forestry and water quality saw her nominated to sit on a reference group formed to develop a National Objectives Framework to support and guide the setting of freshwater objectives in regional plans. Working with stakeholders from government, the regions, NGO organisations and iwi, the group developed a starting point and language for conversations on water, a consistent way of setting freshwater objectives and establishing national bottom lines for water quality.

With Scion's support, Brenda spent two years attending meetings in Wellington and gaining a profound insight into high level policy making, particularly with respect to the way science outputs are used at a national level. Scientific information is critical, but is just one of many factors that inform policy; others are social, economic, business and political considerations.

The hard work of improving New Zealand's freshwater is only starting, and it is a process that will take decades, but Brenda is optimistic for the future and believes that if anyone can do it, New Zealanders can.

Publications, technology translation and science outreach

Accelerating the uptake of new knowledge and technologies

Scion's science outputs emerge from the laboratory and the field in various ways from papers in journals to field trip demonstrations. Making an impact with end users requires effective translation and transfer of our technologies alongside meaningful dialogue between scientists and industry. Highlights from the year are described below.

High-impact publications convey science quality

Publication of papers in top scientific journals maintains Scion's international standing and visibility as a leading research institute in its focus areas. The annual weighted average H-index for Scion publications during the year was 50.60 (45.41 in 2012-13).

During 2013-14 Scion scientists had 128 papers published in peer reviewed publications. Listed below are the top six papers based on the journal's H-index, which is an international measure of the impact of scholarly publications.

- Brockerhoff, E. G., Kimberley, M. O., Liebhold, A., Haack, R., Cavey, J.F. (2013, November). Predicting how altering propagule pressure changes establishment rates of biological invader across species pools. *Ecology*. doi:<http://www.esajournals.org/toc/ecol/0/0>
- Tobimatsu, Y., Wagner, A., Donaldson, L. A., Mitra, P., Niculaes, C., Dima, O., Kim, J-I., Anderson, N., Loque, D., Boerjan, W., Chapple, C., Ralph, J. (2013, August). Visualization of plant cell wall lignification using fluorescence-tagged monolignols. *The Plant Journal* 76(3), 357-366. doi:10.1111/tpj.12299
- Ade, C., Bemm, F., Dickson, J. M. J., Walter, C., Harris, P. J. (2014, April). Family 34 glycosyltransferase (GT34)

genes and proteins in *Pinus radiata* (radiata pine) and *Pinus taeda* (loblolly pine). *The Plant Journal* 78(2), 305-318. doi:10.1111/tpj.12468

- Zhou, X., Smaill, S. J., Clinton, P. W. (2013, December). Methane oxidation needs less stressed plants. *Trends in Plant Science* 18 (12), 657-659. doi:10.1016/j.tplants.2013.09.011
- Challis, K. J., Jack, M. (2013, October). Energy transfer in a molecular motor in the Kramers regime. *Physical Review E - Statistical, Nonlinear, and Soft Matter Physics* 88, 042114 (2013). doi:10.1103/PhysRevE.88.042114
- Challis, K. J., Jack, M. (2013). Thermal fluctuation statistics in a molecular motor described by a multidimensional master equation. *Physical Review E - Statistical, Nonlinear and Soft Matter Physics* 88(6), 062136. doi:10.1103/PhysRevE.88.062136

publishing agreement with international publisher Springer after being published in-house by Scion for 40 years. The key motive for partnering with Springer was to increase global reach and impact. In the 18 months that NZJFS has been published by Springer more than 17,000 people have visited the journal's two websites, and access to individual papers has hugely increased.

Ecosystem services provide more than just wood

Leading scientists and academics came together to produce the first comprehensive overview of ecosystem services in this country, titled *Ecosystem Services in New Zealand - Conditions and Trends*, published in 2014.

With New Zealand's 1.7 million hectares of planted forests providing an ecosystem increasingly being

recognised for benefits other than wood, the inclusion of forestry was important.

Scion economist Dr Richard Yao contributed the chapter - "Planted Forests"- that describes several ecosystem services provided by planted forests, and their estimated economic, environmental and cultural values. The chapter provides government agencies, the forest industry and community a good overview of the ecosystem services provided by planted forests and the monetary value of some quantifiable



Partnership with Springer raises profile of NZJFS

Last year the *New Zealand Journal of Forestry Science* entered into a

services such as timber, carbon sequestration, bioenergy, avoided erosion, recreation and biodiversity enhancement.

Editor, Landcare Research Principal Scientist Dr John Dymond, says a key goal of the book was to improve understanding of the functioning of New Zealand ecosystems and synthesise information from expertise across a wide array of organisations and disciplines. The book will help decision-makers to access current knowledge in a 'one-stop-shop.'



Face to face at workshops and seminars

Trans-Pacific Forestry Value Chain.

In December, Scion hosted a two-day workshop to identify issues, opportunities and projects that will improve the performance of forest and wood products value chains. International speakers were among the 50 attendees from a broad base including government, forest growers, industry associations, researchers and Māori trusts. Outcomes included collaboration with international researchers, an agreed action plan with reported summaries, and the establishment of an industry steering group.

Mānuka – an opportunity for land owners.

About 175 landowners, bee keepers, honey processors and investors gathered in Masterton in February at a Mānuka Honey Seminar to learn about the mānuka industry. While many speakers focused on medicinal properties and the demand for limited mānuka honey supplies, growing mānuka on marginal land was the main theme. Scion took centre stage with the aim to 'sell' the concept of establishing mānuka on marginal lands following practices developed for plantation forestry. The effort was well worth it with approaches to Scion by new parties interested in

mānuka research, access to various sites around New Zealand for trials, and the raising of Scion's profile as a research leader in this area.

Biosecurity risks. The annual biosecurity FOA/MPI workshop held over two days in February at Scion brought together 90 people from the forestry sector, government and CRI scientists to explore issues under the workshop theme 'Biosecurity risk to trade in New Zealand forest products'. Feedback was overwhelmingly positive for the learnings, discussions and interactions between the different representative groups. An important outcome was the building of a genuine partnership with industry and collaborators with interest in forest protection.

"The annual FOA/MPI forest biosecurity workshop hosted by Scion was a big success this year ... as well as highlighting many of the key issues facing the industry, the workshop also provided an excellent forum for Scion researchers and others to present some of their relevant recent research results. This was a very valuable event for industry and government stakeholders as it provided a ready update on key issues and new research results over a day and a half period. Excellent time well spent!"

Bill Dyck,
FOA Forest Biosecurity Manager



Ahead of the Pack. In March, some 40 packaging suppliers and users attended Scion's first packaging workshop aimed at engaging with industry by showcasing Scion's capabilities, and to stimulate networking. The day started with an overview of packaging and plastics trends followed by an interactive tour, and finished with a case study that demonstrated how Scion has developed a commercial product from fundamental research. The one-day event was highly successful and led directly to new work with some of the companies who attended.



Farm foresters' field trips. During two days in April, Scion scientists mingled with more than 200 landowners and land managers in the Waihopai Valley, Marlborough. The event was the 58th NZ Farm Forestry Association Annual Conference where Scion staff shared current research status on topics including: emerging species (redwood, eucalypts, cypress and indigenous species); riparian planting to improve or protect water quality; factors affecting pine productivity; mānuka establishment and management; and soil microbial interaction and growth promotion. Feedback was extremely positive from attendees and further speaking invitations were made to several Scion presenters. Another key benefit for Scion was the revitalisation of connections with this significant stakeholder group.

Managing wildings. In April, the New Zealand Wilding Conifer Management Group and the North Island wilding group met for their AGM and workshop at Scion with over 40 participants. The associated field trip provided a very good overview of the North Island wilding situation and included a number of special wilding situations in the central North Island, for example, near Waiouru. Participants were most impressed with the depth of work that Scion and others are doing on wildings research.

Is wood quality still relevant?

Planting forests is a long-term commitment. Forest managers and wood processors want to realise the greatest value from their resource by getting the correct balance between quality and volume. Scion put this topic squarely on the table at two Wood Quality Workshops, held during May in Christchurch and Rotorua, which far exceeded anticipated registration numbers. More than 100 forest growers, tree breeders, wood

processors, log buyers and researchers came together to discuss high-level topics such as:

- How important is wood quality for our major markets now and in the future?
- How does wood quality vary and what are the key factors driving this variation?
- What are the implications of wood quality variation for processors.



A conclusive outcome from both workshops was that wood quality is highly relevant and needs to be better quantified if we are to create more value from our forest resources. Scion will be exploring this proposition through better communications between all sectors of the forest industry.

GCFF kick-off conference. As the title implies the 'Kick-off Conference' for the 'Growing confidence in forestry's future' (GCFF) programme aimed to create momentum around this major research programme. Held in Rotorua over three days in June 2014, the conference presented first results of this new six-year MBIE and FOA levy trust co-funded research programme. About 70 people attended, from MBIE, MPI, industry, iwi, regional council, and researcher collaborators from Australia, the USA, CIRIs and universities.

A format of two days of presentations and discussions, followed by a day field trip to Tarawera Forest and a visit to Scion's laboratories, allowed participants to get a deeper understanding of what the GCFF programme is all about. Interactions were fostered between the research teams, collaborators, stakeholders and other interested parties. Several new people are now involved in the establishment of the new GCFF

innovation clusters, and others also signed up for future event information and newsletters.

Educational outreach

Several hundred school students and staff had direct contact with our scientists during the year. Such interactions included: curriculum-based visits to Scion laboratories, which may have included some experimental work; scientists giving talks to school in person and by Skype; staging exhibits at Bay of Plenty careers expos; networking with local science teachers; providing judges for the Bay of Plenty Science Fair; and hosting a tour of our campus for school science technicians.

Also, Scion supported the government funded Futureintech programme, which promotes technology and science careers, by providing time for some science staff to take on the role of Futureintech ambassadors. Those staff shared their time, knowledge and expertise to motivate school students on topics as broad as chemistry to as narrow as spectroscopy. Feedback was consistently high for the value of such interactions with working scientists.



Telling our stories

Scion Connections, our quarterly newsletter, underwent a makeover a year ago and now carries more content. It is provided in hard copy and as an electronic newsletter with 970 'subscribers' as at 30 June 2014. Individual stories were also posted to our website under "Our science stories", directly accessible from the homepage.

A 24-page profile of Scion was published as a lift-out insert in the *Rotorua Daily Post* in August 2013, and additional copies were used when engaging with public audiences throughout the year.

Six new videos were made and viewed 6110 times on YouTube. In addition to media releases, a number of scientists gave feature length radio interviews on a range of topics and the podcasts were linked from our website.

The National Library of New Zealand featured the novel 'biospife' in a long-running exhibition on innovation in New Zealand. Scion developed the biospife (a utensil for eating kiwifruit) in partnership with ZESPRI.

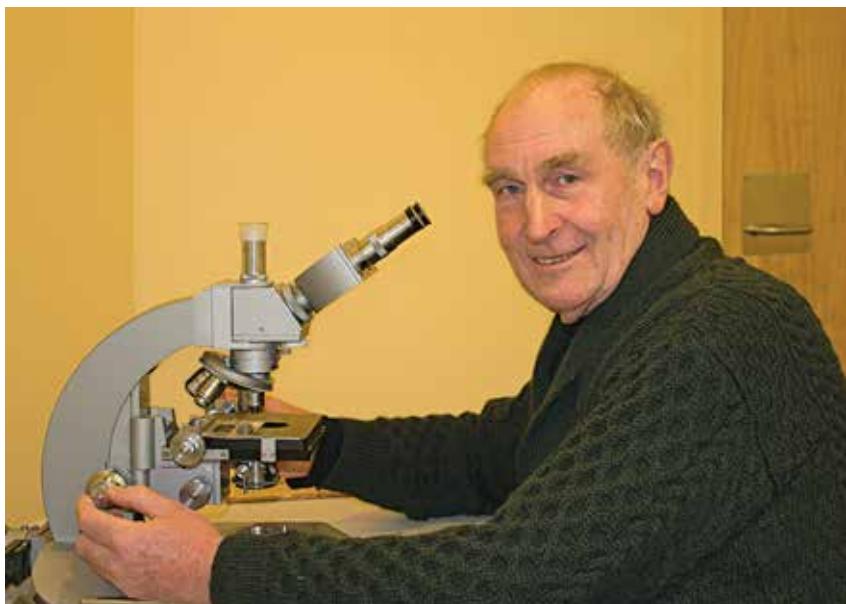
Sponsorship

The conferences and events listed below received Scion sponsorship during the year. Such investment helps to keep Scion's science and technology capabilities in front of key audiences. Conferences and other industry events provide ideal opportunities to build networks and exchange knowledge within and between science and end user communities. In addition to sponsorship, our scientists also presented at many of these conferences and also staffed trade displays.

- Australasian Plant Pathology Society (APPS) Conference
- Bay Of Plenty Science Fair
- Canterbury Rural Firefighter Challenge
- Federation of Māori Authorities Conference
- ForestTech
- ForestWood 2014 Conference
- NZ Entomological Society Conference
- NZ Farm Forestry Association Conference
- NZ Institute of Forestry 2013 Conference
- NZ Packaging Council Awards
- Pine Manufacturers Association and NZ Wood Processors Association Conference
- TV Rotorua science programme sponsorship
- Waiariki Institute of Technology graduation ceremony
- Waikato University Earth and Ocean Sciences Postgraduate Conference
- WasteMINZ Conference
- Water NZ Conference & expo
- Waterways Postgraduate Student Conference.

Achievements and accolades

Our strength lies in our talented people and teamwork



Dr Ian Hood

Awards and honours

Doctor of Science. Dr Ian Hood was awarded the degree of Doctor of Science in Science from the University of Auckland. He received the prestigious D.Sc. for his contribution to advancing aspects of forest pathology and the ecology of wood decomposition in indigenous forests and exotic tree plantations. This was achieved through original research into diseases of forest trees and the biology of the principal decomposers of woody debris in these ecosystems.

Future Forests Research Achievement Awards

- Dave Henley won the Contribution to a Science Team Award.
- Dave Pont won the Science of International Quality Award.
- Paul Milliken won the Innovation Adding Value to the Sector Award.
- Jeremy Snook won the Communication and Sector Engagement Award.

NZ Innovators Awards. The Biopolymer Network Ltd (BPN) won the 2013 Innovation Excellence in Research category for its bioplastics foam, ZealaFoam™. Research capability was provided by the biofoams team at Scion.

Ray Meyer Medal. The Institute of Professional Engineers New Zealand jointly awarded the Ray Meyer Medal for Excellence in Student Design to two winners. One winner was the Biped Felling Machine by University of Canterbury students George Wareing, Sean Bayley, Scott Paulin and Thomas Gilbert, supervised by Dr Stefanie Gutshmidt (Academic Supervisor) and Scion's Dr Richard Parker (Industrial Supervisor).

Best paper. Dr Nicolas Meurisse was awarded a Royal Entomological Society UK Award for Best Paper Published in 2012/2013 in the journal *Agricultural and Forest Entomology*. The paper is "Historical

distribution of the oak processionary moth *Thaumetopoea processionea* in Europe suggests recolonization instead of expansion" by Groenen, F. & Meurisse, N. *Agricultural and Forest Entomology* (2012), 14(2), 147-155.

Scion Awards 2013. Scion recognised the following staff for their outstanding achievements and contributions over the 2013/14 year:

- *Science Impact Award* won by Dr Eckehard Brockerhoff.
- *Engineering Impact Award* won by the TERAX™ team led by Dr Daniel Gapes.
- *Quality Initiative Award* won by Gregor MacDonald.
- *Excellence in Customer Engagement Award* (two awards made) won by Dr Heidi Dungey and by Loretta Garrett.
- *New Opportunity Award* won jointly by Dr Emily Telfer and Lisa Stanbra.
- *People's Choice Award* (three awards made) won by Joy Wraight, Marcel van Leeuwen and jointly by Jo Mackenzie and Cayleen Murphy.

Emeritus. Dr Dave Cown was awarded Emeritus status on his retirement from Scion.

Grants

Judith Gardner and Ian Simpson each received a Queen Elizabeth II Technicians' Study Award to undertake study in Australia and the United Kingdom respectively.

Belinda Gresham received a Queen Elizabeth II Technicians' Study Award to travel to Australia to develop diagnostic skills in identifying Australian insects, specifically bark beetles, wood-borers and psyllids, that are important to New Zealand forestry.

Drs Alankar Vaidya and Lloyd Donaldson were awarded funding from the Dumont d'Urville New Zealand-France Science & Technology Support Programme.

Professional positions

Dr Eckehard Brockerhoff had his appointment as Adjunct Associate Professor in the School of Biological Sciences, University of Canterbury, renewed for a further three-year term to 31 May 2017.

Dr Peter Clinton was the invited Co-chair of the International Symposium on Forest Soils - "Linking ecosystem processes and management to forest biodiversity and functions" - held in China in September.

Dr Peter Clinton was invited to be a proposal reviewer for the Australian Research Council.

Dr Warren Grigsby joined the editorial board of the *Journal of Wood Chemistry and Technology*.

Dr Elspeth MacRae was elected to the Packaging Council of New Zealand Executive Committee.

Dr Warren Parker was appointed Chair of the New Zealand Conservation Authority.

Dr Stephen Pawson continued to serve as President of the Entomological Society of New Zealand (April 2013 to April 2015).

Dr Tim Payn was nominated to serve on the Regional Advisory Group for

the Atlantic European Regional Office of the European Forest Institute.

Dr Tim Payn was invited by the FAO (Food and Agricultural Organisation of the United Nations) Forestry Department to be lead author of one of nine scientific papers to be written on global forests in 2014.

Dr Tim Payn was invited to become a member of the new AGMARDT (The Agricultural and Marketing Research and Development Trust) Advisory Group to provide expert opinion and advice on grant applications.

Dr Toni Withers was invited to sit on the Environmental Protection Authority's Insect Advisory Panel for pest management.

Financial results summary

	2012 Actual	2013 Actual	2014 Budget	2014 Actual
Revenue, \$m	44.06	45.49	47.89	48.14
EBIT, \$m	2.07	2.55	2.27	4.28
EBIT Margin	4.7%	5.6%	5.0%	8.9%
EBIT-R, \$m	2.89	3.52	3.34	5.03
EBIT-R Margin	6.6%	7.7%	7.0%	10.5%
Total Assets, \$m	40.01	41.52	43.39	43.70
Return on Equity	6.0%	5.8%	5.3%	9.4%
Equity Ratio	68.8%	69.6%	70.2%	72.0%
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 amounts are approved by the Minister.

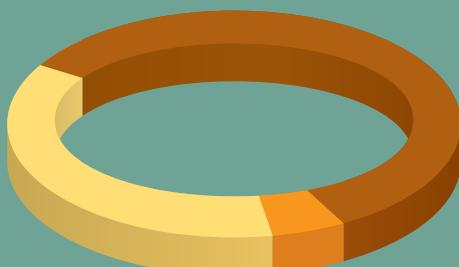
EBIT-R Margin: EBIT-R ÷ revenue.

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.)



OUR REVENUE

- MBIE **57%**
- Government department **8%**
- Other commercial **35%**



HOW OUR REVENUE IS SPENT

- Employee remuneration **51%**
- External services and contractors **19%**
- Net profit before tax **8%**
- Depreciation and amortisation **7%**
- Premises costs **5%**
- Consumables **3%**
- Travel **3%**
- Other operating costs **2%**
- Non operating costs **1%**
- Training and recruitment **1%**

Glossary

AUT	Auckland University of Technology	LiDAR	Light detection and ranging
B3 ALLIANCE	Better Border Biosecurity Alliance	MBIE	Ministry of Business, Innovation and Employment
BOPRC	Bay of Plenty Regional Council	MfE	Ministry for the Environment
BPA	Bioresource Processing Alliance	MPI	Ministry for Primary Industries
BPN	Biopolymer Network Ltd	NCEAS	National Centre for Ecological Analysis and Synthesis
CRI	Crown Research Institute	NIWA	National Institute of Water and Atmospheric Research
DOC	Department of Conversation	NRFA	National Rural Fire Authority
EECA	Energy Efficiency and Conservation Authority	NSCs	National Science Challenges
EPA	Environmental Protection Authority	NZ NPPO	New Zealand National Plant Protection Organisation
ESR	Environmental Science and Research	NZ WCMG	New Zealand Wilding Control Management Group
FAO	Food and Agricultural Organisation of the United Nations	NZTE	New Zealand Trade and Enterprise
FFR	Future Forests Research Ltd	OSU	Oregon State University, USA
FGLT	Forest Growers Levy Trust	PGP	Primary Growth Partnership
FIF	Forest Investment Finder	PMA	Pine Manufacturers Association
FOA	New Zealand Forest Owners Association	PSAF	Pre-Seed Accelerator Fund
FSC	Forest Stewardship Council	RDC	Rotorua District Council
GCFF	Growing Confidence in Forestry's Future research programme	RNC	Red needle cast
GM	Genetic modification	RPBC	Radiata Pine Breeding Company Ltd
GNS	GNS Science	RPS	Regional Policy Statement
HSNO	Hazardous Substances and New Organisms	Scion Core	Scion core funding
HTHF	Healthy Trees, Healthy Future research programme	SCC	Sciences, Computers & Consultants, France
IFO (France)	International Fruit Obtention, France	SFF	Sustainable Farming Fund (MPI funding)
IPCC	Intergovernmental Panel on Climate Change	STIMBR	Stakeholders in Methyl Bromide Reduction
IPENZ	Institution of Professional Engineers New Zealand	SWI	Solid Wood Innovation
IPPC	International Plant Protection Convention	UBC	University of British Columbia, Canada
ISK	Industrial Symbiosis Kawerau	USDA	United States Department of Agriculture
KBBE	Knowledge Based Bio-Economy	Woodco	Wood Council of New Zealand
KIER	Korean Institute for Energy Research	WPA	Wood Processors Association



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